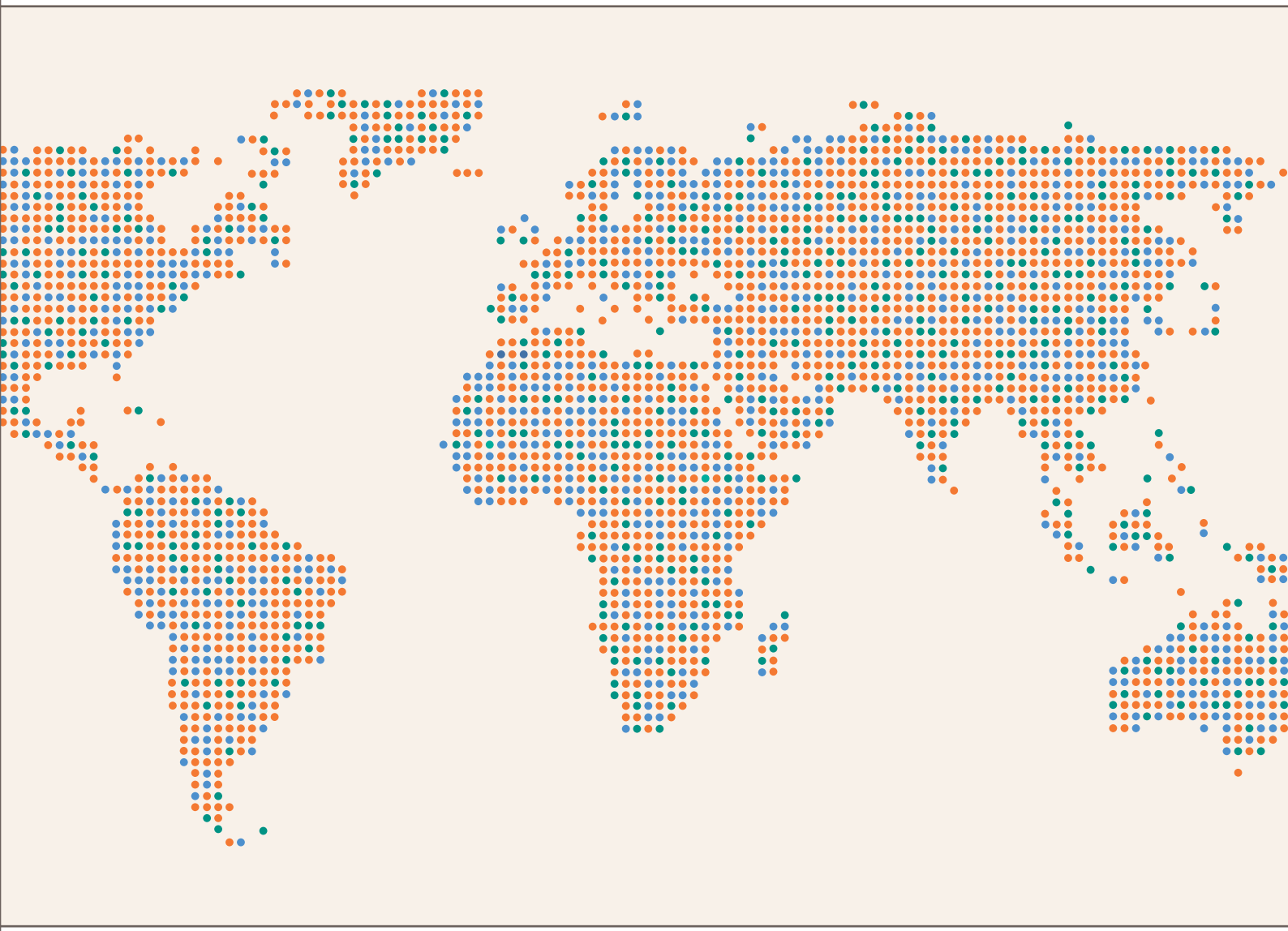
Food and Agriculture Organization of the United Nations

IFCN Dairy Research Network



WORLD MAPPING OF ANIMAL FEEDING SYSTEMS IN THE DAIRY SECTOR

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IFCN DAIRY RESEARCH NETWORK

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TABLE OF **CONTENTS**

LIST OF FIGURES AND TABLES

FOREWORD

The International Dairy Federation (IDF) established a Task Force on Animal Feeding in 2010. It comprises 28 expert members from 18 IDF member countries and representatives of the Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health (OIE), the International Feed Industry Federation (IFIF) and the European Feed Manufacturer's Federation (FEFAC). The first meeting was held at the IDF World Dairy Summit in Auckland (NZ) in November 2010. The aim of this group was to address animal feed and feeding issues from a cross-sectional perspective, with the following specific objectives:

» to develop options for, and examine the implications of, changing animal diets with the aim of reducing the carbon footprint (predominantly related to methane emissions from enteric fermentation);
» to develop options for, and examine the implications of, changing animal diets in view of the nutrient composition of milk in the context of human health and nutrition; and
» to identify the consequences of changing animal diets with regard to animal welfare, animal health and productivity.

The ultimate goal of the Task Force is the development of a technical document on animal feeding in the dairy sector, taking into account the various requirements referred to above.

The development of a *World Mapping of Animal Feeding Systems in the Dairy Sector* became the first project of the Task Force.

It was quickly realized that this endeavour to gain a global view of animal feeding systems in the dairy sector would require coordinated action by global organizations. Thus, a tripartite effort was undertaken by the IDF, FAO and IFCN.

The three partner organizations undertook separate but complementary approaches in order to develop an inventory of the various dairy feeding systems in the world. Each approach has strengths and limitations in contributing to this project. However, the complementary nature of these three approaches makes it possible to obtain an overall mapping of the global situation on this issue.

DISCLAIMER

The views expressed in this document are those of the authors and not necessarily those of the organizations that asked them to bring together and present the information that is published here. In particular, it must be emphasized that the three parts have been prepared in accordance with the respective approaches of the three organizations and what is said in one part does not reflect the views of either of the other bodies.

ACKNOWLEDGEMENTS

The three collaboration partners, FAO, IDF and IFCN, thank most warmly the main authors and contributors to the report: Harinder Makkar, Viola Weiler and Guya Gianni from FAO; Benoît Rouillé, Jamie Jonker, Anne Jourden, Thierry Geslain, Jennifer Huet and Joerg Seifert from IDF; and Torsten Hemme, Othman Alqaisi, Dorothee Boelling and Asaah Ndambi from IFCN. Thanks are also due to Philippe Ankers from FAO for his suggestions, which substantially improved this document. The very many experts in many countries who responded to the questionnaires issued and thereby provided the basic data on which the three parts of the document are based are also thanked.

This publication was possible with financial support from Evonik Industries, European Feed Manufacturers' Federation (FEFAC), Cargill Animal Nutrition, International Feed Industry Federation (IFIF) and le Centre National Interprofessionnel de l'Economie Laitière (CNIEL).

EXECUTIVE SUMMARY

Animal feeding is the first step in the production of milk and affects the rest of the production chain. External factors also influence dairy feeding systems and several indicators are available to characterize milk production systems in relation to the feeding of animals. These may be more or less pertinent, depending on the questions asked or problems encountered. Generally, it is first and foremost a matter of correctly defining the indicators in order to use them in an appropriate manner and interpret them correctly.

The use of simple indicators should therefore make it possible to understand better the feeding systems throughout the world by comparing them. This approach makes it possible, using a global survey, to present the diversity of feeding systems within and among countries, using common criteria for comparison.

This summary combines the results of the surveys conducted by the International Dairy Federation (IDF), the IFCN Dairy Research Network (IFCN) and the Food and Agriculture Organization of the United Nations (FAO). Where practical, data across the surveys have been combined into maps representing an average-sized dairy farming system for each country. The IFCN survey includes the results on dairy cattle feeding systems for 44 countries; the IDF survey includes results on dairy cattle feeding systems for 15 countries; and the FAO survey includes results on dairy cattle, water buffalo, sheep and goat feeding systems for 43 countries.

After an introduction, the document is divided into four parts:

- **The first part** is a synthesis of the three studies described in the other three parts.
  - Results of the feeding schemes obtained from the IDF and IFCN studies are summarized in world maps for dairy cattle. The parameters included are stocking rate, average milk yield and the percentages of roughage, concentrate and processed feed utilized.
  - World maps for the feeding baskets (percentage of constituents in feeds) from the FAO study are also presented for the improved dairy cattle and water buffaloes, sheep and goats; both during lactating and dry stages.
- **The second part** describes and summarizes results of the study carried out by IDF. Results of the feeding schemes (stocking rate, milk yield, percentages of roughage, concentrates and processed feed, feed efficiency etc.) are paired with useful demographic data on the size and scope of the dairy industry structure in participating countries. The data are presented by country in a concise factsheet format.
- **The third part** describes and summarizes results of the study carried out by FAO. Results of the feeding schemes for dairy animals including cattle, buffaloes, sheep and goats in participating countries are presented, using a feeding basket approach that indicates the percentage of the diet supplied by roughage, concentrate and compound feed at the national level.

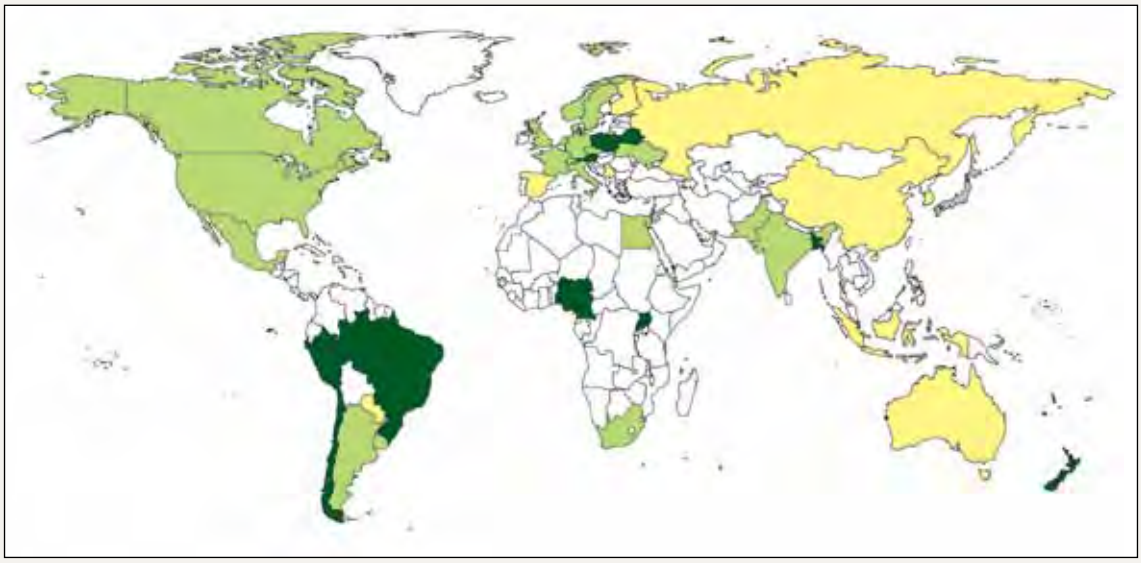
» **The fourth part** describes and summarizes results of the study led by IFCN. The results of dairy farming systems from typical farms are presented, giving a descriptive analysis of feeding systems, milk yields, land use and labour. This approach has also been used to analyse feed costs, feed prices and feed efficiency. The feed data have been validated via interaction between the local researcher and the researcher in the IFCN Dairy Research Network.

A total of 47 different feeding systems were characterized. These systems differed in the total amount and composition in terms of levels of roughage, by-products and concentrate fed to dairy animals. Different countries took different approaches, from altitude to the type of feed given, for characterization of the feeding systems.

Geospatial displays of data represent an easy way to demonstrate the diversity of animal feeding approaches. Below are examples of two world maps from this report (based on IFCN and IDF data) that explore this diversity for dairy cattle. The first world map displays the percentage of roughage expressed as the percentage of dry matter intake of roughage to the total feed consumed by an animal on a yearly basis. The second world map displays the percentage of concentrate expressed as the percentage of dry matter intake of concentrates to the total feed consumed by an animal on a yearly basis. By definition, the percentage of concentrates and roughage represent the totality of feed consumed by the animals (100 percent). The percentage of roughage and concentrate intake may vary according to such factors as availability of land for on-farm production, geographic and/or climatic factors and availability of alternative or by-product feeds.

An approach similar to that described above and termed "feeding basket" was used to map ration constituents in the FAO study. In general, feed constituents determined through the three different studies (IDF, FAO and IFCN) followed an almost similar pattern. The FAO study has demonstrated that: (a) crop residues are an important part of the diet for cows and buffaloes in Asia and that the compound feed use in Asia and Africa is very low; (b) improved dairy buffaloes receive more concentrates and compound feed than local buffaloes; (c) for both cattle and buffaloes in Asia and Africa, the use of home-made concentrate is higher than the use of compound feed; (d) lactating sheep diets worldwide received similar proportions of roughage, concentrate and compound feed. In most countries the roughage in the diets of both lactating and dry sheep is composed of grasses (fresh and hay); (e) the major component in the diet of lactating goats is roughage; and (f) milk is produced from human-inedible feed resources by the dairy sector in most developing countries.

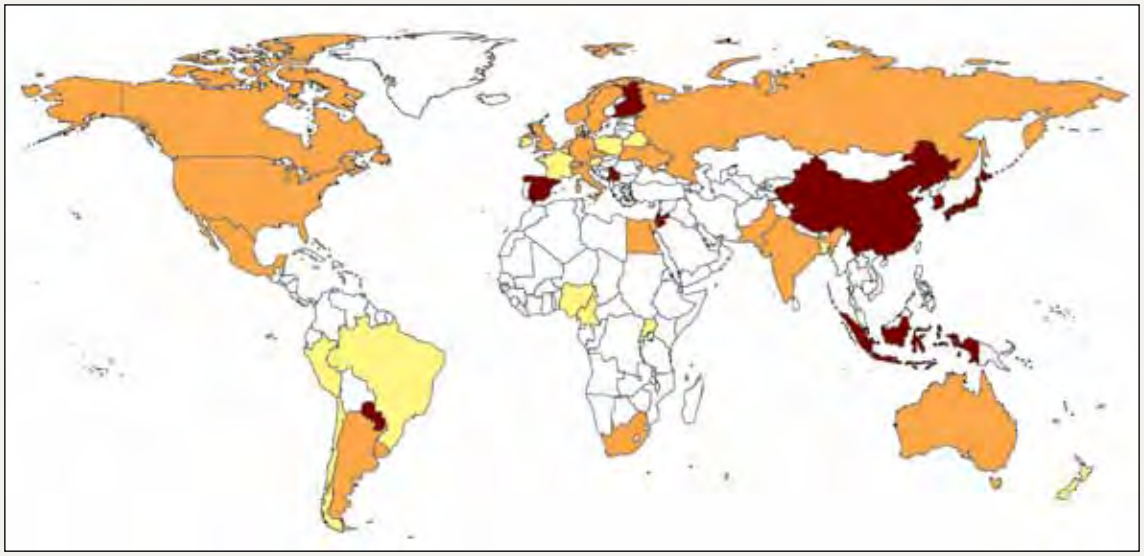
Finally, additional indicators may be useful, although perhaps not as commonly used. For example, feed efficiency (ratio between the yearly milk yield expressed as energy-corrected milk and total yearly intake of feed dry matter) is an increasingly important indicator that clearly links the economic and environmental sustainability of milk production. Increasing the feed efficiency by 5–10 percent would have a substantial effect on decreasing both the cost of production per unit of milk and the environmental footprint.



SHARE OF ROUGHAGE IN THE RATION

(%)

- >80≤100
- >60≤80
- >40≤60
- <40
- NO DATA



SHARE OF CONCENTRATE IN THE RATION

(%)

- >40
- >20≤40
- ≤20
- NO DATA

1 INTRODUCTION

Animal feeding is the first step in the production of milk and affects the rest of the production chain. External factors also influence dairy feeding systems and several indicators are available to characterize milk production systems in relation to the feeding of animals. They may be more or less pertinent depending on the questions asked or problems encountered. Generally, it is first and foremost a matter of correctly defining the indicators in order to use them in an appropriate manner and interpret them correctly.

The use of simple indicators should therefore make it possible to understand better the feeding systems throughout the world by comparing them. This approach makes it possible, using a global survey, to present the diversity of the feeding systems within and among countries, with common criteria for comparison.

1.1. GLOBAL OVERVIEW OF ANIMAL FEEDING SYSTEMS

Apart from this report, there has been no published comprehensive review of the diversity of animal feeding systems utilized for dairy animals around the world. Although some of the information contained in this report may have been previously available at a country or sub-country basis, much information is new, particularly from developing nations and relating to small ruminant species. There are some commonalities of the animal feeding systems utilized for dairy animals around the world that can characterize certain segments of dairy production. However, as this report will demonstrate, making broad assumptions about animal feeding systems utilized for dairy animals around the world belies the real diversity that exists.

Developed countries generally have animal feeding systems adapted for large-scale (herd size) higher-yielding dairy cows that are concentrated in confinement production systems (either seasonally or year-round). There is a greater reliance on both stored forage and purchased grains and concentrate. However, it is easy to find feeding systems that do not fit into that broad generalization. For example, animal feeding systems in New Zealand are predominately pasture-based with a low reliance on purchased grains and concentrate (typically less than 10 percent of the diet) even though the average herd size is relatively large compared with those in most other developed countries.

Developing countries generally have animal feeding systems adapted for small-scale (herd size) lower-yielding dairy cows, where locally produced roughage represents the major source of feed utilized. However, that broad generalization misses the important delineation between the roughage sources. For example, animal feeding systems for dairy cows in Venezuela rely almost entirely on grass as the roughage source whereas systems in Thailand rely substantially on crop residues (cereal straw, corn stover, etc.).

Additionally, developing countries are more likely to have animal feeding systems adapted for small-scale (herd size) water buffalo, sheep and goat production systems, where locally produced roughage constitutes the major proportion of feed utilized. However, that broad generalization again misses an important delineation, that between the use of roughage and the use of concentrate. For example, animal feeding systems for dairy goats in Indonesia rely almost entirely on roughage whereas up to 40 percent of the feed utilized in systems in Jordan and Lebanon is from concentrates.

1.2. FOUNDATION FOR THE FUTURE

This report builds a knowledge foundation for animal feeding systems that will serve as a valuable resource for the dairy industry in the future through the wealth of information on the diversity of animal feeding systems for dairy cows, water buffaloes, sheep and goats contained herein. This information, used as a technical resource, will enhance feeding systems already in use by examining the success of similar systems from around the world. Additionally, the animal feeding systems in the report will be used for the development of new feeding systems as dairy production systems change and advance in both developed and developing countries.

The diversity of animal feeding systems contained in this report will serve as a valuable tool for advancing the global sustainability of dairy production. Accurate information on feeding systems is necessary for comprehensive life-cycle analysis of dairy production on a variety of spatial distinctions, which this report provides. Resource efficiency and carbon footprint analysis will be enhanced through the use of more accurate animal feeding systems, as described in this report. The animal feeding systems can be used as a source of data to assist in modelling changes in a variety of production aspects (such as breeding technology, intensification and milk composition targets) prior to implementing actual changes.

This report should not be viewed as the end of examination of the diversity of animal feeding systems in dairy production. Rather it is intended to be the beginning of understanding and sharing information on this diversity. Future work will improve data collection and expand the universe of animal feeding systems reported.

1.3. REPORT CONSTRUCTION

This report combines the results of the surveys conducted by the International Dairy Federation (IDF), the IFCN Dairy Research Network (IFCN) and the Food and Agriculture Organization of the United Nations (FAO). The quality and transparency of the data is presented in the most standardized manner possible. Where practical, data across the surveys have been combined into maps representing an average-sized dairy farming system for each country. The IFCN survey contains results on dairy cattle feeding systems for 44 countries; the IDF survey includes results on dairy cattle feeding systems for 15 countries; and the FAO survey includes results on dairy cattle, water buffalo, sheep and goat feeding systems for 43 countries.

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  - World maps for the feeding baskets (percentage constituents in feeds) from the FAO study are also presented for improved dairy cattle and water buffaloes, sheep, and goats; both during lactating and dry stages.
- **The second part** describes and summarizes results of the study carried out by IDF. Results of the feeding schemes (stocking rate, milk yield, percentages of roughage, concentrates and processed feed, feed efficiency etc.) are paired with useful demographic data on size and scope of the dairy industry structure in participating countries. The data are presented by country in a concise factsheet format.
- **The third part** describes and summarizes results of the study carried out by FAO. Results of the feeding schemes for dairy animals including cattle, buffaloes, sheep and goats in participating countries are presented, using a feeding basket approach to indicate the percentage of the diet supplied by roughage, concentrate and compound feed.
- **The fourth part** describes and summarizes results of the study led by IFCN. The results of dairy farming systems from typical farms are presented, giving a descriptive analysis of feeding systems, milk yields, land use and labour. This approach has also been used to analyse feed costs, feed prices and feed efficiency. The feed data have been validated via interaction between the local researcher and the researcher in the IFCN Dairy Research Network.

The **Conclusion** provides both a summary of findings and views on the way forward.

2

MAPPING OF ANIMAL FEEDING SYSTEMS

A SYNTHESIS OF RESULTS OBTAINED USING THREE COMPLEMENTARY APPROACHES

Geospatial displays of data represent an easy way to demonstrate the diversity of animal feeding approaches in the dairy sector. This section is presented in two parts.

In the first part (Section 2.1), the indicators depicted in the world maps are stocking rate, average milk yield and the percentages of roughage, concentrate and processed feed utilized and are based on the IFCN and IDF data for dairy cattle. For common IDF and IFCN maps, the figures presented are the results of a cross-validation between IDF and IFCN data. If some of the data was missing (either IFCN or IDF), the IDF and IFCN experts involved decided to keep the data from either IFCN or IDF. When both approaches provided data for a parameter (stocking rate, average milk yield and percentages of roughage, concentrates and processed feeds), the IDF and IFCN experts involved decided to calculate the average figures, using a weighted method. Experts assumed that the IFCN study case was always close to one of the IDF feeding systems, based on three criteria: farm size, herd size and feeding system.

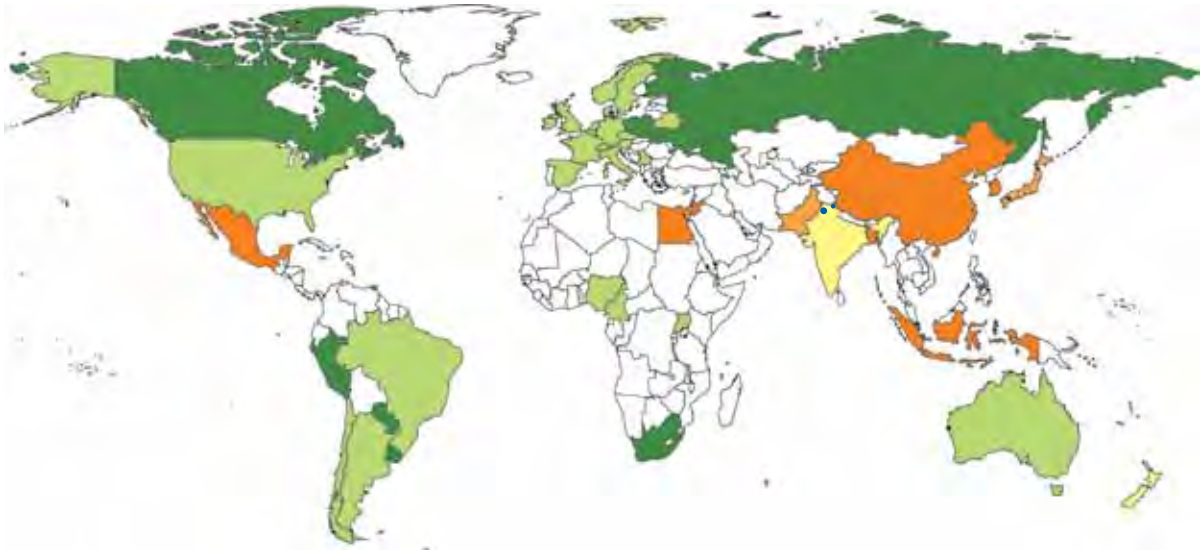
The second part (Section 2.2) shows maps generated from the FAO feeding basket data and these are for water buffaloes, dairy sheep, dairy goats and improved dairy cattle. Similar to the IDF and IFCN maps, these maps also present the percentage of various feed constituents fed to these animal species, both at lactating and dry stages.

2.1. MAPPING OF FEEDING AND OTHER RELATED PARAMETERS

2.1.1. STOCKING RATE

The stocking rate is defined as the number of animals per hectare of roughage production. This indicator can reflect the capacity of a farm to grow roughage for feeding its animals. In general, higher stocking rates result in lower amounts of roughage produced on the farm per animal, which suggests that the dairy feeding system will be more reliant on purchasing roughage to meet animal needs.

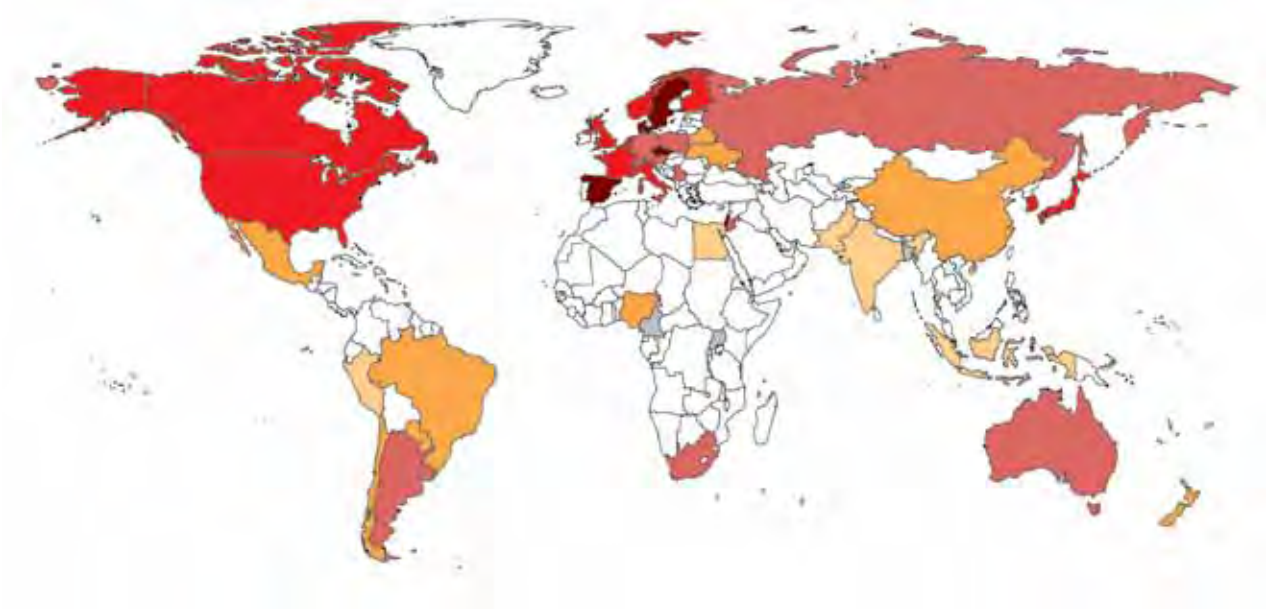
Differences in stocking rate are notable for a variety of reasons. Small dairy farm enterprises with only a few lactating animals (such as those observed in China and India) typically have higher stocking densities, reflecting the small land holdings per farm delegated for roughage production. Larger dairy enterprises with more lactating cattle (such as those observed in North America and Europe) typically have lower stocking densities, reflecting greater land holdings (owned or leased) for roughage production. A notable exception is New Zealand, where an improved pasture-based feeding system combined with a large average herd size results in a higher stocking rate.



2.1.2. AVERAGE MILK YIELD

The average milk yield represents the mean volume of milk produced per animal per year for the entire herd. Average milk yield is expressed as kilograms of energy-corrected milk (ECM; standardized to a fat content of 40 g/l and protein content of 32 g/l) per cow per year.

In general, average milk yield is highest in North America and Western Europe and lowest in Asia and Africa. The main goal of these systems is to maximize the average milk yield per cow. Other systems throughout the world do not wish to reach the same objective. Average milk yield is a general reflection of the adequacy of the feeding system utilized by the dairy producer. Other factors such as the genetic potential of the animal, environmental conditions and management practices also influence average milk yield.



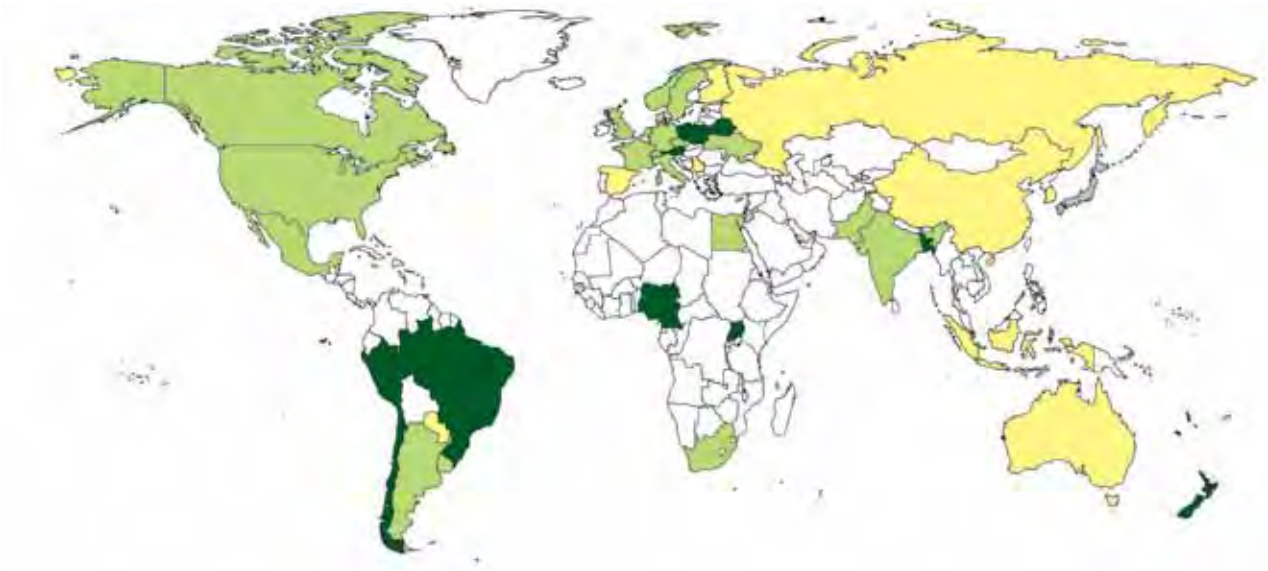
ANNUAL MILK YIELD FOR AVERAGE SIZE TYPICAL FARM

1 000 Kg ECM/year

- >9
- >7≤9
- >5≤7
- >1≤3
- <1
- NO DATA

2.1.3. PERCENTAGE OF ROUGHAGE

Percentage of roughage is expressed as the percentage of dry matter intake of roughage to the total feed consumed by an animal on a yearly basis. Most of the time, roughage is produced and consumed by animals on the same farm. In some feeding systems, a substantial portion of the roughage may be purchased. In most feeding systems in this report, roughage represents a major part of the feed consumed by the animal. The share of roughage in the total feed intake is of crucial importance for dairy production. This is mainly because most of the time it represents the main feed and therefore has a strong impact on feed efficiency. The percentage intake of roughage can vary according to such factors as availability of the roughage due to geographic and/or climatic factors and the availability of alternative or by-product feeds.



SHARE OF ROUGHAGE IN THE RATION

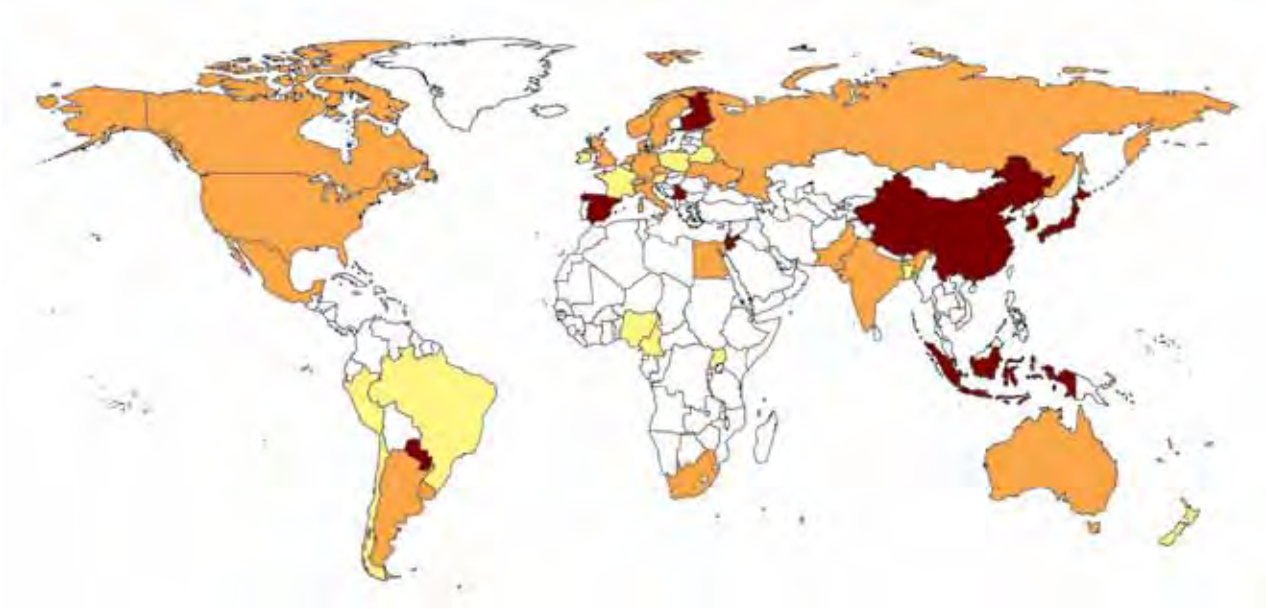
(%)

- >80≤100
- >60≤80
- >40≤60
- <40
- NO DATA

2.1.4. PERCENTAGE OF CONCENTRATES

Concentrates are supplements to the roughage part of the cow's diet and provide energy and protein (typically from grains or oilseeds). Raw materials and processed (compound) feed may be used as concentrates. The percentage of concentrates is expressed as the percentage of dry matter intake of concentrates to the total feed consumed by an animal on a yearly basis. By definition, concentrates and roughage represent the totality of feed consumed by the animals (100 percent).

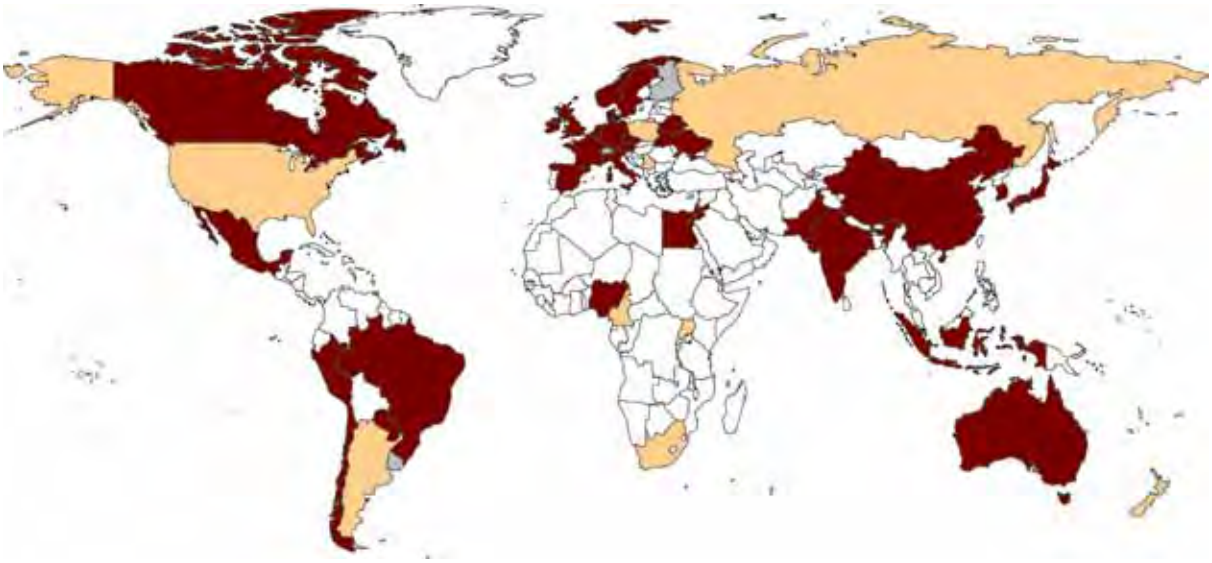
Concentrates may be grown on the farm (such as grains and oilseeds) or purchased off the farm as raw materials (grains and oilseeds), processed feeds (processed and/or blended feeds) or by-products (such as distiller's grains, citrus pulp or cottonseed). Different amounts of concentrates are used in feeding systems depending on roughage availability and the farmer's milk yield objective. The percentage intake of concentrates can vary according to such factors as availability of land for on-farm production, geographic and/or climatic factors and availability of alternative or by-product feeds.



2.1.5. PERCENTAGE OF PROCESSED FEED

Processed feed is a subcomponent of concentrates and is comprised of multiple raw materials, combined by mechanical mixing. The compound feed that results can be in granulated form or mashes of mixed, non-granulated compound feeds. The percentage of processed feed is expressed as the percentage of dry matter intake of processed feed to the total feed consumed by an animal on a yearly basis.

In some aspects, it possible to distinguish between concentrates produced and consumed directly on-farm and those having undergone an industrial transformation before being purchased by a farmer. The processing of ingredients off-farm sometimes makes it difficult to have precise knowledge on the final composition of processed feeds. The percentage intake of processed feed can vary according to such factors as availability of land for on-farm production of concentrates, geographic and/or climatic factors influencing roughage production and availability of alternative or by-product feeds.



SHARE OF PROCESSED CONCENTRATE IN THE CONCENTRATE

(%)

- >40
- >20≤40
- ≤20
- NO DATA

2.2. MAPPING OF FEEDING BASKETS

For each animal species, the roughage, concentrate and compound feed use have been mapped together, but separately for the lactating and dry stages. Countries for which the data were not available have been shown in white background. This was done to distinguish them from countries for which the value was zero.

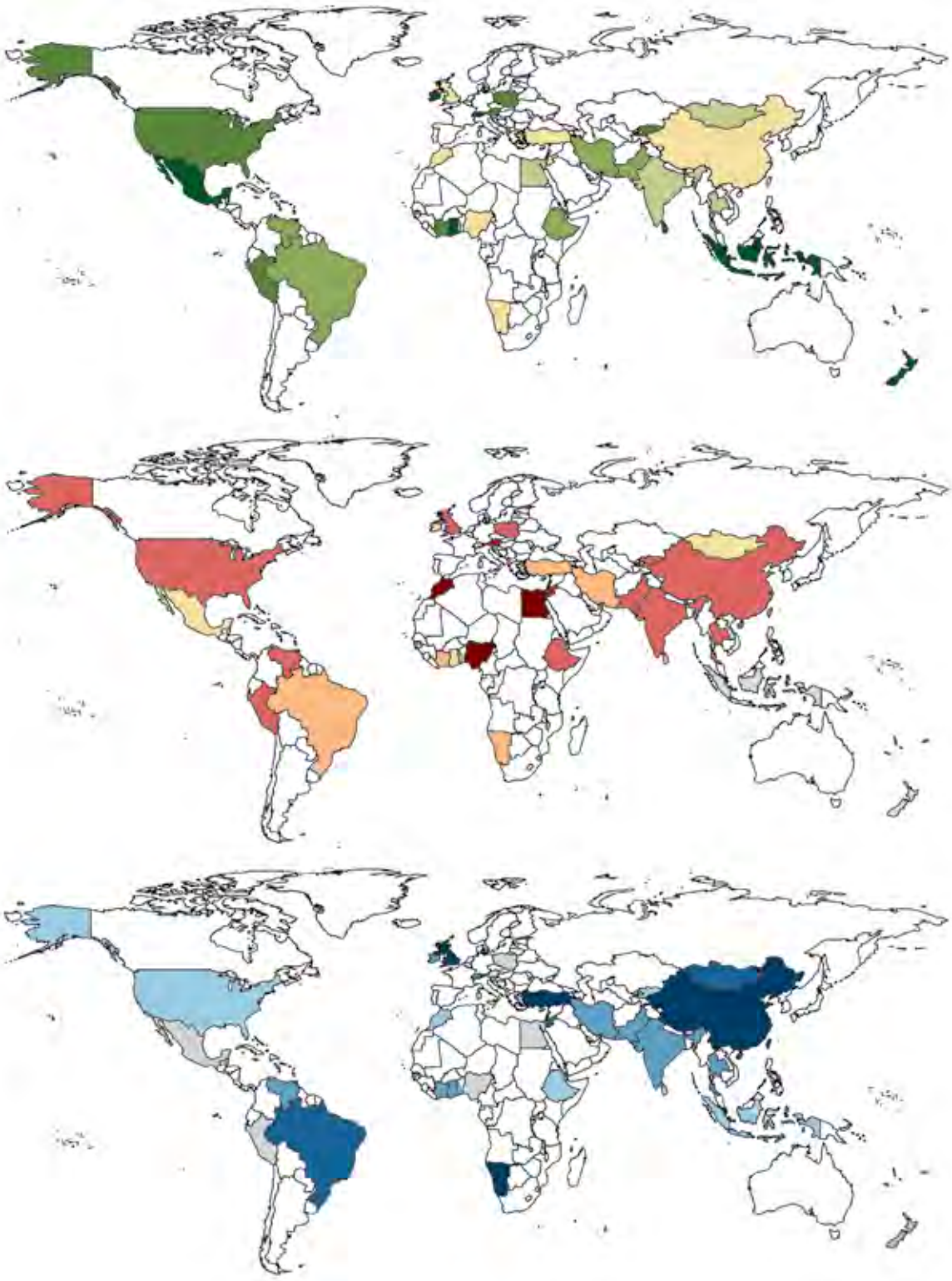
For all animal species, the inclusion of roughage is higher during the dry stage than during the lactating stage, whereas that of the concentrate and compound feed is higher during the lactating stage. The maps for dairy cattle in the FAO study (presented in this section) are separate for lactating and dry animals and represent the improved cattle; hence, they cannot be directly compared with those obtained from the IDF/IFCN data (presented in Section 2.1); however, the overall trend in the use of roughage and concentrate is similar in all the studies.

The world maps for improved cattle, buffaloes, sheep and goats are presented below. These maps are self-explanatory and hence no description is given. Details on feeding baskets for these animal species are given in Section 4 (FAO data).

Salient findings that emerged from these maps are:

» Crop residues are an important part of the diet for cows in Asia. The compound feed use in Asia and Africa is low (up to 5 percent).
» Improved dairy buffaloes receive more concentrates and compound feed than local animals. Crop residues are a major source of roughage for both improved and local dairy buffaloes in India. The use of compound feed is low in Asia, as for cattle.
» For both cattle and buffaloes in Asia and Africa, the use of home-made concentrate is higher than compound feed.
» Lactating sheep diets worldwide include similar proportions of roughage, concentrate and compound feed. In most countries in Africa, the Americas and Asia, the roughage in the diets of both lactating and dry sheep is composed of grasses (fresh and hay).
» The major component of the diet of lactating goats is roughage.
» In most developing countries, milk is produced from crop residues, grasses and agro-industrial by-products. Very low levels of cereals are used in the diets of dairy animals, suggesting that a human-edible animal product of high quality (milk) is produced from human-inedible feed resources by the dairy sector in most developing countries.

2.2.1. CATTLE, LACTATING

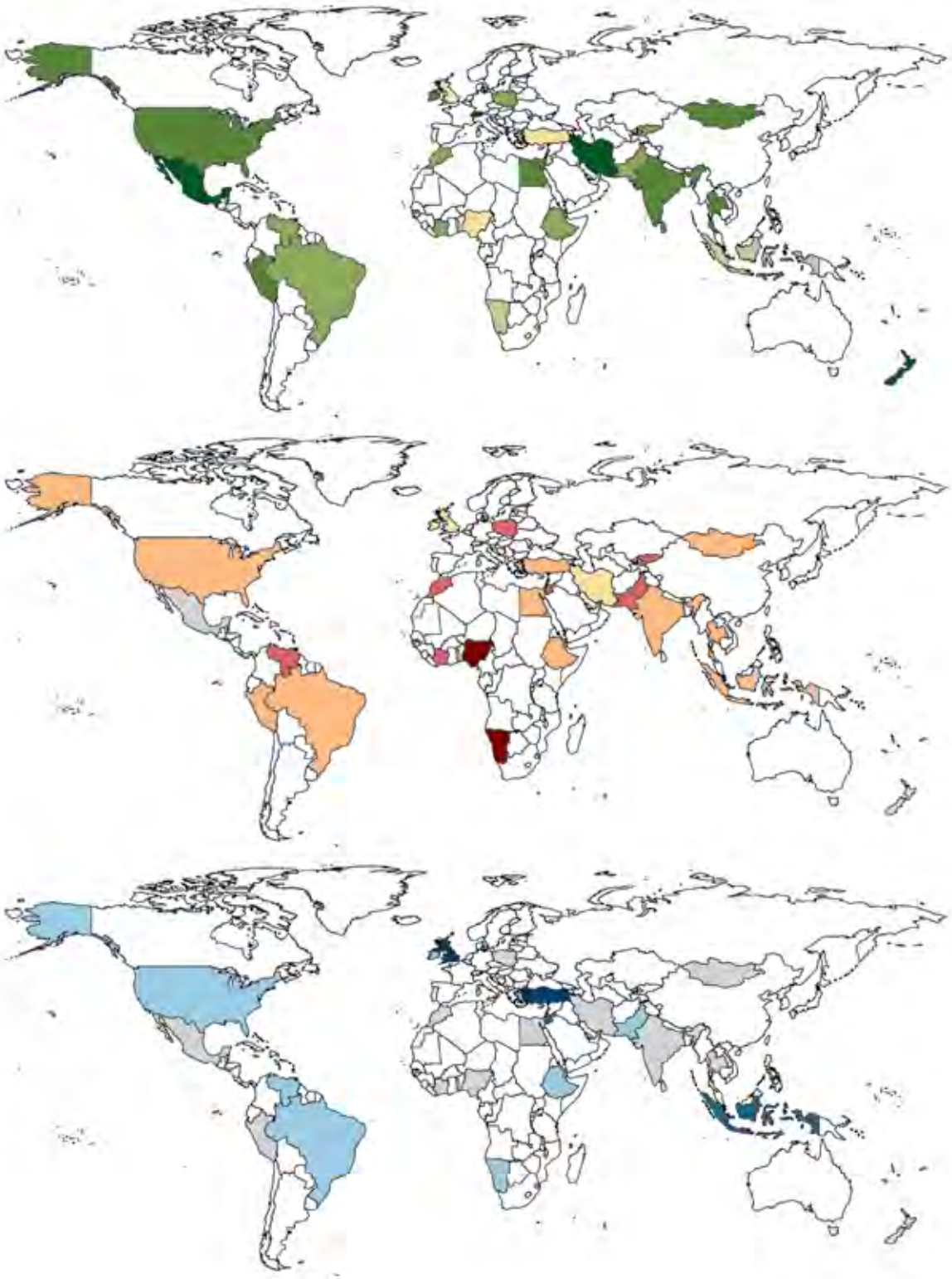


ROUGHAGE
(%)
- <50
- 50-60
- 60-70
- 70-80
- >80

CONCENTRATE FEED
(%)
- 0
- 1-10
- 10-20
- 20-30
- 30-40
- >40

COMPOUND FEED
(%)
- 0
- 1-10
- 10-20
- 20-30
- >30

2.2.2. CATTLE, DRY

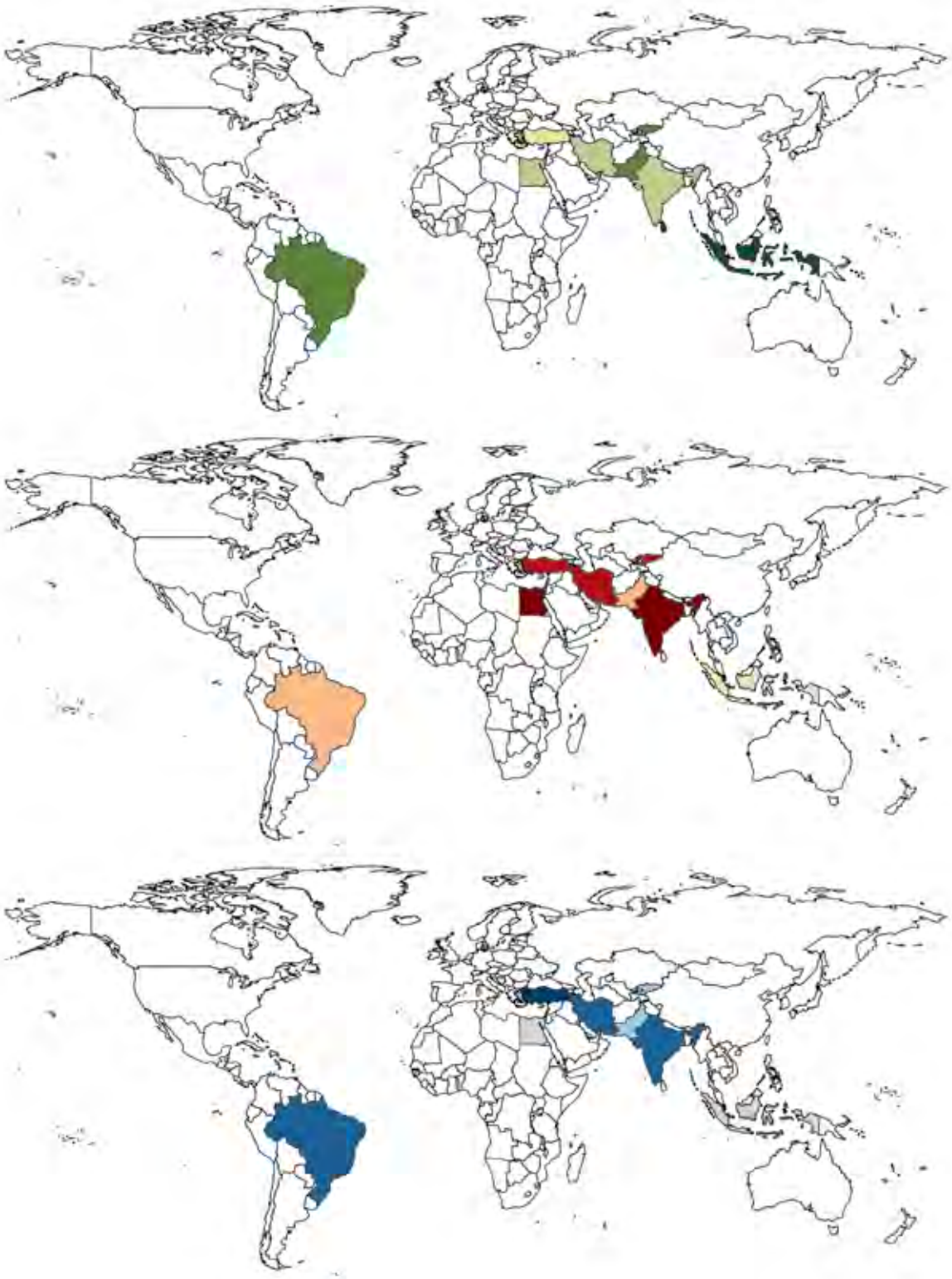


ROUGHAGE
(%)
- <70
- 70-80
- 80-90
- 90-95
- 95-100

CONCENTRATE FEED
(%)
- 0
- 1-5
- 5-10
- 10-20
- >20

COMPOUND FEED
(%)
- 0
- 1-10
- 10-20
- >20

2.2.3. BUFFALOES, LACTATING

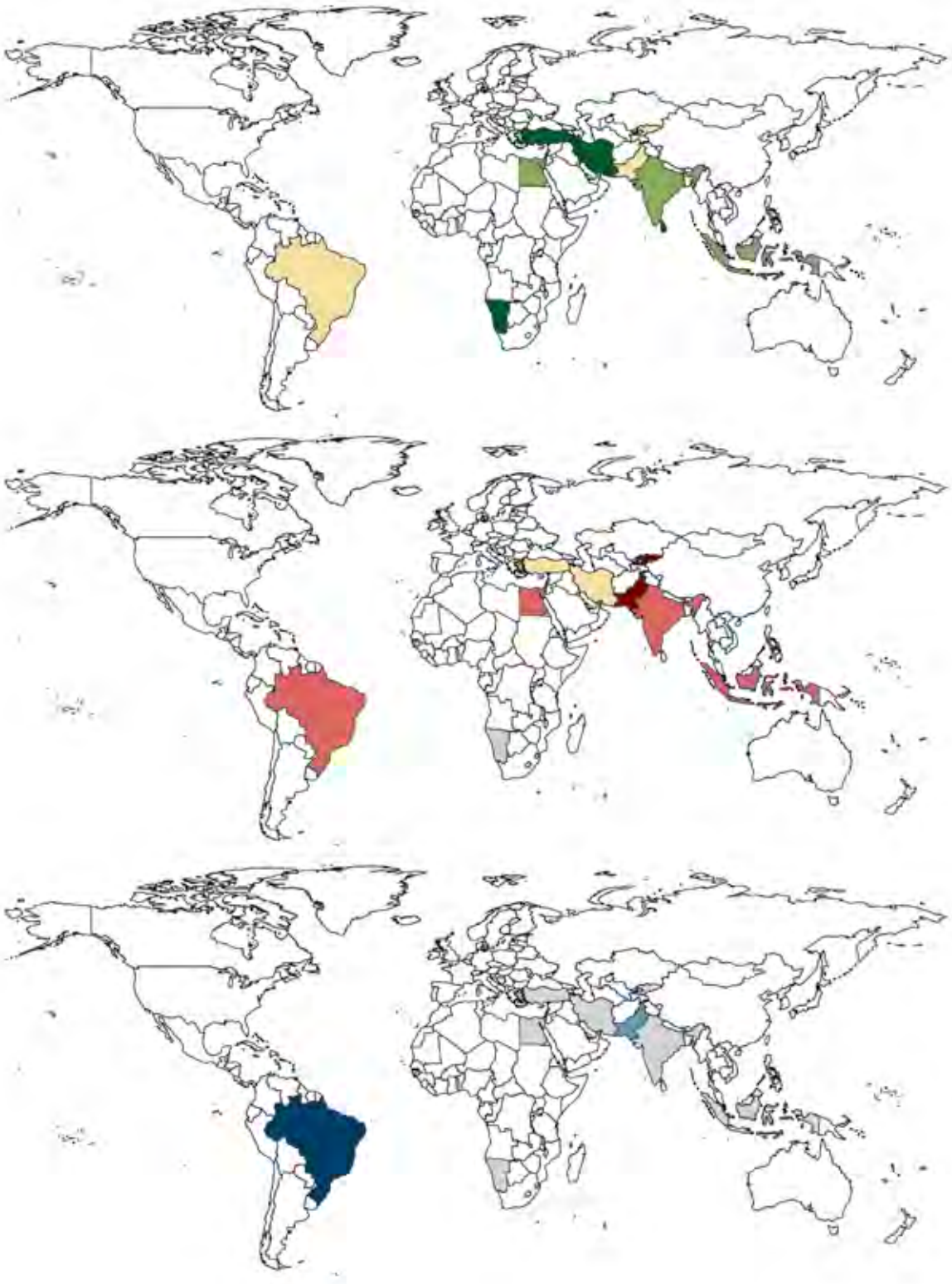


ROUGHAGE
(%)
- <60
- 60-70
- 70-80
- >80

CONCENTRATE FEED
(%)
- 5-10
- 10-20
- 20-30
- >30

COMPOUND FEED
(%)
- 0
- 1-10
- 10-20
- >20

2.2.4. BUFFALOES, DRY



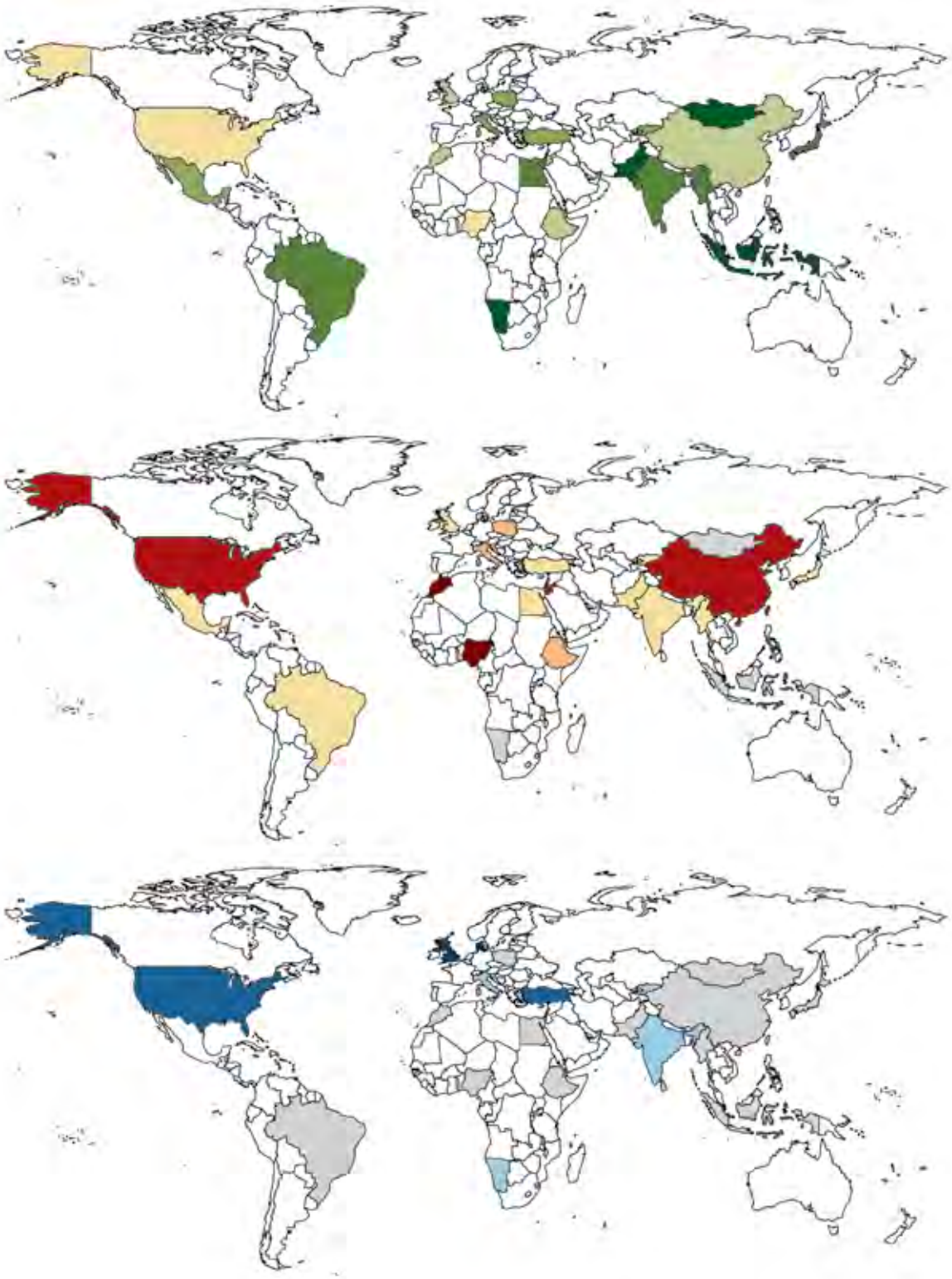
ROUGHAGE
(%)
- 80-85
- 90-95
- 95-100

CONCENTRATE FEED
(%)
- 0
- 1-5
- 5-10
- >10

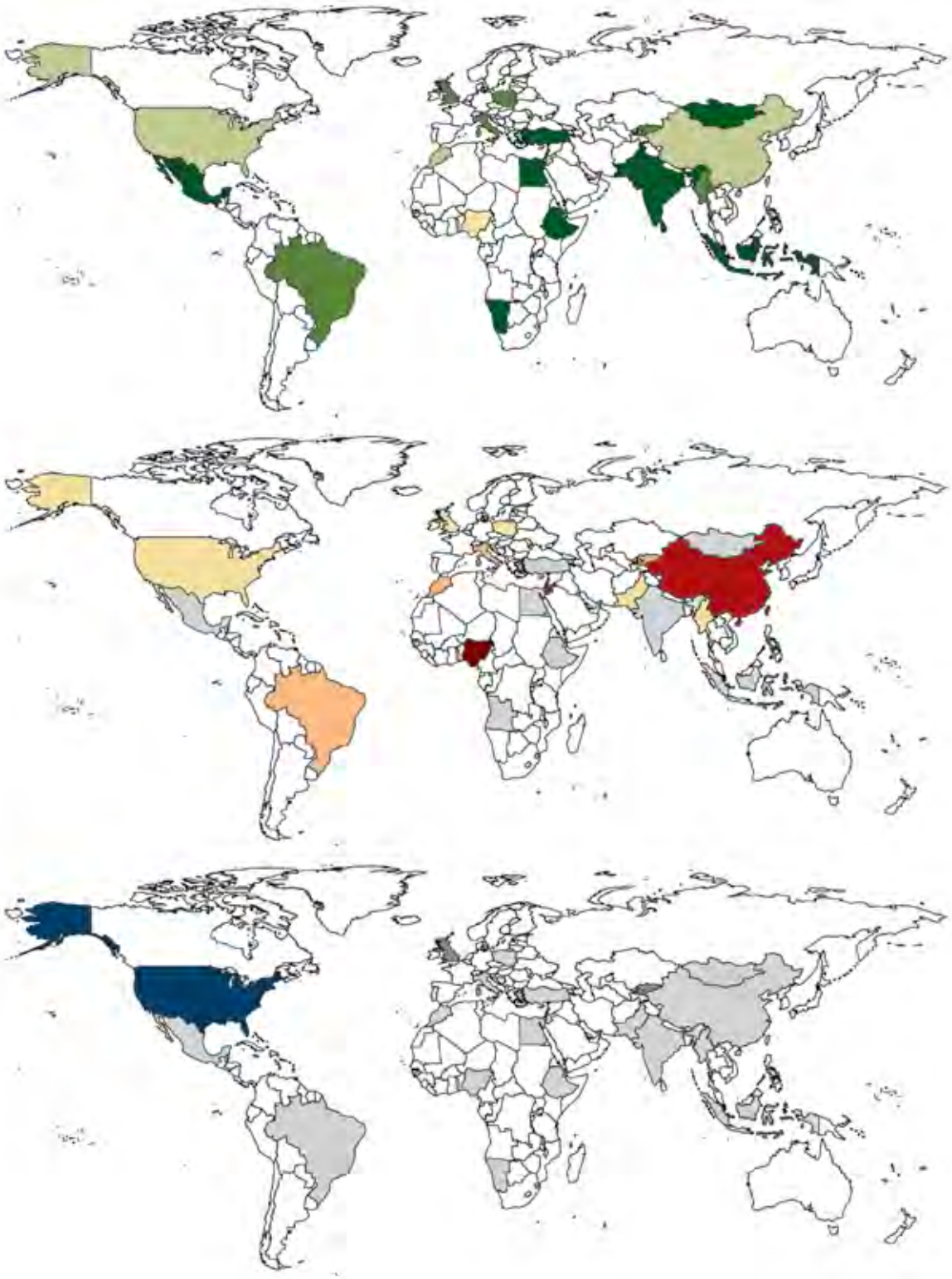
COMPOUND FEED
(%)
- 0
- 6
- 7

Note: Data for Namibia is for wild buffaloes

2.2.5. GOATS, LACTATING



2.2.6. GOATS, DRY

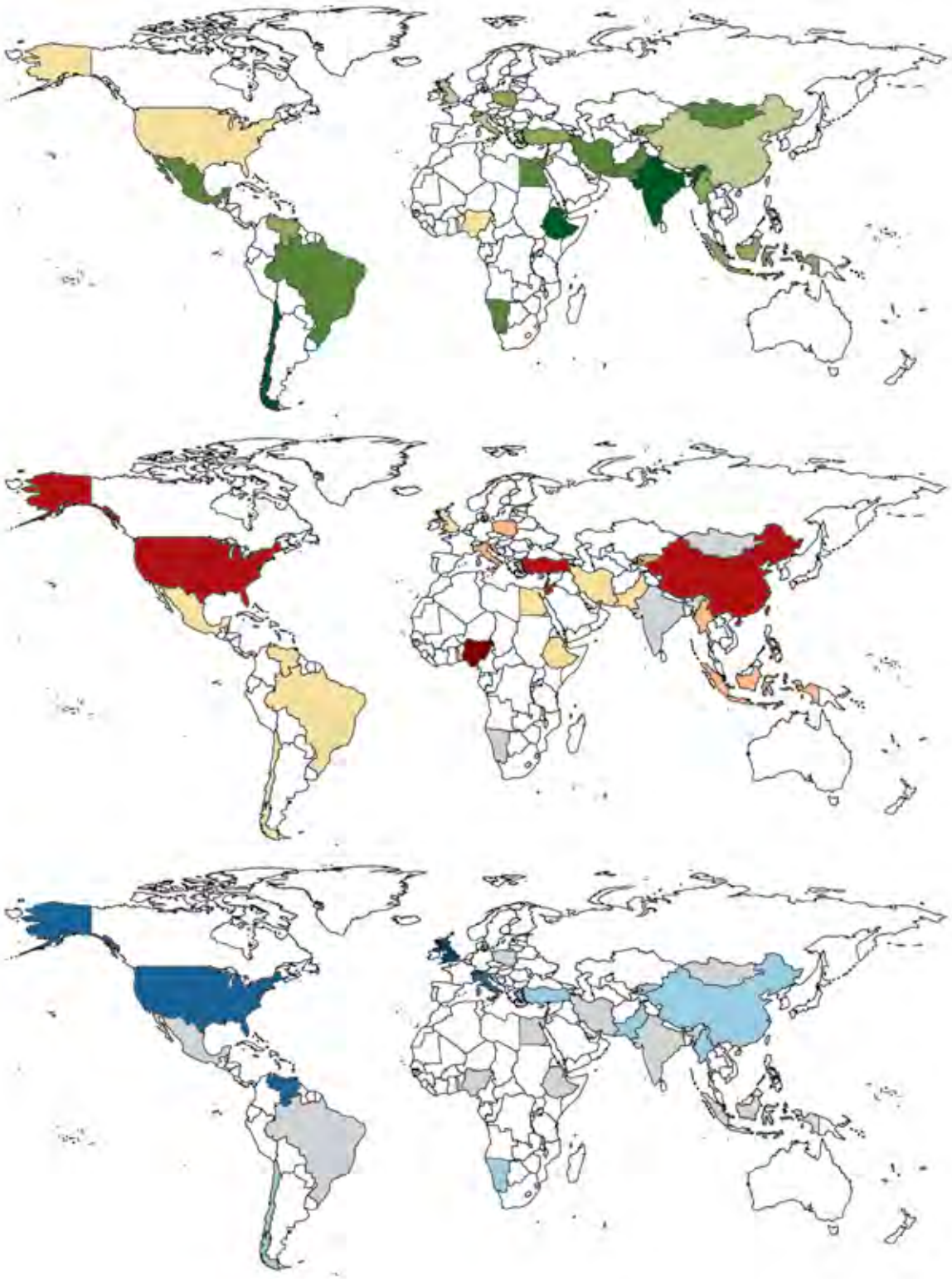


ROUGHAGE
(%)
- <70
- 70-80
- 80-90
- 90-100

CONCENTRATE FEED
(%)
- 0
- 1-10
- 10-20
- 20-30
- >30

COMPOUND FEED
(%)
- 0
- 1-5
- 5-10

2.2.7. SHEEP, LACTATING

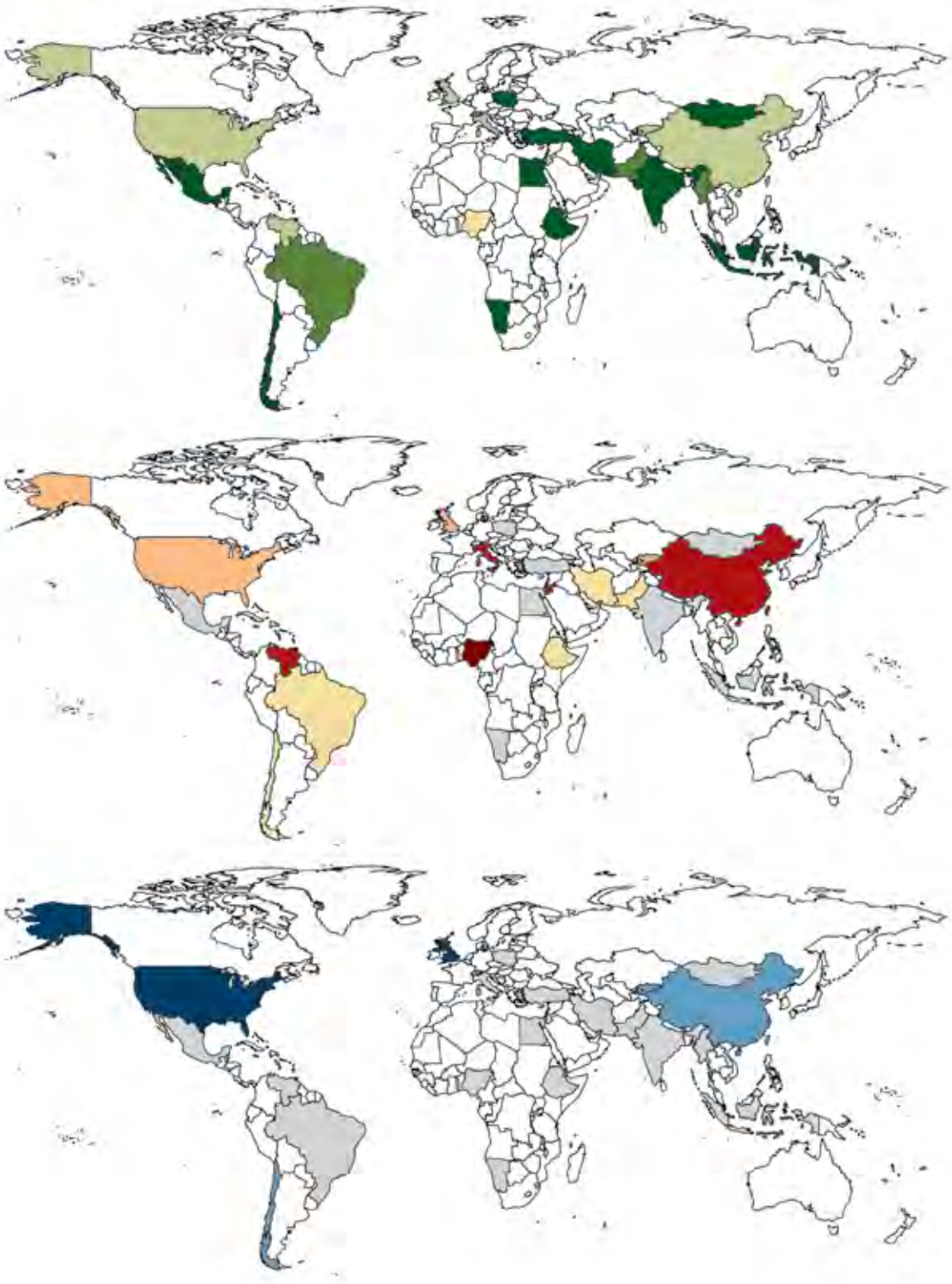


ROUGHAGE
(%)
- <50
- 50-75
- 80-90
- 90-95
- 95-100

CONCENTRATE FEED
(%)
- 0
- 1-10
- 10-20
- 20-50
- >50

COMPOUND FEED
(%)
- 0
- 1-10
- 10-20
- >20

2.2.8. SHEEP, DRY



ROUGHAGE
(%)
- <80
- 80-90
- 90-95
- 95-100

CONCENTRATE FEED
(%)
- 0
- 1-5
- 5-10
- 10-20
- >20

COMPOUND FEED
(%)
- 0
- 1-5
- 5-10

3

DIVERSITY OF FEEDING SCHEMES, FEED CONSUMPTION AND FEED EFFICIENCY AN APPROACH USED BY THE INTERNATIONAL DAIRY FEDERATION

Analysis of feeding systems through an expert survey of member countries

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3.1. INTRODUCTION

The International Dairy Federation (IDF), founded in 1903, is a non-profit private sector organization that represents the interests of various stakeholders in dairying at the international level. IDF members are organized in National Committees for each member country. These national associations are composed of expert representatives of all dairy-related national interest groups including dairy farmers, the dairy processing industry, dairy suppliers, academics and governments/food control authorities. Through expert consultations with the National Committees, IDF is able to identify, elaborate and disseminate best practices at international level to guide the dairy sector on a variety of issues along the dairy production chain, including animal health and welfare, protection of the environment, nutrition, food standards and food safety and hygiene.

In 2009, in recognition of the importance of animal feeding on the dairy value market chain, IDF appointed a Task Force on Animal Feeding composed of experts nominated by IDF National Committees. During the first meeting in November 2010 at the World Dairy Summit in Auckland, the Task Force on Animal Feeding recognized the need for understanding dairy feeding systems across the globe and embarked on the "World Mapping of Animal Feeding Systems in the Dairy Sector."

3.2. IDF METHODS

For the project "World Mapping of Animal Feeding Systems in the Dairy Sector", IDF utilized the services of National Committees to conduct an expert survey of dairy feeding practices in IDF member countries. This approach aimed to describe the diversity of feeding systems within a given country based on data obtained from national experts in dairy feeding practices that are pertinent and specific to those countries. Each system has been identified and described on the basis of the expert survey.

The IDF approach to the examination of feeding systems in the dairy sector was conducted in three phases:

1. creation of an Expert Survey Tool in collaboration with all partners of this project (FAO, IFCN and IDF);
2. conduction of the expert survey through the IDF National Committees; and
3. processing and interpreting the expert survey results.

3.2.1. EXPERT SURVEY TOOL

The Expert Survey Tool was developed by IDF in close collaboration with FAO and IFCN through an iterative process. The final Expert Survey Tool is a questionnaire comprised of two parts and designed to provide three sets of information:

» **An update on the scale of dairy production in the world by participating country:** Data include the number of animals (cows and buffaloes), the volume of milk production and the dominant dairy breed(s).

» **A detailed description of an average farm in a country**: The average farm was assessed by the number of animals, the level of production and/or the protein and fat composition of the milk. The average farm structural data also included the number of workers per farm and average crop production area for roughage and pasture.

» **A description of the feeding systems used:** This represents the core analysis of the project. Each country was tasked with the responsibility to provide details on the main animal feeding systems used within the country. The animal feeding systems could be differentiated by factors such as geographic, climatic, structural or other considerations. The number of animal feeding systems within a country was limited to the main five systems and included information on a wide range of feeds (expressed as an estimate of dry matter

intake per cow, in kg DM/cow/year). Roughages were mainly represented by crop residues, pasture, silage (maize, grass primarily) and hay. Concentrates were distributed across multiple categories of grains, oilseeds, by-products and processed feeds.

The IDF National Committees were requested to clearly indicate the sources (name of the organization, year, method of data collection and frequency of up-dating) for all responses to the Expert Survey Tool. If sourced data were unavailable, the IDF National Committees could utilize national experts to provide informed opinion for that set of data. The suggested reference year for the Expert Survey Tool is 2009. The Expert Survey Tool is displayed in Table 3.1 (explanatory notes are not shown).

Table 3.1. INTERNATIONAL DAIRY FEDERATION WORLD MAPPING OF ANIMAL FEEDING SYSTEMS IN THE DAIRY SECTOR EXPERT SURVEY TOOL

GENERAL DATA ON YOUR COUNTRY	2009 DATA	COUNTRY DATA IF DIFFERENT [1]	DATA SOURCE
Number of dairy farms (cow and/or buffalo)			
Number of dairy cows ('000 head)			
Number of dairy buffaloes('000 head)			
Cow & buffalo milk production ('000 tonnes)			
Breed(s) [2]			
Average data per farm			
Number of cows per farm			
Milk production per cow (kg/year)			
Fat content of dairy cow milk (g/l)			
Protein content of dairy cow milk (g/l)			
Number of buffaloes per farm			
Milk production per buffalo (kg/year)			
Fat content of buffalo milk (g/l)			
Protein content of buffalo milk (g/l)			
Number of workers per farm (head/farm)			
Farm area (ha) [3]			
Main fodder crops area (ha) [4]			
Surface dedicated to pasture (ha)			

		N° 1	N° 2	N° 3	N° 4	N° 5	SOURCE OF THE DATA [6]
Designation of the feeding systems [5]							
Description of the feeding system (if space here is not sufficient, use a separate sheet)							
Importance of the feeding system: **- % of total dairy farms**							
Importance of the feeding system: **- % of national milk production**							
Average number of cows per farm in the feeding system							
Roughage (kg DM/cow/year)							
Pasture (grazing)							
Hay							
Grass silage							
Maize silage							
Green fodder (cut and brought directly to animals)							
Crop residues (straws, stovers)							
Others (please specify)							
Cereal grains (kg DM/cow/year)							
Wheat and barley							
Rice							
Maize							
Sorghum							
Others (please specify):							
Others (please specify):							
Others (please specify):							
Oilseeds (kg DM/cow/year)							
Soya							
Rape							
Cotton							
Others (please specify):							
Others (please specify):							
Others (please specify):							
By-products (kg DM/cow/year)							
Cereal bran							
Soy meal							
Rapeseed meal							
Cottonseed cake							
Copra meal							
Other meals/cakes (please specify):							
Other meals/cakes (please specify):							
Other meals/cakes (please specify):							
Pulp, molasses, vinasses (please specify)							
Roots, tuber (please specify)							
Others (please specify):							
Others (please specify):							
Others (please specify):							
Compound feed (kg DM/cow/year) [7]							
TOTAL (kg DM/cow/year)							

3.2.2. DATA VALIDATION

Data submitted via the Expert Survey Tool were validated in several ways. National milk production data and average data per farm were compared with two other sources of general data on dairy farms: (1) data from the IDF World Dairy Situation (2009) and (2) data from the IFCN database on average farm feeding systems (2009). Other numerical data, which was complemented by a written commentary, was validated by each National Committee. This data validation was limited to only the first part of the survey (Table 3.1, "General data on your country").

3.3. SURVEY RESULTS

This section presents the results from 15 IDF National Committees. The first sub-section presents aggregated data for comparisons across all countries that completed the survey. The second sub-section is organized by country as "Feeding System Factsheets". The factsheets have been standardized in form and content based upon the structure of the Expert Survey Tool (Table 3.1) to allow for additional comparison among and between countries.

3.3.1. AGGREGATED SURVEY RESULTS

The aggregated results are presented for Australia (AU), Austria (AT), Canada (CA), Denmark (DK), France (FR), Germany (DE), India (IN), Israel (IL), Japan (JP), Korea (KR), New Zealand (NZ), Norway (NO), South Africa (ZA), Switzerland (CH) and the United Kingdom (UK).

The aggregated results show the diversity in scale of dairy production among responding countries. The number of farms in a country was highly variable (Figure 3.1): from less than 1 000 (Israel) to more than 100 000 (Germany). Similarly, the number of animals (cows and buffaloes) per country ranged from 120 000 (Israel) to 39 million (India). The median herd size was 69 animals (Figure 3.2). The smallest herds were found in Austria (13 animals) and the largest were found in New Zealand (365 animals).

Figure 3.1. NUMBER OF DAIRY FARMS BY COUNTRY

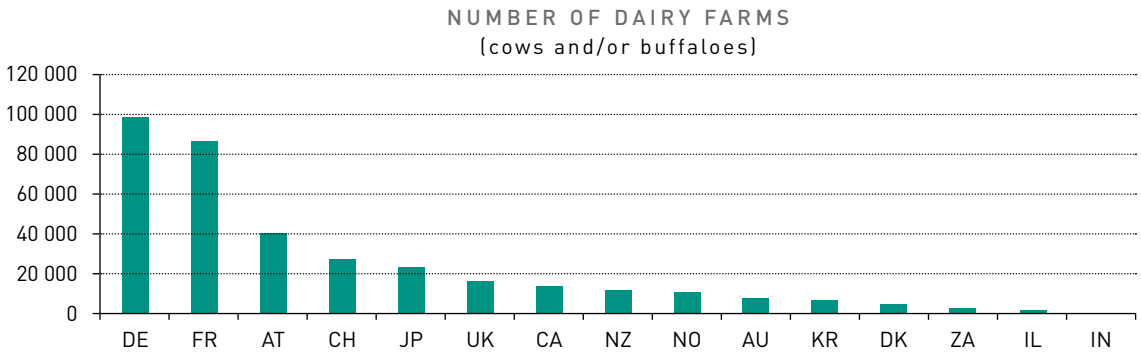
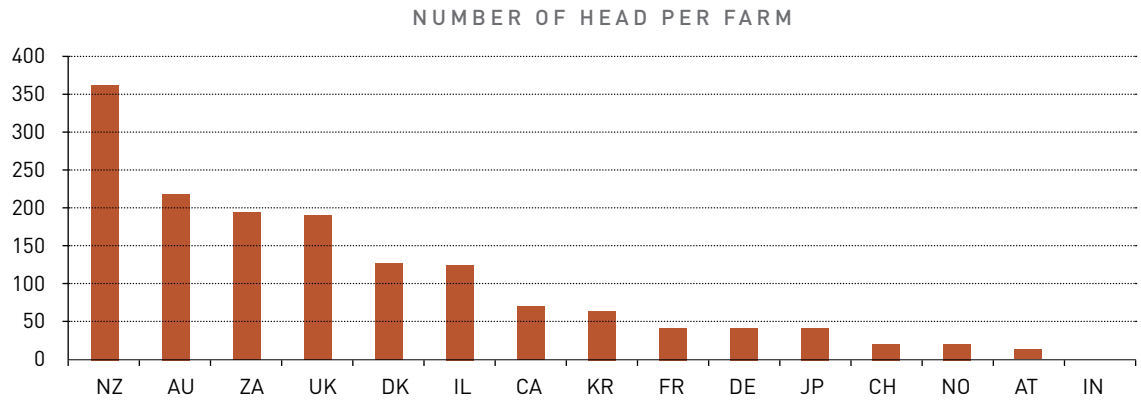
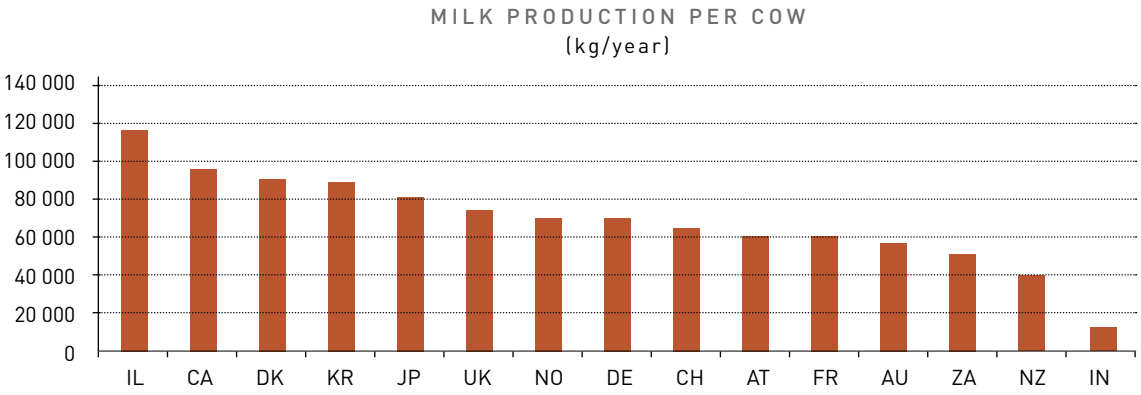


Figure 3.2. **NUMBER OF ANIMALS PER DAIRY FARM BY COUNTRY**



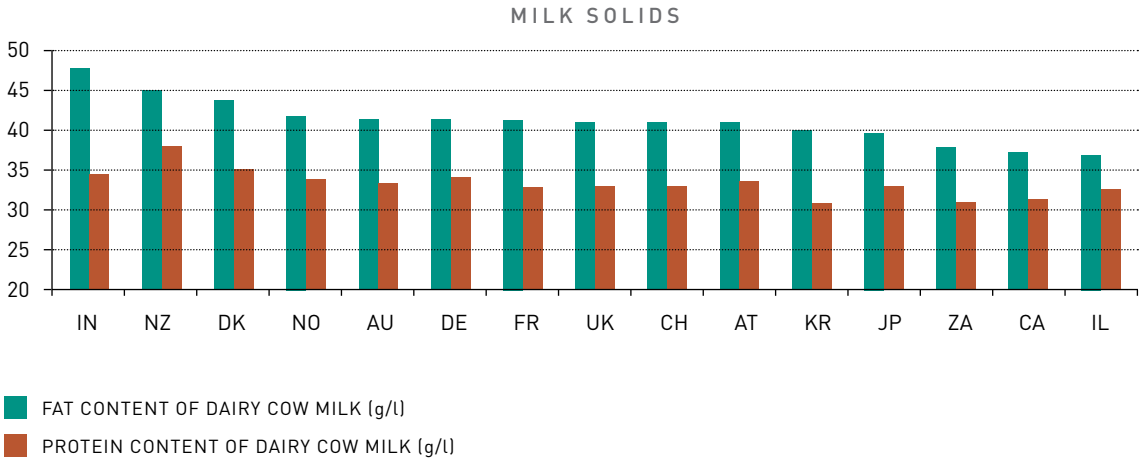
Milk production per cow generally ranged between 5 000 and 9 000 kg/dairy cow/year. Production per cow presented important differences: from 1 290 kg milk/dairy cow/year in India to more than 11 600 kg milk/dairy cow/year in Israel. Combining production data with total number of animals led to annual total milk production volumes that were highly variable for the 15 countries that responded to the survey. The median was approximately 8 million tonnes per year, but ranged from 1 million tonnes (Israel) to more than 100 million tonnes (India).

Figure 3.3. **MILK PRODUCTION PER COW PER YEAR BY COUNTRY**



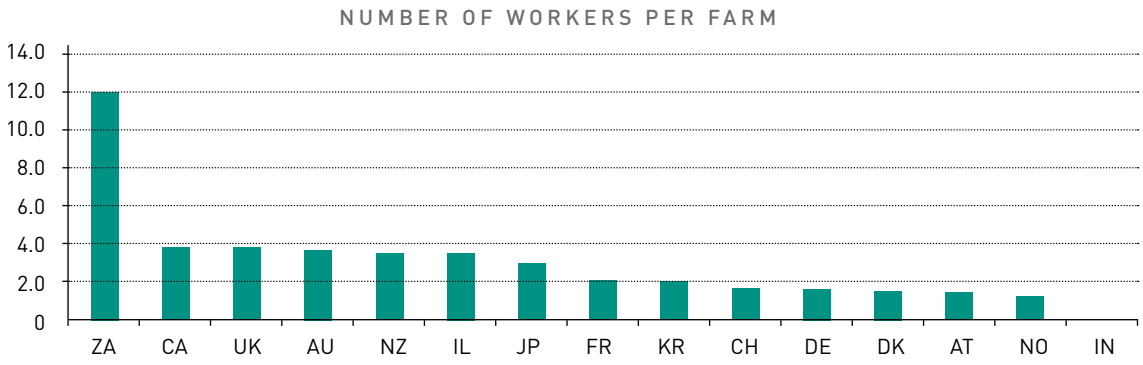
Milk fat and milk protein composition varied across the 15 countries from 37 to 48 g/l and 31 to 38 g/l, respectively (Figure 3.4). The median contents were 41 g/l for milk fat content and 33 g/l for milk protein content. Fat content is high for India (4.8 percent) because the figure shows a mix of cow and buffalo data. Separated values for India are not available from the IDF data.

Figure 3.4. **MILK FAT AND PROTEIN CONTENTS**



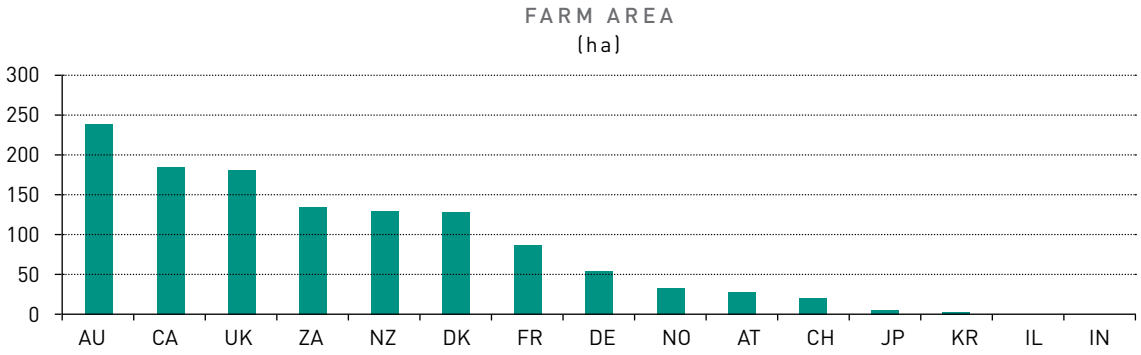
Much less variability in labour force was observed between the 15 countries (Figure 3.5). The average number of workers per farm varied from 1 to 4, with a single exception. South Africa reported an average of 12 workers per farm. India did not report this parameter.

Figure 3.5. **NUMBER OF WORKERS PER FARM BY COUNTRY**



The median farm size was approximately 88 ha (1 ha = 10 000 m^2). The largest farm sizes were in Australia, Canada and the United Kingdom with, respectively, 240, 185 and 183 ha. As with most previous data, marked large diversity in the average size of the dairy farms existed.

Figure 3.6. **FARM SIZE BY COUNTRY**



Responses to the Expert Survey Tool by country are summarized in Table 3.2.

Table 3.2. **DAIRY FARM DEMOGRAPHIC INFORMATION BY COUNTRY**

GENERAL DATA	AT	AU	CH	DE	DK	FR	UK	IL	JP	KR
Number of dairy farms (cow and/or buffalo)	40 600	7 511	27 131	97 400	4 380	86 000	16 404	951	23 100	6 767
Number of dairy cows and/or buffaloes ('000 head)	563	1 600	579	4 169	540	3 794	1 857	119	985	445
Cow & buffalo milk production ('000 tonnes)	3 230	9 294	4 094	29 119	4 734	23 316	13 762	1 290	7 910	2 110
Number of cows per farm	13	220	21	43	129	44	192	125	43	66
Milk production per cow (kg/year)	6 068	5 608	6 391	6 977	9 022	6 064	7 411	11 667	8 100	8 913
Fat content of dairy cow milk (g/l)	40.9	41.5	41	41.5	43.8	41.3	41	37	39.7	40
Protein content of dairy cow milk (g/l)	33.7	33.4	33	34.2	35.1	32.9	33.1	32.7	33	31
Number of buffaloes per farm	-	-	-	-	-	-	-	-	-	-
Milk production per buffalo (kg/year)	-	-	-	-	-	-	-	-	-	-
Fat content of buffalo milk (g/l)	-	-	-	-	-	-	-	-	-	-
Protein content of buffalo milk (g/l)										
Average number of workers per farm (workers/farm)	1.4	3.7	1.7	1.6	1.5	2.1	3.8	3.5	3.0	2.0
Farm area (ha)	29	240	21	55	129	88	183	-	5	2
Main fodder crops area (ha)	29	240	21	32	103	58	122	-	3	1
Surface dedicated to pasture (ha)	15	168	-	23	16	46	-	-	-	-

GENERAL DATA	NO	ZA	CA	NZ	IN		MIN	MAX	MEDIAN
Number of dairy farms (cow and/or buffalo)	10 067	2 750	13 214	11 600	-		951	97 400	12 407
Number of dairy cows and/or buffaloes ('000 head)	206	533	979	4 400	38 928		119	38 928	979
Cow & buffalo milk production ('000 tonnes)	1 500	2 712	7 902	16 100	108 630		1 290	108 630	7 902
Number of cows per farm	21	196	72	365	-		13	365	69
Milk production per cow (kg/year)	7 057	5 023	9 592	3 914	1 229		1 229	11 667	6 977
Fat content of dairy cow milk (g/l)	41.9	37.9	37.3	45	47.8		37	48	41
Protein content of dairy cow milk (g/l)	33.9	31.1	31.5	38	34.6		31	38	33
Number of buffaloes per farm	-	-	-	-					
Milk production per buffalo (kg/year)	-	-	-	-	1 668		1 668	1 668	1 668
Fat content of buffalo milk (g/l)	-	-	-	-	76		76	76	76
Protein content of buffalo milk (g/l)					37		37	37	37
Average number of workers per farm (workers/farm)	1.2	12.0	3.8	3.5	-		1	12	3
Farm area (ha)	33	135	185	131	-		2	240	88
Main fodder crops area (ha)	33	122	128	131	-		1	240	58
Surface dedicated to pasture (ha)	4	81	19	100	-		4	168	23

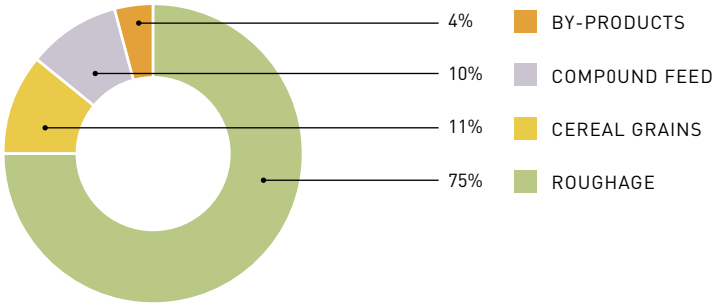
3.3.2. FEEDING SYSTEM FACTSHEETS BY COUNTRY

An individual Feeding System Factsheet was developed for each country. The factsheets start with general data on milk production, farm structure, total feed intake and feed efficiency; all these data are presented under the feeding system identified (the feeding system categories are different for each country). Then, an average overall percentage (%) use of feedstuffs is presented. The constituents of the feeding basket are divided into four main categories (roughage, cereals, compound feed and by-products) and are presented for each of the feeding systems categorized. Thereafter, the average total feed intake for dairy cows and a detailed description of diet constituents are presented.

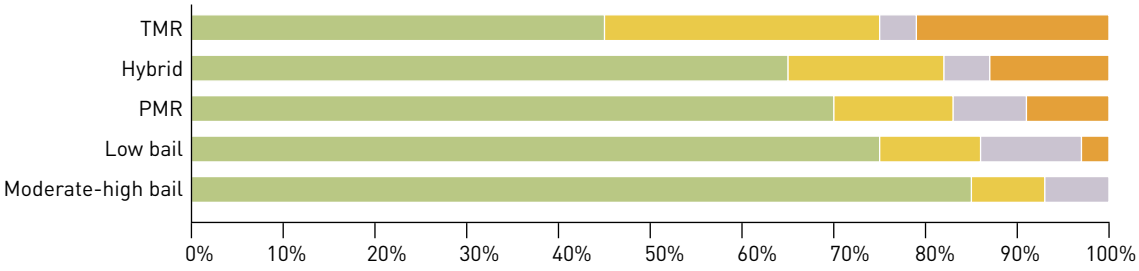
FEEDING SYSTEMS IN AUSTRALIA

SYSTEMS	MODERATE–HIGH BAIL	LOW BAIL	PARTIAL MIXED RATION (PMR)	HYBRID	TOTAL MIXED RATION (TMR)
Contribution to national milk production (%)	57	17	17	8	1
Dairy farms in each feeding system (% of total)	55	28	12	5	1
Total feed intake (kg DM/cow/year)	5 525	5 275	5 550	5 625	5 775
Annual feed efficiency (kg milk/kg DM)	0.90	0.86	0.91	0.92	0.94
Average number of cows per farm	310	233	411	467	491

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	LOW BAIL	MODERATE - HIGH BAIL	PMR	HYBRID	TMR
Roughage	85%	75%	70%	65%	45%
Cereal grains	8%	11%	13%	17%	30%
Compound feed	7%	11%	8%	5%	4%
By-products		3%	9%	12%	21%

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	MODERATE–HIGH BAIL	LOW BAIL	PMR	HYBRID	TMR
Roughage	**4 150**	**4 500**	**3 900**	**3 650**	**2 575**
Pasture	3 200	3 600	2 700	1 800	-
Hay	400	350	450	750	1 000
Grass silage	400	350	400	600	800
Others: winter and summer forage crops (grazing)	100	150	100	-	-
Maize silage	-	-	200	450	700
Crop residues	50	50	50	50	75
Cereal grains	**600**	**400**	**700**	**975**	**1 750**
Wheat and barley	500	375	600	800	1 500
Maize	50	25	50	75	100
Others: lupins	50	-	50	100	150
By-products	**150**	**-**	**525**	**700**	**1 200**
Rapeseed meal	125		175	200	400
Others: bread, potatoes, citrus pulp, brewers grain, dried distillers grains, other milling and feed processing by-products	-	-	200	300	400
Soymeal	25	-	50	75	125
Cereal bran	-	-	50	75	125
Pulp, molasses, vinasses	-	-	50	50	100
Cottonseed cake	-	-	-	-	50
Compound feed	**625**	**375**	**425**	**300**	**250**

Source: Dairy Australia

In Australia, the average feed intake of a cow was 5 500 kg DM/year. The diet consisted of 75 percent roughage (mainly pasture), 11 percent cereal grains, 10 percent compound feed and 4 percent by-products.

The five feeding systems characterized were: low bail, moderate-high bail, partial mixed ration, hybrid and total mixed ration.

» **Moderate–high bail:** This feeding system was used in 55 percent of the dairy farms. Each farm on average had 310 cows and contributed 57 percent to the national milk production. A cow on average consumed 3 200 kg DM/year through grazing. Other feedstuffs consumed were: forages 950 kg DM/year and a total of > 1 000 kg/year for grains, compound feed and by-products. The total feed intake was 5 525 kg DM/cow/year and the annual feed efficiency was 0.90.

» **Low bail:** This feeding system was used in 28 percent of the dairy farms. Each farm on average had 233 cows and contributed 17 percent to the national milk production. Grazing contributed 3 600 kg DM to the yearly diet of a cow, other forages contributed 900 kg DM and grains and compound feed < 1000 kg. The total feed intake was 5 275 kg DM/cow/year and the annual feed efficiency was 0.86.

- **Partial mixed ration:** These feeding systems were used in 12 percent of the dairy farms. Each farm on average had 411 cows and contributed 17 percent to the national milk production. Cows were on grazing for most part of the year, consuming on an average of 2 700 kg DM/cow/year and were supplemented with partial mixed ration containing substantial amounts of cereal grains, compound feed and by-products. The total feed intake was 5 550 kg DM/cow/year and the annual feed efficiency was 0.91.
- **Hybrid:** This feeding system was used in 5 percent of the dairy farms. Each farm on average had 467 cows, and contributed 8 percent to the national milk production. Farms using this system were more common in the regions that have hot, dry conditions in summer, which are not suitable for pasture growth. This system was based on grazing (1 800 kg DM/cow/year) for less than nine months in a year, with the provision of partial mixed ration. Grains and compound feed were also sometimes used. The total feed intake was 5 625 kg DM/cow/year and the annual feed efficiency was 0.92.
- **Total mixed ration:** This feeding system was used in only 1 percent of the dairy farms. Each farm on average had 491 cows and contributed only 1 percent to the national milk production. Cows were housed and fed with total mixed ration. There was no grazing. The total feed intake was 5 775 kg DM/cow/year and the annual feed efficiency was 0.94.

Farms using the partial mixed ration, hybrid and total mixed ration systems represented only 18 percent of all farms but contributed 26 percent to the total milk production. This was because these systems had a higher number of cows per farm and higher milk production per cow compared with farms using the low and moderate–high bail systems.

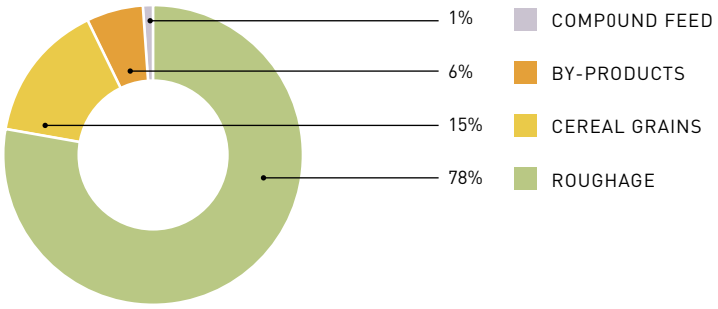
In recent years, the proportion of Australian farms using partial mixed ration, hybrid or total mixed ration systems has increased. Farmers who choose one of these systems do so for many reasons, including a desire to achieve higher intakes; obtain better control over diets, heat stress or wet weather damage to pastures; utilize cost-effective by-products; and reduce levels of feed wastage.

About 95 percent of all Australian farmers used grazed pasture in their feeding system. The low bail and moderate–high bail systems used the highest proportion of grazed pasture. In the total mixed ration system, hay and silage were used as roughage in conjunction with grains, compound feed and by-products.

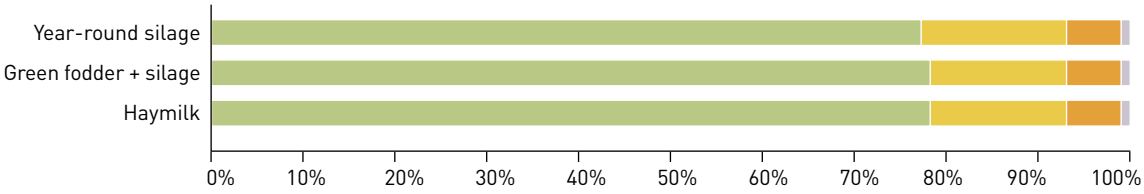
FEEDING SYSTEMS IN AUSTRIA

SYSTEMS	YEAR-ROUND SILAGE	GREEN FODDER + SILAGE	"HAYMILK"
Contribution to national milk production (%)	50	35	15
Dairy farms in each feeding system (% of total)	40	40	20
Total feed intake (kg DM/cow/year)	6 205	6 280	6 340
Annual feed efficiency (kg milk/kg DM)	1.00	1.01	1.01
Average number of cows per farm	16	11	10

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	HAYMILK	GREEN FODDER + SILAGE	YEAR-ROUND SILAGE
Roughage	79%	79%	78%
Cereal grains	15%	15%	15%
By-products	6%	6%	6%
Compound feed	1%	1%	1%

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	YEAR-ROUND SILAGE	GREEN FODDER + SILAGE	"HAYMILK"
Roughage	**4 865**	**4 940**	**5 000**
Grass silage	3 300	1 650	-
Green fodder	-	2 200	1 150
Hay	365	730	2 700
Maize silage	1 200	360	-
Pasture	-	-	1 150
Cereal grains	**930**	**930**	**930**
Wheat and barley	450	450	450
Maize	280	280	280
Others: rye and oat	100	100	100
Others: triticale and other grains	100	100	100
By-products	**370**	**370**	**370**
Other meals/cakes: brewer grains	140	140	140
Pulp, molasses, vinasses: sugar beet	80	80	80
Soymeal	70	70	70
Other meals/cakes: rape cake	50	50	50
Cereal bran: wheat	30	30	30
Compound feed	**40**	**40**	**40**

Source: Grüner Bericht

In Austria, the annual average feed intake was 6 252 kg DM/cow/year. The ration was mainly composed of roughage (78 percent), split between pasture, hay, grass and maize silage and green fodder. Cereal gains represented 15 percent of feed and were mostly wheat, barley, maize grain, rye and oats, triticale and other seeds. The remaining 7 percent of the feed was made up of compound feed (1 percent) and by-products (6 percent). By-products used were wheat bran, rapeseed cake, brewer grains, soymeal and sugar beet.

The three feeding systems identified were: year-round silage, green fodder plus silage and "haymilk".

» **Year-round silage:** This feeding system was used in 40 percent of the dairy farms. Each farm on average contained 16 cows and contributed 50 percent to the national milk production. This system was used all over the country but predominantly in locations where forage availability was good. Cows were fed with a silage-based ration (68 percent of roughage intake) throughout the year. The total feed intake was 6 205 kg DM/cow/year and the annual feed efficiency was 1.0.

» **Green fodder plus silage:** This feeding system was used in 40 percent of the dairy farms. Each farm on average contained 11 cows and contributed 35 percent to the national milk production. This system existed all over the country. Cows were fed with a silage-based ration during the winter season and with green-fodder-based ration during the other periods. The total feed intake was 6 280 kg DM/cow/year and the annual feed efficiency was 1.01.

» **"Haymilk":** This feeding system was used in 20 percent of the dairy farms. Each farm on average had 10 cows and contributed 15 percent to the national milk production. This system was predominant in mountainous and grassland areas in the western parts of Austria. Cows were fed with a hay ration during the winter season and with green pastures and without any silage during summer. The total feed intake was 6 340 kg DM/cow/year and the annual feed efficiency was 1.01.

The main difference between the haymilk system and the other systems was the absence of silage in the haymilk system. In contrast, systems with year-round silage feeding were without pastures. The amount of cereal grains, by-products and compound feed was about the same in all the systems. Only roughage changed in these systems. Roughage consumption (DM/cow/year) was estimated to be 5 000 kg in the haymilk system, 4 865 kg in the year-round system and 4 940 kg in the green-fodder system.

In the haymilk system, hay represented 54 percent of roughage, green fodder 23 percent and pasture 23 percent. In the year-round silage system, grass silage represented 68 percent of roughage and maize silage 25 percent. In the green-fodder plus silage system, green fodder represented 45 percent of roughage and grass silage 33 percent.

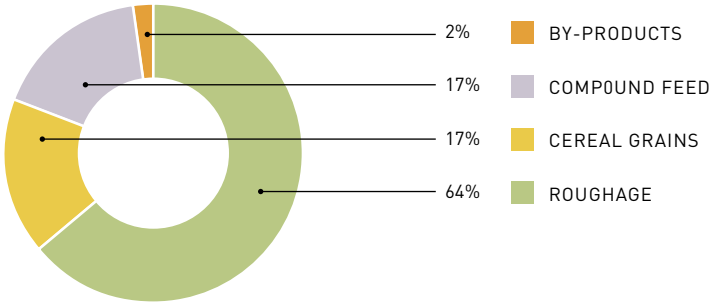
Usually, dairy cows were reared intensively. Indeed, 81 percent of roughage consumption was grass silage, hay and green fodder.

In the Alpine regions, organic farming is traditionally of high importance and represents an important share (> 18 percent in Austria) of all farms and land areas, with the proportion of organic farms being > 23 percent. In mountainous regions, climatic and geo-morphological restrictions are the limiting factors to production so that high-output strategies are not economically efficient. Therefore, high-input farming systems are rare in the disadvantaged regions and many farms take part in the Austrian agro-environmental programme ÖPUL. In comparison with conventional farms, the milk yield per cow per year and the proportion of concentrate and corn silage in the total ration are both lower and the proportion of green fodder and grazing is higher.

FEEDING SYSTEMS IN CANADA

SYSTEMS	PREDOMINANT FEEDING SYSTEM (ROUGHAGE-CONCENTRATE: 2:1) SYSTEM
Contribution to national milk production (%)	High
Dairy farms in feeding system (% of total)	Majority (about 75%)
Total feed intake (kg DM/cow/year)	7 093
Annual feed efficiency (kg milk/kg DM)	1.09
Average number of cows per farm	72

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF THE MAIN FEEDING SYSTEM

INTAKE (kg DM/cow/year)	PREDOMINANT FEEDING SYSTEM (ROUGHAGE-CONCENTRATE: 2:1) SYSTEM
Roughage	**4 528**
Grass silage	2 568
Hay	1 048
Maize silage	659
Others	154
Pasture	99
Cereal grains	**1 203**
By-products	**161**
Compound feed	**1 201**

Source: Valacta Report

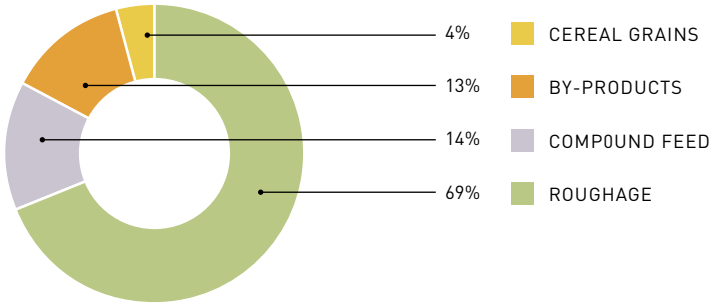
In Canada, only one feeding system, which was used in 75 percent of the total dairy herds, was identified. The average number of cows per farm was 72.

The total feed intake was 7 093 kg DM/cow/year. Roughage, mostly grass silage, predominated with 64 percent of the total feed intake. The diet also contained on average 17 percent cereal grains, 17 percent compound feed and 2 percent by-products. Roughage intake of 4 528 kg DM/cow/year on average was composed of 2 568 kg DM/cow/year of grass silage and 1 048 kg DM/cow/year of hay. The low use of pasture compared with other sources of roughage reflects the high intensification of the system. The annual feed efficiency in this system was 1.09.

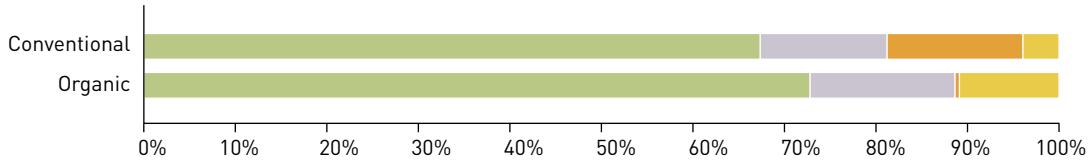
FEEDING SYSTEMS IN DENMARK

SYSTEMS	CONVENTIONAL	ORGANIC FARMING
Contribution to national milk production (%)	90	10
Dairy farms in feeding system (% of total)	91	9
Total feed intake (kg DM/cow/year)	7 386	7 186
Annual feed efficiency (kg milk/kg DM)	1.12	1.10
Average number of cows per farm	128	132

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	ORGANIC	CONVENTIONAL
Roughage	74%	68%
Compound feed	16%	14%
By-products	0.3%	15%
Cereal grains	11%	4%

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	CONVENTIONAL FARMING	ORGANIC FARMING
Roughage	**5 021**	**5 296**
Maize silage	2 842	982
Grass silage	1 708	2 632
Pasture	130	966
Crop residues	192	112
Others: fodder beets, whole crops	116	385
Hay	33	219

INTAKE (kg DM/cow/year)	CONVENTIONAL FARMING	ORGANIC FARMING
Cereal grains	**263**	**758**
Wheat and barley	263	758
By-products	**1 094**	**18**
Rapeseed meal	497	-
Others: brewers grains, beet pulp, molasses	288	18
Soymeal	236	-
Others	73	-
Compound feed	**1 008**	**1 114**

Source: Knowledge Center for Agriculture

In Denmark, the average annual feed intake was 7 285 kg DM/cow/year. The average national diet was based on 71 percent roughage (mainly maize silage), 15 percent compound feed, 7 percent cereal grains and 8 percent by-products. The most-used by-products were soy and rapeseed meals (66 percent of the total by-products).

The two feeding systems identified corresponded to the two main types of milk production in the country: conventional and organic farming.

» **Conventional:** This feeding system was used in 91 percent of the dairy farms. Each farm on average had 128 cows and contributed 90 percent to the national milk production. The average number of cows per farm was larger than in the other countries of the European Union (EU) detailed in this report. The yearly diet per cow comprised 5 021 kg roughage (mainly grass silage), 1 094 kg by-products (mainly rapeseed and soy meals), 1 008 kg compound feed and 263 kg cereal grains. Roughage comprised 57 percent corn silage, 34 percent grass silage and only 3 percent pasture. The total feed intake was 7 387 kg DM/cow/year and the annual feed efficiency in this system was 1.12.

» **Organic:** This feeding system was used in 9 percent of the dairy farms. Each farm on average had 132 cows and contributed 10 percent to the national milk production. The yearly diet comprised 5 296 kg roughage, 1 114 kg compound feed, 444 kg wheat and barley and only 18 kg various by-products. Roughage used comprised 50 percent grass silage, 19 percent maize silage and 18 percent pasture. The feed intake was 7 186 kg DM/cow/year and the annual feed efficiency in this system was 1.10.

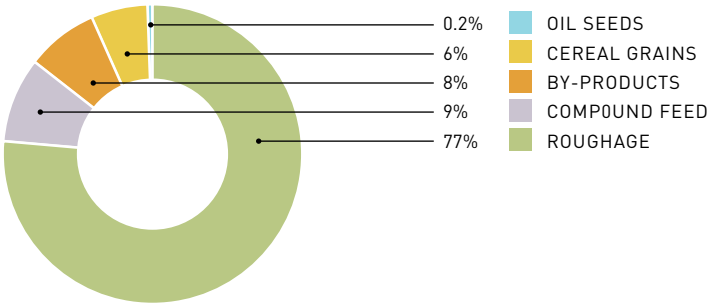
The main difference between these systems was the use of pasture and by-products. In the organic system, the proportions of pasture and cereal grains used were higher than in the conventional system. By-products represented only 0.3 percent of the total feed intake in the former system versus 15 percent in the latter. In both systems, wheat and barley were the two main cereal grains used.

Overall, dairy cows were often kept in zero grazing to produce maximum milk using a minimum of land. This explains the higher number of cows and the high usage of grass and maize silages.

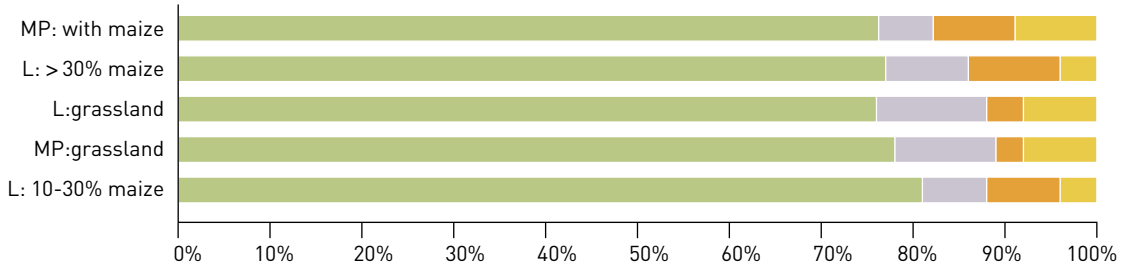
FEEDING SYSTEMS IN FRANCE

SYSTEMS	LOWLAND; > 30% MAIZE SILAGE	LOWLAND; 10–30% MAIZE SILAGE	MOUNTAIN & PIEDMONT GRASSLAND	LOWLAND GRASSLAND	MOUNTAIN & PIEDMONT WITH MAIZE
Contribution to national milk production (%)	35.6	23.9	18.4	15.7	6.4
Dairy farms in feeding system (% of total)	38.2	22.2	15.9	8.1	15.6
Total feed intake (kg DM/cow/ year)	7 060	6 613	6 275	6 118	6 841
Annual feed efficiency (kg milk/kg DM)	1.15	1.11	1.11	1.11	1.11
Average number of cows per farm	62	56	41	59	47

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	L:10-30% MAIZE	MP: GRASSLAND	L: GRASSLAND	L: >30% MAIZE	MP: WITH MAIZE
Roughage	81%	78%	76%	77%	77%
Compound feed	7%	11%	12%	9%	6%
By-products	8%	3%	4%	10%	9%
Cereal grains	4%	8%	8%	4%	9%

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	LOWLAND; > 30% MAIZE SILAGE	LOWLAND; 10–30% MAIZE SILAGE	LOWLAND; GRASSLAND	MOUNTAIN & PIEDMONT; GRASSLAND	MOUNTAIN & PIEDMONT; WITH MAIZE
Roughage	**5 417**	**5 338**	**4 636**	**4 908**	**5 267**
Maize silage	3 186	1 976	308	6	1 707
Pasture	918	1 577	1 916	1 991	1 599
Hay	702	909	1 462	2 231	989
Grass silage	397	773	660	609	902
Others: sorghum silage, fodder beet	15	24	90	-	-
Green fodder, straw and exotics fodder	199	79	201	71	71
Cereal grains	**262**	**278**	**506**	**494**	**600**
Wheat and barley	202	242	360	453	516
Maize	60	36	146	41	84
By-products	**706**	**504**	**258**	**208**	**584**
Soy meal	412	310	113	83	430
Others: other concentrated by-products	92	64	60	27	74
Rapeseed meal	77	91	45	6	61
Others: dried beet pulp, dried hay	69	10	34	84	16
Others: brewers grains	53	22	-	8	3
Other: sunflower and linseed cake	3	7	6	-	-
Compound feed	**666**	**463**	**716**	**659**	**380**
Oilseeds	**9**	**30**	**2**	**6**	**10**
Others: oilseeds	8	26	2	5	9
Rape	1	4	0	1	1

Source: Institut de l'Elevage

In France, the average annual feed intake was 6 754 kg DM/cow/year. The diet was based on 78 percent roughage, mainly pasture and maize silage. Other components represented less than 10 percent each: 9 percent compound feed, 8 percent by-products, 5 percent cereal grains and less than 1 percent oilseeds.

Five different feeding systems were characterized, mainly based on altitude (mountain versus lowland) and the share of maize and grass.

» **Lowland with > 30 percent maize silage:** This feeding system was used in 38 percent of the dairy farms. Each farm on average had 62 cows and contributed 36 percent to the national milk production. Cows were fed mainly with maize silage (45 percent), pasture (13 percent), by-products (10 percent), compound feed (9 percent) and cereal grains (4 percent). The total feed intake and the annual feed efficiency were 7 060 kg DM/cow/year and 1.15, respectively.

» **Lowland with 10–30 percent maize silage:** This feeding system was used in 22 percent of the dairy farms. Each farm on average had 56 cows and contributed 24 percent to the national milk production. The diet was made up of pasture (24 percent) and maize silage (30 percent); other components were compound feed, by-products, cereal grains and oils seeds, representing 8, 7, 4 and < 1 percent of the total feed intake, respectively. The annual feed efficiency in this system was 1.11.

» **Lowland – grassland:** This feeding system was used in 8 percent of the dairy farms. Each farm on average had 59 cows and contributed 16 percent to the national milk production. The roughage component of the diet was made up of pasture (31 percent) and hay (24 percent), while compound feed, by-products and cereal grains represented 12, 4 and 8 percent, respectively. The annual feed efficiency in this system was 1.1.

» **Mountain & Piedmont with maize:** This feeding system was used in 16 percent of the dairy farms. Each farm on average had 47 cows and contributed 6 percent to the national milk production. The roughage fraction of the annual feed intake was made up of 25 percent maize silage and 23 percent pasture. Other components were 6 percent compound feed, 9 percent by-products and 9 percent cereal grains. The annual feed efficiency in this system was 1.1.

» **Mountain & Piedmont – grassland:** This feeding system was used in 16 percent of the dairy farms. Each farm on average had 41 cows and contributed 18 percent to the national milk production. These farms presented the smallest number of cows on average. The roughage component in the total feed intake consisted of pasture (32 percent) and hay (36 percent). The rest of the feed intake comprised 11 percent compound feed, 3 percent by-products and 8 percent cereal grains. The annual feed efficiency in this system was 1.1.

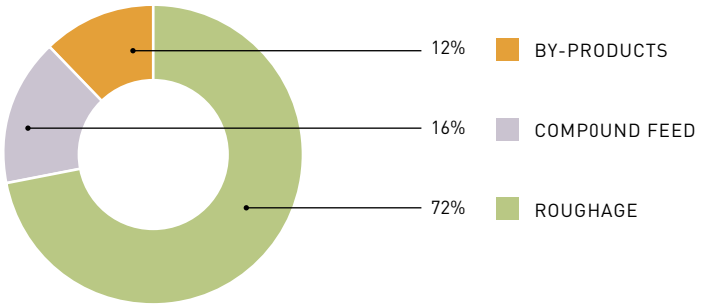
It is worth noting that all these five feeding systems used between 13 and 32 percent of pasture. This clearly underlines the strong link that milk production has with land use. Some feeding systems used almost only grass in the form of pasture, hay and/or grass silage as roughage to feed the cows.

The importance and the nature of concentrate feed (by-products, cereal grains and oilseeds) and compound feed depended on the nature of the main roughage. For instance, feeding systems that used a high proportion of maize silage needed protein concentrates to complement the ration. With the grass-based diets, high energy by-products or cereal grains were needed. The more a system used pasture, the less it required by-products such as soymeal.

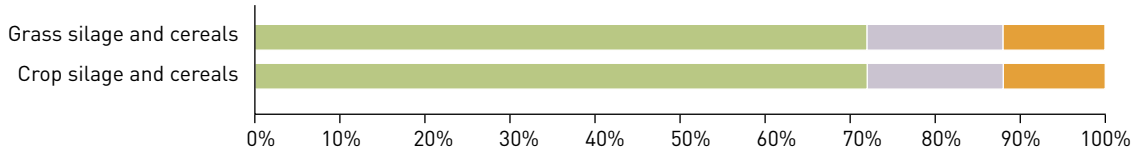
FEEDING SYSTEMS IN GERMANY

SYSTEMS	CROP SILAGE AND CEREALS	GRASS SILAGE AND CEREALS
Contribution to national milk production (%)	47	32
Dairy farms in feeding system (% of total)	22	40
Total feed intake (kg DM/cow/year)	6 686	6 448
Annual feed efficiency (kg milk/kg DM)	1.05	1.03
Average number of cows per farm	90	31

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	CROP SILAGE AND CEREALS	GRASS SILAGE AND CEREALS
Roughage	72%	72%
Compound feed	16%	16%
By-products	12%	12%

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	CROP SILAGE AND CEREALS	GRASS SILAGE AND CEREALS
Roughage	**4 813**	**4 641**
Maize silage	2 635	2 541
Grass silage	2 069	1 995
Pasture	109	105
By-products	**780**	**753**
Soymeal	468	452
Rapeseed meal	312	301
Compound feed	**1 093**	**1 054**

Source: ZMB Jarhbuch Milch and IFCN

In Germany, the annual average feed intake was 6 594 kg DM/cow/year. It was based on 72 percent roughage composed of 53 percent maize silage, 42 percent grass silage, 16 percent compound feed and 12 percent of by-products such as soymeal and rapeseed meal. No cereal grains were directly given to the animals but some grains were used via compound feeds.

Two different feeding systems were identified in Germany: crop silage plus cereals and grass silage plus cereals. They depend basically on silage production from on-farm production of crops and cereals or on grass silage and cereals. The by-products used were mainly rapeseed meal and soymeal.

» **Crop silage and cereals:** This feeding system was used in 22 percent of the dairy farms. Each farm on average had 90 cows and contributed 47 percent to the national milk production. The annual diet of a cow was composed of 4 813 kg roughage, 1 093 kg compound feed and 780 kg by-products. The total feed intake was 6 686 kg DM/cow/year and the annual feed efficiency in this system was 1.05.

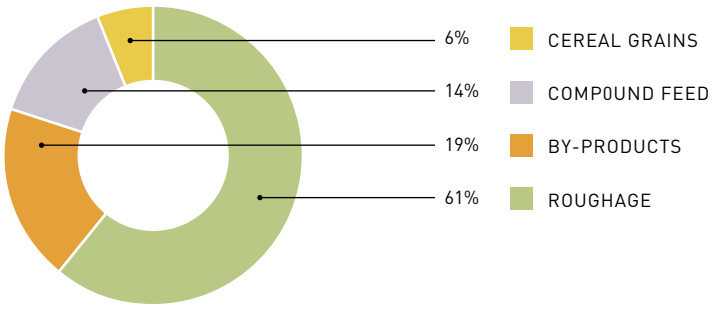
» **Grass silage and cereals:** This feed system was used in 40 percent of the dairy farms. Each farm on average had 31 cows and contributed 32 percent to the national milk production. The yearly diet of a cow comprised 4 641 kg roughage, 1 054 kg compound feed and 753 kg by-products. The total feed intake was 6 447 kg DM/cow/year and the annual feed efficiency in this system was 1.03.

Both systems are quite similar in composition as far as roughage and concentrate fractions are concerned. The only difference being that one system uses crop silage and the other grass silage. Overall, dairy cows were managed with zero grazing to produce the maximum amount of milk from a minimum surface area.

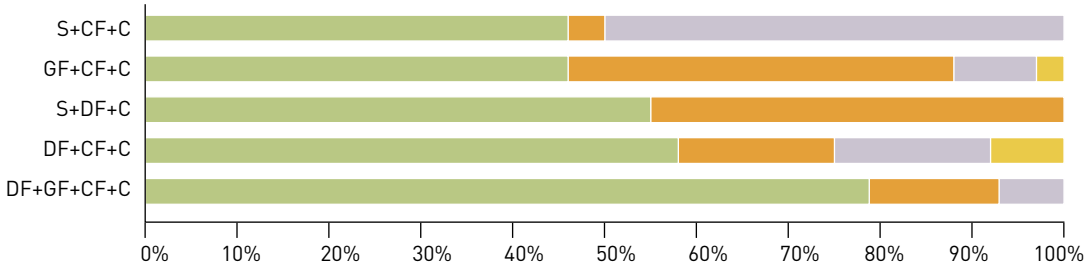
FEEDING SYSTEMS IN INDIA

SYSTEMS	DRY FODDER + CATTLE FEED + CONCENTRATES (DF+CF+C)	DRY FODDER + GREEN FODDER + CATTLE FEED + CONCENTRATES (DF+GF+CF+C)	GREEN FODDER + CATTLE FEED + CONCENTRATES (GF+CF+C)	SILAGE + DRY FODDER + CONCENTRATES (S+DF+C)	SILAGE + CATTLE FEED + CONCENTRATES (S+CF+C)
Contribution to national milk production (%)	60	25	13	1	1
Dairy farms in feeding system (% of total)	74	20	5	0.05	0.05
Total feed intake (kg DM/cow/year)	4 203	3 807	3 773	5 325	5 223
Annual feed efficiency (kg milk/kg DM)	0.63	0.52	0.50	0.87	0.85
Average number of cows per village	40	45	60	65	50

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	DF+GF+CF+C	DF+CF+C	S+DF+C	GF+CF+C	S+CF+C
Roughage	78%	58%	55%	46%	46%
By-products	14%	17%	45%	42%	4%
Compound feed	7%	17%		9%	50%
Cereal grains		8%		3%	

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	DF+CF+C	DF+GF+CF+C	GF+CF+C	S+DF+C	S+CF+C
Roughage	**2 440**	**2 986**	**1 738**	**2 952**	**2 380**
Crop residues	2 440	818	658	657	-
Green fodder	-	1 668	1 080	930	625
Pasture	-	500	-	-	-
Maize silage		-	-	1 365	1 755
Cereal grains	**329**	**-**	**110**	**-**	**-**
Maize	305	-	110	-	-
Wheat and barley	23	-	-	-	-
By-products	**730**	**546**	**1 575**	**2 373**	**215**
Cereal bran	657	-	53	-	-
Cottonseed cake		546	110	2 373	215
Others: chunnies (mainly maize by-product)	31	-	1 260	-	-
Rapeseed meal	42	-	-	-	-
Other meals/ cakes: maize cake	-	-	99	-	-
Other meals/ cakes: groundnut cake	-	-	55	-	-
Compound feed	**704**	**275**	**350**	**-**	**2 628**

Source: India IDF

In India, the average intake was 4 466 kg DM/cow/year. The diet was based on 61 percent roughage (mainly crop residues and green fodder), 19 percent by-products (cereal bran, cottonseed cake, chunnies – by-products of pulses), 14 percent compound feed and 6 percent cereal grains such as maize, wheat and barley.

Five feeding systems were characterized: dry fodder + cattle feed + concentrates system, dry fodder + green fodder + cattle feed + concentrates system, green fodder + cattle feed + concentrates system, silage + dry fodder + concentrates system and silage + cattle feed + concentrates system.

» **Dry fodder + cattle feed + concentrates:** This feeding system was used in 60 percent of the dairy farms, with an average of 40 cows per village and contributed 47 percent to the national milk production. Cows were fed with 4 203 kg DM/cow/year, comprising 2 440 kg crop residues, 730 kg by-products (mainly cereal bran), 704 kg compound feed and 329 kg cereal grains such as maize. The annual feed efficiency in this system was 0.63

» **Dry fodder + green fodder + cattle feed + concentrates:** This feeding system was used in 20 percent of the dairy farms, with an average of 45 cows per village and contributed 25 percent to the national milk production. The feed intake was 3 807 kg DM/cow/year, comprising 2 986 kg of mostly green fodder (56 percent roughage), 546 kg cottonseed cake and 275 kg compound feed. The annual feed efficiency in this system was 0.52.

» **Green fodder + cattle feed + concentrates:** This feeding system was used in 5 percent of the dairy farms, with an average of 60 cows per village and contributed 13 percent to

the national milk production. Cows were fed with 3 773 kg DM/year comprising 1 738 kg roughage, 1 575 kg by-products, 350 kg compound feed and 110 kg maize grains. The roughage component contained 62 percent green fodder and the by-product component contained 80 percent chunnies. The amounts of roughage and by-products were quite similar in this system. The annual feed efficiency in this system was 0.50.

» **Silage + dry fodder + concentrates**: This feeding system was used in 0.05 percent of the dairy farms, with an average of 65 cows per village and contributed only 1 percent to the national milk production. The yearly diet of a cow was composed only of roughage (2 952 kg) and cottonseed cake (2 373 kg). Maize silage represented 46 percent of roughage; green fodder represented 32 percent and crop residues 22 percent. The amounts of roughage and by-products were 55 and 45 percent, respectively. The total feed intake was 5 325 kg DM/cow/year and the annual feed efficiency was 0.87.

» **Silage + cattle feed + concentrates:** This feed system was used in only 0.05 percent of the dairy farms, with an average of 50 cows per village and contributed 1 percent to the national milk production. In one year, a cow was fed 2 628 kg compound feed, 2 380 kg roughage and 215 kg by-products. This was the only system in which the intake of compound feed was higher than the intake of roughage. The total yearly feed intake was 5 223 kg DM/cow/year and the annual feed efficiency in this system was 0.85.

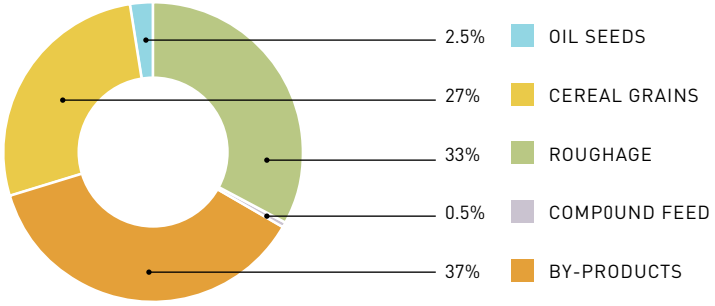
Pasture grazing was included in the dry fodder + green fodder + cattle feed + concentrates system only. In three systems, cereal grains were not used. The amount of by-products was higher in two systems: silage + dry fodder + concentrates system and green fodder + cattle feed + concentrates system.

In India, the ration based on roughage was usually supplemented with by-products or compound feed and not with cereal grains.

FEEDING SYSTEMS IN ISRAEL

SYSTEMS	TOTAL MIXED RATION (TMR)
Contribution to national milk production (%)	100
Dairy farms in feeding system (% of total)	100
Total feed intake (kg DM/cow/year)	8 760
Annual feed efficiency (kg milk/kg DM)	1.17
Average number of cows per farm (cow/farm)	125

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	TOTAL MIXED RATION (TMR)
Roughage	**2 891**
Wheat silage	1 621
Maize silage	701
Hay	438
Crop residues	131
Cereal grains	**2 365**
Maize	1 314
Wheat and barley	964
Sorghum	88
By-products	**3 241**
Other meals/cakes: gluten feed	657
Others: DDGS	657
Rapeseed meal	438
Soy meal	350
Other meals/cakes: sunflower meal	350
Others: whey and wet corn gluten feed	307
Cereal bran	263
Pulp, molasses, vinasses: soy molasses	219
Compound feed	**44**
Oilseeds	**219**
Cotton	219

Source: Israel Ministry of Agriculture

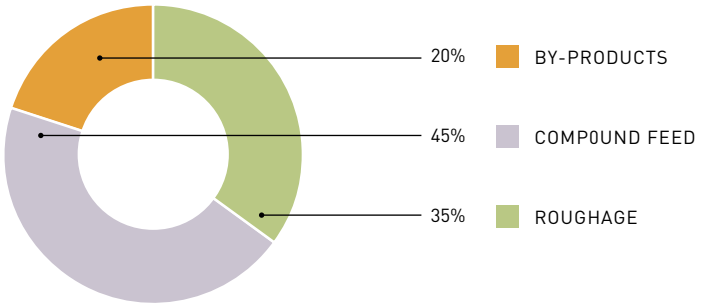
Israel had one feeding system: a total mixed ration (TMR) system, representing 100 percent of total dairy farms, with 125 cows per farm.

The total yearly feed intake of a cow was 8 760 kg DM. Roughage was 33 percent of the total feed intake (2 891 kg) and was mainly composed of wheat silage (56 percent) and maize silage (24 percent). The diet contained 27 percent of cereal grains such as maize, wheat, barley and sorghum, 3 percent of cotton oil and 1 percent of compound feed. The annual feed efficiency in the system was 1.17.

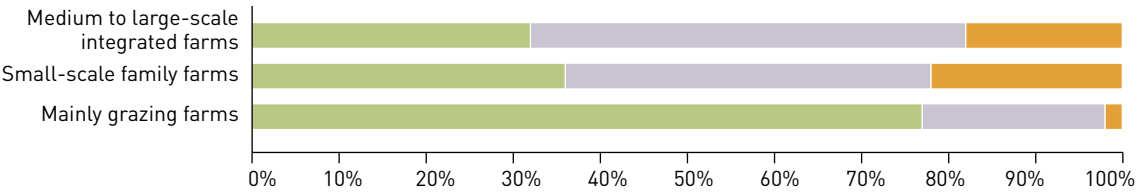
FEEDING SYSTEMS IN JAPAN

SYSTEMS	SMALL-SCALE FAMILY FARMS	MEDIUM TO LARGE-SCALE INTEGRATED FARMS	MAINLY GRAZING FARMS
Importance in national milk production (%)	64	33	3
Dairy farms in feeding system (% of total)	71	25	4
Total feed intake (kg DM/ cow/year)	7 180	7 140	7 050
Annual feed efficiency (kg milk/kg DM)	1.10	1.10	1.09
Average number of cows per farm	50	100	40

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	MAINLY GRAZING FARMS	SMALL-SCALE FAMILY FARMS	MEDIUM TO LARGE-SCALE INTEGRATED FARMS
Roughage	77%	36%	32%
Compound feed	21%	42%	50%
By-products	2%	22%	18%

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	SMALL-SCALE FAMILY FARMS	MEDIUM TO LARGE-SCALE INTEGRATED FARMS	MAINLY GRAZING FARMS
Roughage	**2 600**	**2 280**	**5 400**
Hay	900	1 100	500
Maize silage	1 000	700	400
Grass silage	400	400	200
Pasture	100	-	3 800
Crop residues	100	80	200
Green fodder	100	-	300
By-products	**1 580**	**1 260**	**150**
Other: brewer's grain	600	500	-
Cereal bran	400	200	-
Other cakes: tofu cake	200	200	-
Cottonseed cake	200	180	50
Pulp: beet pulp	180	180	100
Compound feed	**3 000**	**3 600**	**1 500**

Source: Japan IDF

In Japan, the average yearly feed intake of a cow was 7 132 kg DM. The diet was based on 42 percent roughage (mainly hay, pasture and maize silage), 42 percent compound feed and 16 percent by-products (brewer's grains, cereal bran and beet pulp).

Three feeding systems existed: small-scale family farms, medium to large-scale integrated farms and mainly grazing farms.

» **Small-scale family farms:** This feeding system was used in 71 percent of the dairy farms. Each farm on average had 50 cows and contributed 64 percent to the national milk production. Cows were housed in tie-stall barns, mainly fed separately. The total feed intake was 7 140 kg DM/cow/year, which was composed of 36 percent roughage (mainly maize silage), 42 percent compound feed and 22 percent by-products such as brewer's grain. The annual feed efficiency was 1.10.

» **Medium to large-scale integrated farms:** This feeding system was used in 25 percent of the dairy farms. Each farm on average had 100 cows and contributed 33 percent to the national milk production. Cows were housed in free-stall barns, and fed mainly with total mixed ration. The yearly diet of a cow was 2 280 kg roughage (mainly hay), 3 600 kg compound feed and 1 260 kg by-products. The annual feed efficiency was 1.10.

» **Mainly grazing farms:** This feeding system was used in 4 percent of the dairy farms. Each farm on average had 40 cows and contributed only 3 percent to the national milk production. Cows were grazed for 8 months a year and then housed in the winter season. The yearly ration per cow of 7 050 kg DM consisted of 77 percent roughage (mostly pasture), 28 percent compound feed and 2 percent by-products. The annual feed efficiency in this system was 1.09.

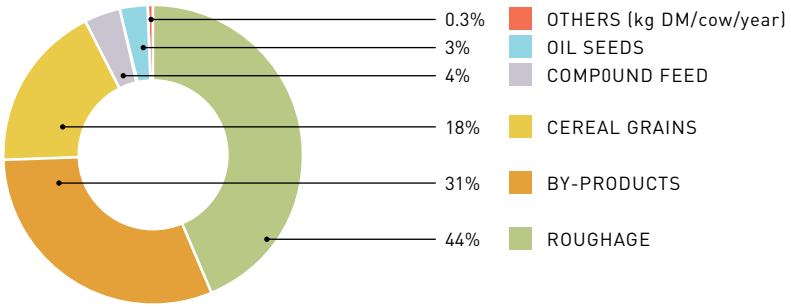
It should be noted that there was relatively low use of pasture in medium to large scale integrated farm systems. The small-scale family system and medium to large scale system were quite similar. The main differences between them were the higher amount of maize silage (1 000 kg versus 700 kg DM/cow/year) and lower amount of hay (900 kg versus 1 100 kg) in the former. In the mainly grazing system, the amount of roughage used was the highest with 3 800 kg DM/cow/year of pasture. No cereal grains were used in any of the three systems.

Typically, the small-scale family farms were predominant in the country with high usage of compound feed and maize silage. Dairy cows had a high yield and the system aimed for maximum production, with an area of only 5 hectares per farm on average.

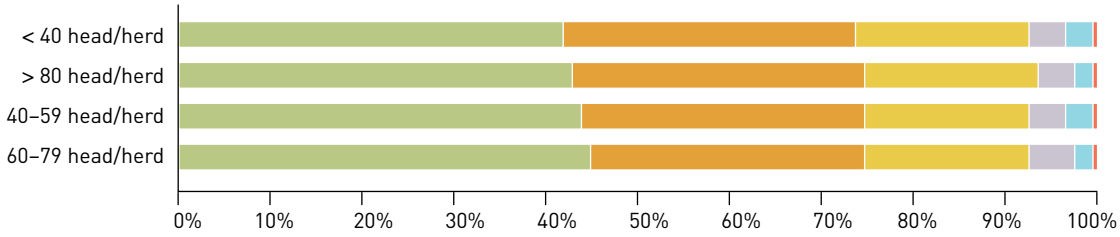
FEEDING SYSTEMS IN KOREA

SYSTEMS	< 40 HEAD/HERD	40–59 HEAD/HERD	60–79 HEAD/HERD	> 80 HEAD/HERD
Importance in national milk production (%)	-	-	-	-
Dairy farms in feeding system (% of total)	-	-	-	-
Total feed intake (kg DM/cow/year)	8 837	8 840	8 076	8 837
Annual feed efficiency (kg milk/kg DM)	1.23	1.23	1.17	1.23
Average number of cows per farm	17	29	38	59

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	60–79 HEAD/HERD	40–59 HEAD/HERD	≥ 80 HEAD/HERD	< 40 HEAD/HERD
Roughage	45%	44%	43%	42%
By-products	30%	31%	32%	32%
Cereal grains	18%	18%	19%	19%
Compound feed	5%	4%	4%	4%
Oil seeds	2%	3%	2%	3%
Others (kg DM/cow/year)	0.2%	0.5%	0.2%	0.1%

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	< 40 HEAD/HERD	40–59 HEAD/HERD	60–79 HEAD/HERD	≥ 80 HEAD/HERD
Roughage	**3 735**	**3 872**	**3 630**	**3 791**
Hay	1 833	2 191	2 263	2 110
Crop residue: rice straw	1 430	1 103	813	993
Silage	140	247	302	407
Others: pellet and other crop residues	86	268	180	156
Green fodder	246	63	73	127
Cereal grains	**1 640**	**1 589**	**1 439**	**1 686**
Maize	1 113	1 084	932	1 040
Wheat	333	318	319	407
Others: wheat flour	195	187	187	239
By-products	**2 866**	**2 771**	**2 440**	**2 799**
Soymeal	598	581	499	558
Corn gluten feed	317	306	273	318
Palm meal	260	250	230	276
Copra meal	240	232	204	234
Pulp: Beet pulp	253	250	188	181
Sesame meal	184	175	170	213
Lupin hull	179	171	163	200
Molasses	159	153	140	167
Brewers grain, tapioca, dried distillers grains with solubles	158	154	131	146
Rapeseed meal	147	142	124	140
Corn germ and citrus meal	148	145	118	125
Cereal bran: wheat	117	112	107	132
Cereal bran: rice	96	93	84	99
Cottonseed cake	9	9	9	11
Compound feed	**332**	**310**	**365**	**365**
Oilseeds	**253**	**250**	**188**	**181**
Cotton	253	250	188	181
Others	**11**	**48**	**14**	**15**

Source: Korea IDF

In Korea, the average yearly intake of a cow was 8 648 kg DM. The diet was composed of 44 percent roughage (mainly hay), 31 percent by-products, 18 percent cereal grains, 4 percent compound feed, 3 percent oilseeds and < 1 percent of other feedstuffs. The three most widely used feedstuffs in Korean dairy farms were hay, rice straw and maize, which contributed 24, 13 and 12 percent to the total feed intake, respectively.

Four feeding systems were identified on the basis of herd size: < 40 head/herd, 40–59 head/herd, 60–79 head/herd and > 80 head/herd.

» **< 40 head/herd:** In this feeding system, cows were fed with 42 percent roughage, 32 percent by-products and 19 percent cereal grains. The remaining 7 percent was split between

compound feed, oilseeds and other feedstuffs. Hay represented 21 percent of the total feed intake, crop residue 16 percent and maize 13 percent. The total feed intake was 8 838 kg DM/cow/year. The annual feed efficiency in this system was 1.23.

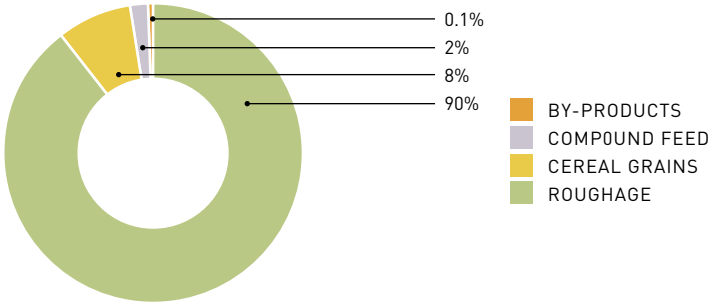
- **40–59 head/herd:** In this feeding system, cows were fed with 44 percent roughage, 31 percent by-products, 18 percent cereal grains and the remaining 7 percent was split between compound feed, cottonseed oil and other feedstuffs. The total feed intake and the annual feed efficiency were 8 839 kg/cow/year and 1.23 respectively.
- **60–79 head/herd:** In this feeding system, the total feed intake was 8 076 kg DM/cow/year. The diet was composed of 45 percent roughage, 30 percent by-products, 18 percent cereal grains and the remainder was constituted of compound feed, cottonseed oil and other feedstuffs. The annual feed efficiency was 1.17.
- **>80 head/herd:** In this feeding system, cows were fed with 43 percent roughage, 32 percent by-products, 19 percent cereal grains and the remaining 6 percent was split between compound feed, oilseeds and other feedstuffs. The total feed intake and the annual feed efficiency were 8 838 kg DM/cow/year and 1.23, respectively.

The description of feeding systems was based on the number of cows per farm and this explains why the four systems were quite similar. In each system, the shares of roughage, by-products, cereal grains, compound feed, oilseeds and other feedstuffs were very similar.

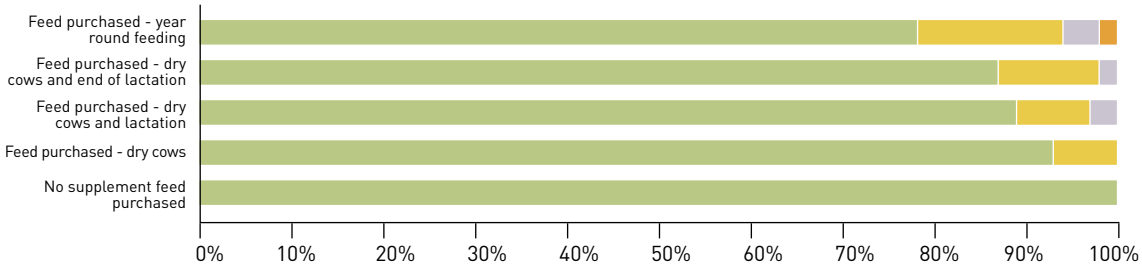
FEEDING SYSTEMS IN NEW ZEALAND

SYSTEMS	FEED PURCHASED FOR DRY AND LACTATING COWS	FEED PURCHASED FOR DRY COWS	FEED PURCHASED FOR DRY COWS AND TO EXTEND BOTH ENDS OF LACTATION	NO SUPPLEMENT FEED PURCHASED	FEED PURCHASED FOR YEAR-ROUND FEEDING
Contribution to national milk production (%)	35	30	20	10	5
Dairy farms in feeding system (% of total)	38	33	18	13	3
Total feed intake (kg DM/cow/year)	5 300	5 300	5 400	5 200	5 600
Annual feed efficiency (kg milk/kg DM)	0.87	0.87	0.88	0.85	0.91
Average number of cows per farm	300	270	350	250	500

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	NO SUPPLEMENT FEED PURCHASED	FEED PURCHASED - DRY COWS	FEED PURCHASED - DRY COWS AND LACTATION	FEED PURCHASED - DRY COWS AND END OF LACTATION	FEED PURCHASED - YEAR ROUND FEEDING
Roughage	100%	93%	89%	87%	79%
Cereal grains		7%	8%	11%	16%
Compound feed			3%	2%	4%
By-products					2%

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	FEED PURCHASED FOR DRY AND LACTATING COWS	FEED PURCHASED FOR DRY COWS	FEED PURCHASED FOR DRY COWS AND END OF LACTATION	NO SUPPLEMENT FEED PURCHASED	FEED PURCHASED FOR YEAR-ROUND FEEDING
Roughage	**4 700**	**4 950**	**4 700**	**5 200**	**4 400**
Pasture	3 800	4 100	3 800	4 800	3 400
Maize silage	600	200	600	-	800
Grass silage	200	200	200	400	-
Others: brassica, chicory, kale	100	450	100	-	200
Cereal grains	**100**	**-**	**200**	**-**	**400**
Wheat and barley	50	-	100	-	250
Maize	50	-	100	-	150
By-products	**350**	**350**	**400**	**-**	**600**
Molasses	-	-	-	-	100
Others: palm kernel extract	350	350	400	-	500
Compound feed	**150**	**-**	**100**	**-**	**200**

Source: Dairy NZ

In New Zealand, the annual average feed intake of a cow was 5 322 kg DM. The diet was based on 90 percent roughage (mainly pasture) and other main components were by-products: palm kernel extract and molasses.

The five feeding systems identified were: feed purchased for dry cows and to extend lactation, feed purchased for dry cows, feed purchased for dry cows and to extend both ends of lactation, no supplement feed purchased and feed purchased for year-round feeding.

» **Feed purchased for dry and lactating cows:** This feeding system was used in 38 percent of the dairy farms. Each farm on average had 300 cows and contributed 35 percent to the national milk production. Approximately 10–20 percent of total feed was imported. A cow on average was fed 89 percent roughage, 6.6 percent palm kernel extract and the rest was cereal grains and compound feed in almost similar amounts. The total feed intake and the annual feed efficiency were 5 300 kg DM/cow/year and 0.87, respectively.

» **Feed purchased for dry cows:** This feeding system was used in 33 percent of the dairy farms. Each farm on average had 270 cows and contributed 30 percent to the national milk production. The ration was composed of 93 percent roughage and the rest was palm kernel extract. The total feed intake was 5 300 kg DM/cow/year and the annual feed efficiency was 0.87.

» **Feed purchased for dry cows and end of lactation:** This feeding system was used in 18 percent of the dairy farms. Each farm on average had 350 cows and contributed 20 percent to the national milk production. The average yearly diet of a cow consisted of 4 700 kg roughage (87 percent of the total intake), 7 percent palm kernel extract, 3.7 percent cereal grains and 1.6 percent compound feed. The total feed intake was 5 400 kg DM/cow/year and the annual feed efficiency was 0.88.

» **No supplement feed purchased:** This feeding system was used in 13 percent of the dairy farms. Each farm on average had 250 cows and contributed 5 percent to the national milk production. A cow in one year was fed only with roughage, 92 percent being pasture and the rest grass silage. Concentrate was not used. It was the only system that did not use maize silage. The total feed intake was 5 200 kg DM/cow/year and the annual feed efficiency was 0.85.

» **Feed purchased for year-round feeding:** This feeding system was used in only 3 percent of the dairy farms. Each farm on average had 500 cows and contributed 5 percent to the national milk production. Cows were reared with 4 400 kg DM/cow/year of roughage (79 percent of the total intake), distributed as 3 400 kg pasture, 800 kg silage and 200 kg other forages. Other constituents were 7 percent cereal grains, 9 percent palm kernel extract, 3.6 percent compound feed and 1.8 percent molasses. This was the only country that used molasses in the diet. The total feed intake was 5 600 kg DM/cow/year and the annual feed efficiency was 0.91.

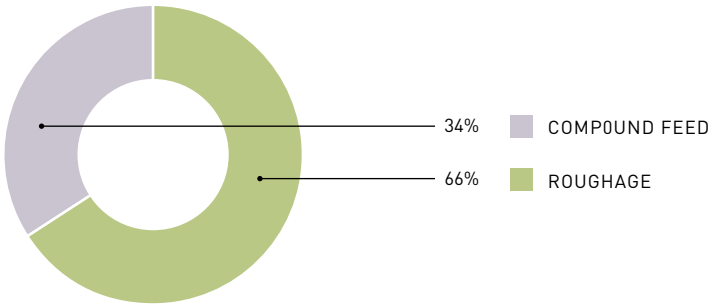
It should be noted that there was absence of hay in all the systems. The quantity of concentrate increased whereas that of roughage decreased.

In New Zealand, farmers usually optimized the use of roughage (mainly pasture) and of palm kernel extract as energy supplement.

FEEDING SYSTEMS IN NORWAY

SYSTEMS	GRASS-SILAGE-BASED SYSTEM
Contribution to national milk production (%)	95
Dairy farms in feeding system (% of total)	95
Total feed intake (kg DM/cow/year)	5 475
Annual feed efficieny (kg milk/kg DM)	0.90
Average number of cows per system	21

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	GRASS-SILAGE-BASED SYSTEM
Roughage	**3 610**
Grass silage	2 666
Pasture	739
Hay	205
Compound feed	**1 865**

Source: Norwegian Herd Recording

In Norway, only one feeding system was identified, representing 95 percent of the dairy sector both in terms of number and the national milk production. The average number of cows per farm was 21.

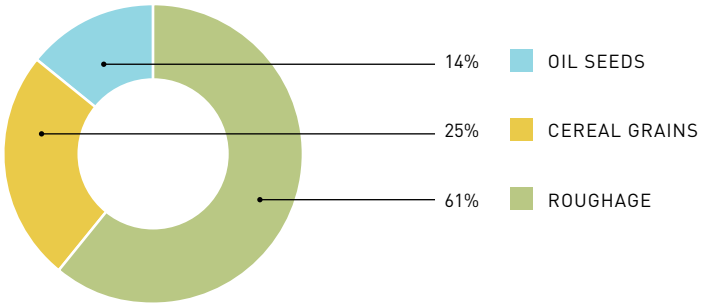
The total feed intake and the annual feed efficiency were 4 575 kg DM/cow/year and 0.90, respectively. Roughage, mostly grass silage, predominated with 66 percent of the total feed intake (3 610 kg DM/cow/year). Pasture represented only 20 percent of the roughage fraction. The diet was supplemented with 34 percent of compound feed.

This feeding system based on roughage was not necessarily extensive because the share of pasture was relatively low and no cereal grains were fed.

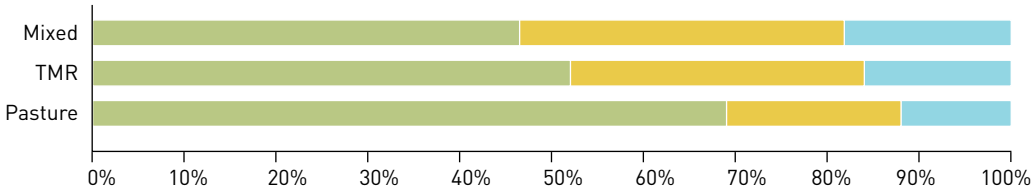
FEEDING SYSTEMS IN SOUTH AFRICA

SYSTEMS	PASTURE	TOTAL MIXED RATION (TMR)	MIXED
Contribution to national milk production (%)	60	35	5
Dairy farms in feeding system (% of total)	56	38	6
Total feed intake (kg DM/cow/year)	5 645	7 308	6 500
Annual feed efficiency (kg milk/kg DM)	0.92	1.11	1.03
Average number of cows per system	420	360	180

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	PASTURE	TMR	MIXED
Roughage	69%	52%	46%
Cereal grains	19%	32%	35%
Oil seeds	12%	16%	18%

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	PASTURE	TMR	MIXED
Roughage	**3 900**	**3 800**	**3 000**
Pasture	3 900	-	1 800
Maize silage	-	3 800	-
Crop residues	-	-	1 200
Cereal grains	**1 095**	**2 308**	**2 300**
Maize	1 095	2 308	2 300
Oilseeds	**650**	**1 200**	**1 200**
Soybean	650	1 200	1 200

Source: MPO and IFCN

In South Africa, the annual average feed intake of a cow was 6 264 kg DM. The diet was composed of 61 percent roughage, consisting of pasture, maize silage and crop residues. The diet also contained 25 percent cereal grains (maize) and 14 percent soybean.

Three feeding systems were identified: pasture system, total mixed ration system and mixed system.

» **Pasture system:** This feeding system was used in 56 percent of the dairy farms. Each farm on average had 420 cows and contributed 60 percent to the national milk production. The diet relied on pasture, which constituted 69 percent of the total feed intake. Other components were cereal grains (19 percent) and oilseeds (12 percent). The total feed intake was 5 645 kg DM/cow/year and the annual feed efficiency was 0.92.

» **Total mixed ration:** This feeding system was used in 38 percent of the dairy farms. Each farm on average had 360 cows and contributed 35 percent to the national milk production. The system was based on maize silage (52 percent of total feed intake). Other components were maize (32 percent) and soybean (16 percent). The total feed intake was 7 308 kg DM/cow/year and the annual feed efficiency was 1.11.

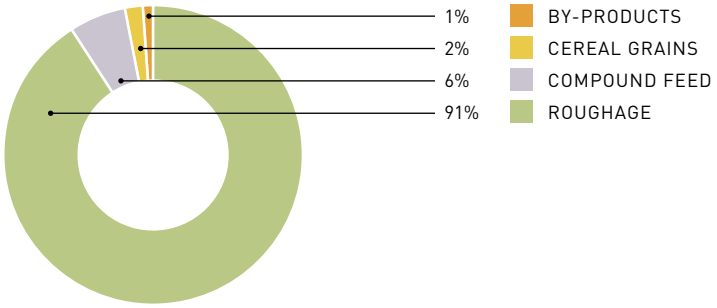
» **Mixed:** This feeding system was used in 9 percent of the dairy farms. Each farm on average had 180 cows and contributed 5 percent to the national milk production. The diet was made up of roughage (46 percent), maize (35.5 percent) and soybean (18.5 percent). The total feed intake was 6 500 kg DM/cow/year and the annual feed efficiency was 1.03.

It should be noted that oilseeds from soybean were used in all three systems.

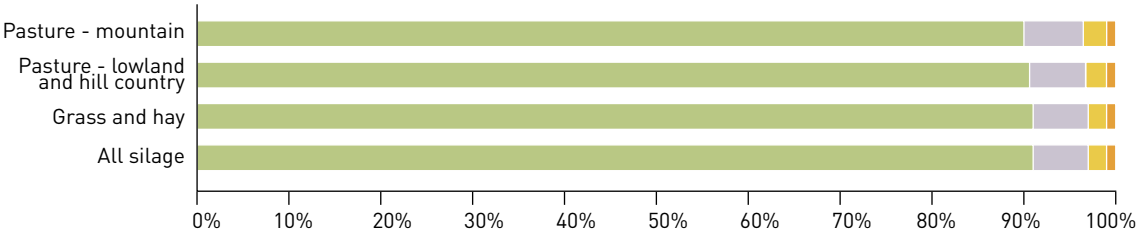
FEEDING SYSTEMS IN SWITZERLAND

SYSTEMS	ALL SILAGE	GRASS AND HAY	PASTURE - LOWLAND AND HILL COUNTRY	PASTURE - MOUNTAIN
Contribution to national milk production (%)	-	-	-	-
Dairy farms in feeding system (% of total)	-	-	-	-
Total feed intake (kg DM/cow/year)	6 600	6 500	6 300	6 000
Annual feed efficiency (kg milk/kg DM)	1.04	1.03	1.01	0.97
Average number of cows per farm	-	-	-	-

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	ALL SILAGE	GRASS AND HAY	PASTURE - LOWLAND AND HILL COUNTRY	PASTURE - MOUNTAIN
Roughage	91%	91%	90%	90%
Compound feed	6%	6%	6%	7%
Cereal grains	2%	2%	2%	3%
By-products	1%	1%	1%	1%

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	ALL SILAGE	GRASS AND HAY	PASTURE - LOWLAND AND HILL COUNTRY	PASTURE - MOUNTAIN
Roughage	**6 000**	**5 900**	**5 700**	**5 400**
Green fodder	-	3 000	-	-
Pasture	-	600	3 600	2 800
Grass silage	2 500	-	800	1 300
Maize silage	2 500	500	-	-
Hay	1 000	1 800	1 300	1 300
Cereal grains	**150**	**150**	**150**	**150**
Wheat and barley	80	80	80	80
Maize	50	50	50	50
Others: triticale	20	20	20	20
By-products	**50**	**50**	**50**	**50**
Soymeal	25	25	25	25
Rapeseed meal	25	25	25	25
Compound feed	**400**	**400**	**400**	**400**

Source: Switzerland IDF

The average yearly feed intake of a cow was 6 350 kg DM. The average ration was mainly made up of roughage (91 percent) and compound feed (6 percent). The remaining 3 percent was made up of cereal grains (2 percent) such as wheat, barley and maize and by-products (1 percent), mainly soy and rapeseed meals.

Four feeding systems were identified: all silage, grass and hay, pasture – lowland and hill country, and pasture –mountain.

- **All silage:** This feeding system used maize silage (38 percent), grass silage (38 percent), hay (15 percent) and concentrate (9 percent). The total feed intake was 6 600 kg DM/cows/year and the annual feed efficiency recorded was 1.04.
- **Grass and hay:** This feeding system used grass, hay or maize silage and concentrate. The roughage portion formed 91 percent of the total diet and the rest was concentrate feed. The total feed intake was 6 500 kg DM/cow/year and the annual feed efficiency recorded was 1.03.
- **Pasture – lowland and hill country:** In this feeding system, cows in summer were on full-time grazing and consumed 3 600 kg DM/cow. In winter, they were fed with hay (1 300 kg DM/cow) or silage (800 kg DM/cow) and concentrate (600 kg DM/cow). The annual total feed intake was 6 300 kg DM/cow/year and the annual feed efficiency was 1.01.
- **Pasture – mountain:** In this feeding system, cows in summer were on full-time grazing in partially alpine pasture and consumed 2 800 kg DM/cow. In winter, cows were fed with hay (1 300 kg DM/cow), grass silage (1 300 kg DM/cow) and concentrate (600 kg DM/cow). The total feed intake was 6 000 kg DM/cow/year, with the annual feed efficiency of 0.97.

The two pasture systems were quite similar; both used a lot of pasture and hay. In the mountain system, there was less use of pasture and more use of grass silage by 800 kg DM and 500 kg DM, respectively. The grass and hay system was the only system in which green fodder was used and grass silage was not used. The amount of compound feed, cereal grains and by-product were the same in each of the four systems.

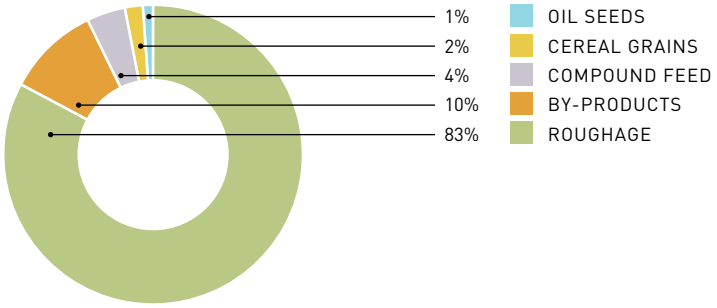
The feeding systems in Switzerland were based on grass, used in many forms: pasture, green fodder, silage and hay. Farmers optimized the use of grass as it is the main feed resource. This also allowed them to reduce the amount of concentrate used.

FEEDING SYSTEMS IN

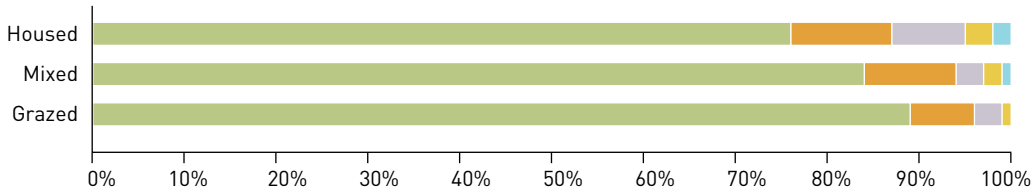
THE UNITED KINGDOM

SYSTEMS	MIXED	HOUSED	GRAZED
Contribution to national milk production (%)	75	17	8
Dairy farms in feeding system (% of total)	78	13	9
Total feed intake (kg DM/cow/year)	6 554	6 730	6 334
Annual feed efficiency (kg milk/kg DM)	1.04	1.06	1.01
Average number of cows per farm	186	224	197

DISTRIBUTION OF FEEDSTUFFS USED



FEEDING BASKETS (% CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS



	GRAZED	MIXED	HOUSED
Roughage	89%	84%	76%
By-products	7%	10%	11%
Compound feed	3%	3%	8%
Cereal grains	1%	2%	3%
Oil seeds	0%	1%	2%

FEEDING BASKETS (ABSOLUTE AMOUNTS OF FEED CONSTITUENTS) OF DIFFERENT FEEDING SYSTEMS

INTAKE (kg DM/cow/year)	MIXED	HOUSED	GRAZED
Roughage	**5 525**	**5 145**	**5 619**
Grass silage	2 734	3 160	2 706
Pasture	1 485	160	2 218
Maize silage	983	1 323	383
Others (whole crop and others not specified)	291	439	282
Crop residues	18	51	8
Hay	14	12	22
Cereal grains	**108**	**197**	**62**
By-products	**653**	**766**	**470**
Compound feed	**208**	**515**	**159**
Oilseeds	**60**	**107**	**24**

Source: Milkbench+

The average intake was 5 217 kg DM/cow/year. The diet was composed of 79 percent roughage (mainly grass silage and maize silage), 13 percent by-products, 5 percent compound feed, 2 percent cereal grains and 1 percent oilseeds.

Three feeding systems were characterized: mixed system, housed system and grazed system. These systems related to the degree of intensity of the production.

» **Mixed:** This feeding system was used in 78 percent of the dairy farms. Each farm on average had 186 cows and contributed 75 percent to the national milk production. Cows were grazed on grass fields for 15–35 weeks in a year. The diet was 80 percent roughage, mainly grass silage. Other components were by-products (10 percent), compound feed (3 percent) and a small amount of grain and oilseeds. The total feed intake was 6 554 kg DM/cow/year and the annual feed efficiency was 1.04.

» **Housed:** This feed system was used in 13 percent of the dairy farms. Each farm on average had 224 cows and contributed 13 percent to the national milk production. Cows were grazed for less than 15 weeks in a year. The ration was composed of 76 percent roughage, 11 percent by-products, 8 percent compound feed, 3 percent cereal grains and < 1 percent oilseeds. The yearly feed intake of a cow was 6 730 kg DM and the annual feed efficiency recorded was 1.06.

» **Grazed:** This feed system was used in 9 percent of the dairy farms. Each farm on average had 197 cows and contributed 8 percent to the national milk production. Cows were grazed for more than 35 weeks in a year. This system was based on feeding of a high quantity of grass silage and pasture. Maize silage represented only 7 percent of the roughage portion. The annual feed efficiency was 1.01 and the total feed intake was 6 334 kg DM/cow/year.

It should be noted that the grazing system was the one that used roughage the most. The use of cereal grains was low in all systems; however, levels of grains and compound feed increased with an increase in the degree of intensification.

3.4. ANALYSIS OF RESULTS

A total of 47 annual feeding systems were identified (see Table 3.3).

3.4.1. ANNUAL DRY MATTER INTAKE

Figures 3.6, 3.7 and 3.8 and Table 3.4 provide a detailed account of the total annual consumption per animal and the feed ingredients used in the diet.

The three feeding systems that had the lowest annual feed consumption per animal were from India, probably related to the poor genetic makeup of the animal and to local limitations in the availability of feed resources, which were primarily composed of roughage and locally available by-products.

Animal feeding systems with an annual feed consumption of between 5 000 and 6 000 kg dry matter per animal were extensive systems, generally with relatively higher levels of roughage consumption, some based on grazing, and mainly found in Oceania (New Zealand and Australia). These feeding systems were primarily based on roughage and grain. Only one system in New Zealand used exclusively roughage. Two other feeding systems in this range of feed consumption were in India: one used roughage and compound feed and the other used roughage and by-products.

Animal feeding systems with an annual feed consumption of between 6 000 and 7 000 kg dry matter were reported predominantly from Switzerland, the United Kingdom, Germany and Australia. The relative proportion of roughage use was rather variable, ranging from 3 000 to 6 000 kg dry material per animal per year. However, roughage, in this case, was mainly combined with cereal grains, by-products and processed feeds. Only one system in South Africa was distinct: the animals consumed a high proportion of cereals and oilseeds.

The animal feeding systems in France, Denmark and Japan had an intake of between 7 000 and 8 000 kg dry matter per animal each year. The systems in this category of intake presented the greatest diversity, particularly the two Japanese feeding systems that used little roughage but high levels of processed feed and by-products. The European animal feeding systems in this category had a significant proportion of roughage and of supplementation, mainly using compound feeds. One system in South Africa was characterized by approximately half of the consumption consisting of cereals and oilseeds.

High levels of annual feed consumption were also reported from Korea and Israel. These production systems were intensive, combining high levels of intake with diets containing high proportions of by-products and cereals and less roughage.

Table 3.3. CODIFICATION OF THE DIFFERENT DAIRY FEEDING SYSTEMS IDENTIFIED

COUNTRY	FEEDING SYSTEM	CODE
Australia	Low bail	AUS-LB
	Moderate–high bail	AUS-MHB
	Partial mixed ration	AUS-PMR
	Hybrid	AUS-HYB
	Total mixed ration	AUS-TMR
Austria	Year-round silage	AU-YRS
	Green fodder plus silage	AU-GFS
	Haymilk	AU-HM
Canada	Predominant	CA-PRE
Denmark	Organic	DK-ORG
	Conventional	DK-CON
France	Mountain & Piedmont grassland	FR-MPG
	Lowland grassland	FR-LG
	Mountain & Piedmont with maize	FR-MPM
	Lowland with 10–30% maize	FR-L1030M
	Lowland with > 30% maize	FR-L30M
Germany	Grass silage and cereals	DE-GSC
	Crop silage and cereals	DE-CSC
India	Green fodder + cattle feed + concentrates	IN-GF+CF+C
	Dry fodder + green fodder + cattle feed + concentrates	IN-DF+GF+CF+C
	Dry fodder + cattle feed + concentrates	IN-DF+CF+C
	Silage + cattle fodder + concentrates	IN-S+CF+C
	Silage + dry fodder + concentrates	IN-S+DF+C
Israel	Total mixed ration	IL-TMR
Japan	Mainly grazing farms	JP-GR
	Medium- to large-scale integrated farms	JP-ML
	Small-scale family farms	JP-SC
Korea	< 40 cows	KO-<40
	40–59 cows	KO-40/59
	60–79 cows	KO-60/79
	> 80 cows	KO->80
New Zealand	No supplement feed purchased	NZ-NFP
	Feed purchased for dry cows	NZ-FPD
	Feed purchased for dry cows and lactation	NZ-FPDL
	Feed purchased for dry cows and end of lactation	NZ-FPDE
	Feed purchased for year-round feeding	NZ-FPYR
Norway	Grass-silage-based system	NO-GS
South Africa	Pasture	ZA-PAS
	Mixed	ZA-MIX
	Total mixed ration	ZA-TMR
Switzerland	Pasture – mountain	CH-PM
	Pasture – lowland and hill country	CH-PLH
	Grass and hay	CH-GH
	All silage	CH-AS
United Kingdom	Grazed	UK-GRZ
	Mixed	UK-MIX
	Housed	UK-HOU

Figure 3.6. **DISTRIBUTION OF FEED INTAKE**

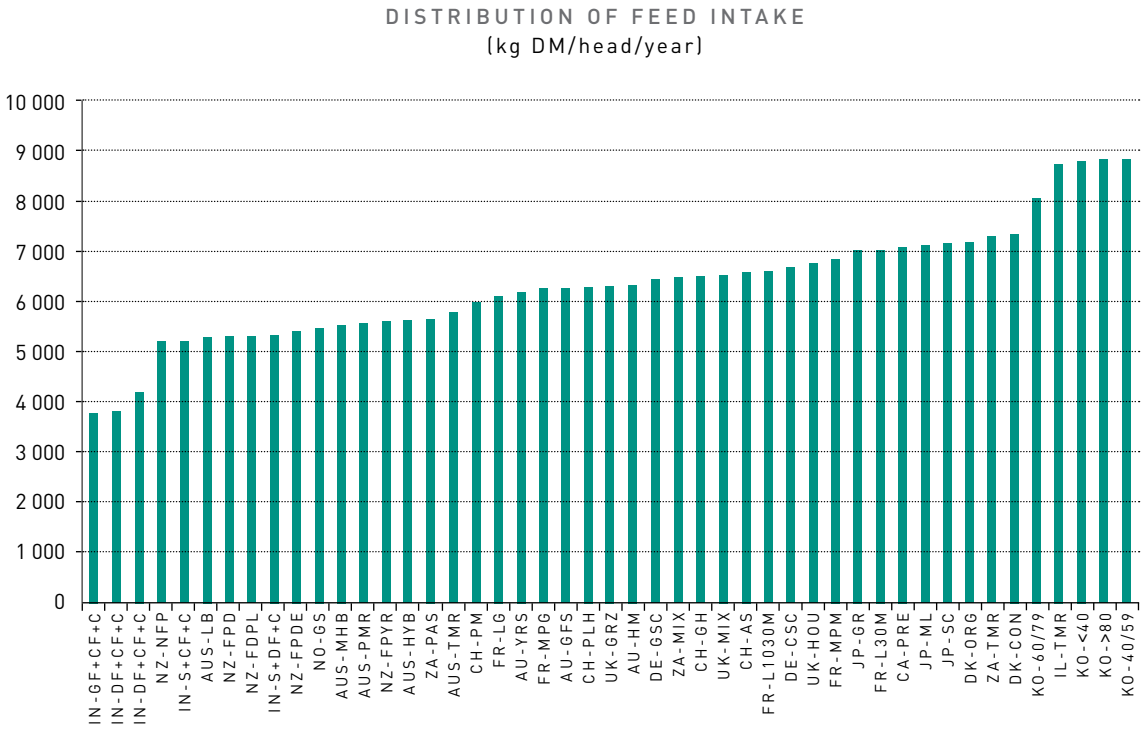


Figure 3.7. **DISTRIBUTION OF MAIN FEED CONSTITUENTS IN TOTAL FEED INTAKE**

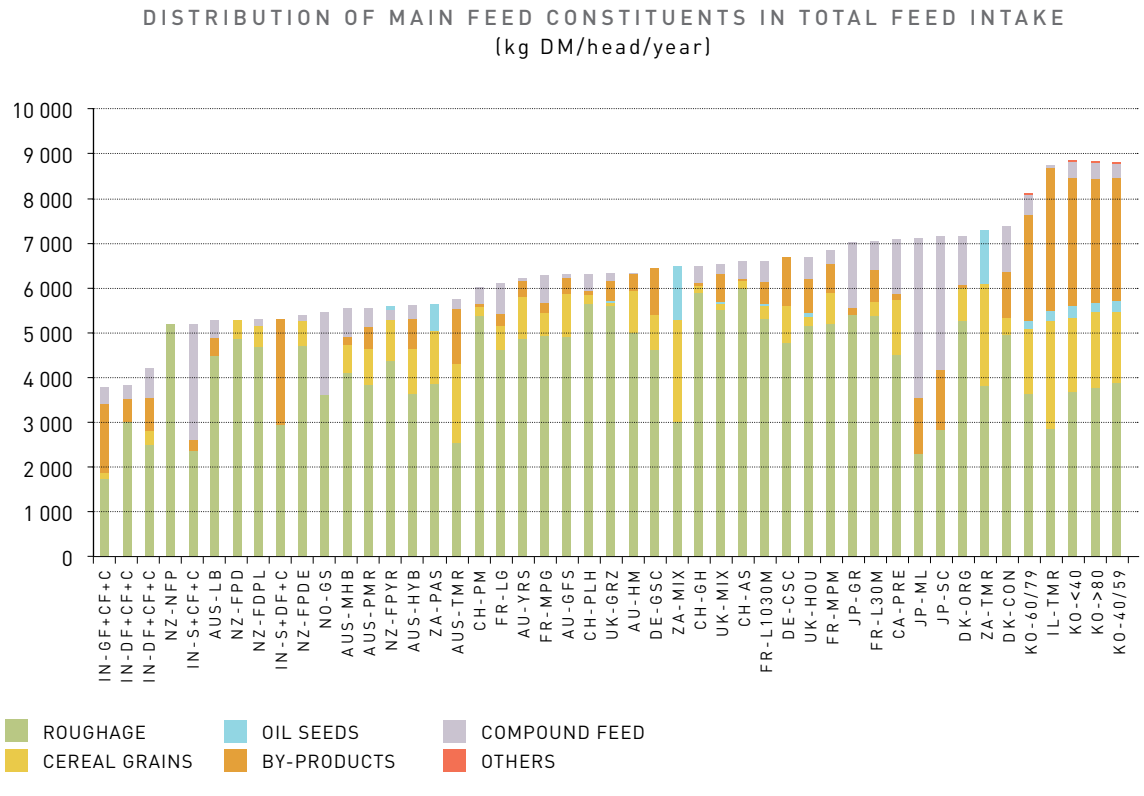
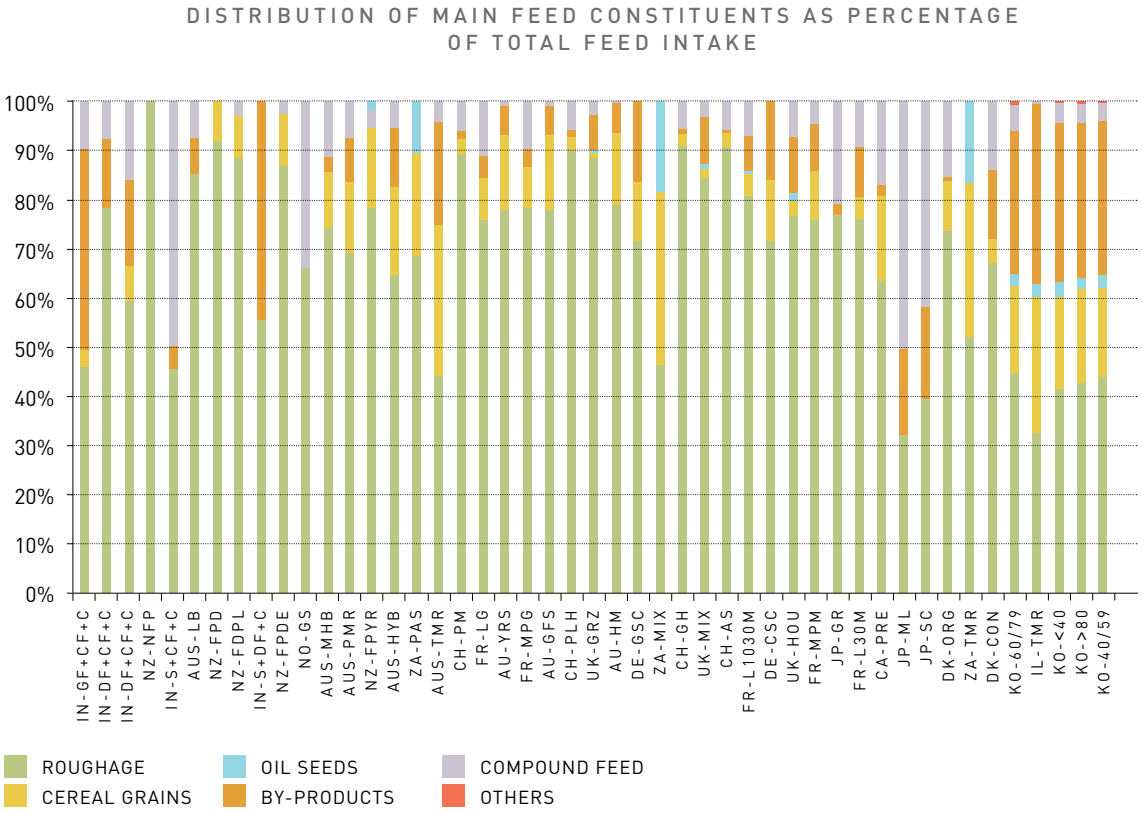


Figure 3.8. DISTRIBUTION OF MAIN FEED CONSTITUENTS AS PERCENTAGE OF TOTAL FEED INTAKE



3.4.2. ROUGHAGE CONSUMPTION

Analysis of the total and relative proportion of roughage consumption also provides an insight into the commonalities and differences in the animal feeding systems (Figures 3.7 and 3.8). Very low consumption of roughage in absolute amount was associated with low total feed consumption, as in Indian systems; however, as a proportion of the diet, intake of roughage was high. Some other feeding systems, such as those in Japan, combined a small proportion of roughage and a high proportion of processed feeds. In this category, roughage very often represented less than 50 percent of the dry matter consumed annually by the animals.

A second category of animal feeding systems had between 40 and 70 percent of total feed intake as roughage, resulting in two distinct diet profiles. Low amounts of concentrates were supplied as a supplement to roughage, and this led to a relatively low total feed intake, as reported for some feeding systems in Australia, Norway and South Africa. This distinct diet profile was characterized by high quantities of concentrates distributed to animals fed a narrow range of roughage (40–50 percent of total feed intake for some animal feeding systems in Korea, Israel and South Africa), despite a high volume of roughage consumption (3 000–4 000 kg of dry matter per year).

The last grouping for roughage intake involved feeding systems in which animals were fed more than 70 percent of total feed intake as roughage (5 000–7 000 kg of dry matter annually). Concentrates were mainly processed feeds and cereals. These systems were dominant in Europe, both in the plains and in the mountains.

3.4.3. BY-PRODUCT CONSUMPTION

Many differences were observed regarding the use of by-product feeds. In fact, they represented 0–45 percent of the total feed intake. Feeding by-products was most prominent in intensive systems that consumed more than 8 000 kg of dry matter per animal per year (Israel and South Korea). By-product use was also significant in one system in India, where supplementation was performed exclusively with by-products.

A wide range of by-products were reported in the study, but their use was variable among countries and systems. The main by-products used were those from grains (wheat, barley and rice), from production of biofuels (soymeal or rapeseed meal, maize and wheat dried distiller grain with solubles), or from sugar production (beet molasses and pulp). In Korean systems, by-products of citrus fruits, palm and copra (coconut) were used. For the Indian system based on roughage and by-products, supplementation was provided exclusively in the form of cottonseed oil cakes. Most of the by-products used were found in a large number of feeding systems worldwide, reflecting the globalization of trade in raw materials and by-products.

It is reasonable to speculated that the raw materials and by-products already utilized in animal feeding systems within a country would also be used in the preparation of processed feeds (i.e. compound feed); however, the Expert Survey Tool was not designed to distinguish ingredients in the processed feeds. Much of this information is proprietary and access to such information on a national scale is difficult.

Table 3.4. DESCRIPTION OF TOTAL FEED INTAKE DIVIDED INTO MAIN FEED CONSTITUENTS (kg DM/head/year) AND PERCENTAGE OF TOTAL FEED INTAKE

COUNTRY	JAPAN		
Feeding system	Mainly grazing farms	Small-scale family farms	Medium to large-scale integrated farms
Code	JP-GR	JP-SC	JP-ML
Roughage	5 400	2 600	2 280
Cereal grains	0	0	0
Oilseeds	0	0	0
By-products	150	1 580	1 260
Compound feeds	1 500	3 000	3 600
Others	0	0	0
TOTAL FEED INTAKE (kg DM/cow/year)	7 050	7 180	7 140
Roughage	77	36	32
Cereal grains	0	0	0
Oilseeds	0	0	0
By-products	2	22	18
Compound feeds	21	42	50
Others	0	0	0
TOTAL (% of total feed intake)	100	100	100

COUNTRY	KOREA			
Feeding system	< 40 cows	40–59 cows	60–79 cows	> 80 cows
Code	KO-<40	KO-40/59	KO-60/79	KO->80
Roughage	3 735	3 872	3 630	3 791
Cereal grains	1 640	1 589	1 439	1 686
Oilseeds	253	250	188	181
By-products	2 866	2 771	2 440	2 799
Compound feeds	332	310	365	365
Others	11	48	14	15
TOTAL FEED INTAKE (kg DM/cow/year)	8 837	8 840	8 076	8 837
Roughage	42	44	45	43
Cereal grains	19	18	18	19
Oilseeds	3	3	2	2
By-products	32	31	30	32
Compound feeds	4	4	5	4
Others	0	1	0	0
TOTAL (% of total feed intake)	100	100	100	100

COUNTRY	NORWAY
Feeding system	**Grass-silage based system**
Code	NO-GS
Roughage	3 610
Cereal grains	0
Oilseeds	0
By-products	0
Compound feeds	1 865
Others	0
TOTAL FEED INTAKE (kg DM/cow/year)	**5 475**
Roughage	66
Cereal grains	0
Oilseeds	0
By-products	0
Compound feeds	34
Others	0
TOTAL (% of total feed intake)	**100**

COUNTRY	NEW ZEALAND				
Feeding system	**No supplement feed purchased**	**Feed purchased for dry cows**	**Feed purchased for dry cows and lactation**	**Feed purchased for dry cows and end of lactation**	**Feed purchased for year-round feeding**
Code	NZ-NFP	NZ-FPD	NZ-FPDL	NZ-FPDE	NZ-FPYR
Roughage	5 200	4 950	4 700	4 700	4 400
Cereal grains	0	350	450	600	900
Oilseeds	0	0	0	0	0
By-products	0	0	0	0	0
Compound feeds	0	0	150	100	200
Others	0	0	0	0	100
TOTAL FEED INTAKE (kg DM/cow/year)	5 200	5 300	5 300	5 400	5 600
Roughage	100	93	89	87	79
Cereal grains	0	7	8	11	16
Oilseeds	0	0	0	0	0
By-products	0	0	0	0	0
Compound feeds	0	0	3	2	4
Others	0	0	0	0	2
TOTAL (% of total feed intake)	100	100	100	100	100

COUNTRY	SOUTH AFRICA		
Feeding system	Pasture	TMR	Mixed
Code	ZA-PAS	ZA-TMR	ZA-MIX
Roughage	3 900	3 800	3 000
Cereal grains	1 095	2 308	2 300
Oilseeds	650	1 200	1 200
By-products	0	0	0
Compound feeds	0	0	0
Others	0	0	0
TOTAL FEED INTAKE (kg DM/cow/year)	**5 645**	**7 308**	**6 500**
Roughage	69	52	46
Cereal grains	19	32	35
Oilseeds	12	16	18
By-products	0	0	0
Compound feeds	0	0	0
Others	0	0	0
TOTAL (% of total feed intake)	**100**	**100**	**100**

COUNTRY	AUSTRIA		
Feeding system	Haymilk	Green fodder plus silage	Year-round silage
Code	AU-HM	AU-GFS	AU-YRS
Roughage	5 000	4 940	4 865
Cereal grains	930	930	930
Oilseeds	0	0	0
By-products	370	370	370
Compound feeds	40	40	40
Others	0	0	0
TOTAL FEED INTAKE (kg DM/cow/year)	**6 340**	**6 280**	**6 205**
Roughage	79	79	78
Cereal grains	15	15	15
Oilseeds	0	0	0
By-products	6	6	6
Compound feeds	1	1	1
Others	0	0	0
TOTAL (% of total feed intake)	**100**	**100**	**100**

COUNTRY	AUSTRALIA				
Feeding system	**Low bail**	**Mod–high bail**	**PMR**	**Hybrid**	**TMR**
Code	AUS-LB	AUS-MHB	AUS-PMR	AUS-HYB	AUS-TMR
Roughage	4 500	4 150	3 900	3 650	2 575
Cereal grains	400	600	700	975	1750
Oilseeds	0	0	0	0	0
By-products	0	150	525	700	1 200
Compound feeds	375	625	425	300	250
Others	0	0	0	0	0
TOTAL FEED INTAKE (kg DM/cow/year)	**5 275**	**5 525**	**5 550**	**5 625**	**5 775**
Roughage	85	75	70	65	45
Cereal grains	8	11	13	17	30
Oilseeds	0	0	0	0	0
By-products	0	3	9	12	21
Compound feeds	7	11	8	5	4
Others	0	0	0	0	0
TOTAL (% of total feed intake)	**100**	**100**	**100**	**100**	**100**

COUNTRY	CANADA	SWITZERLAND			
Feeding system	**Predominant**	**All silage**	**Grass and hay**	**Pasture: lowland and hill country**	**Pasture: mountain**
Code	CA-PRE	CH-AS	CH-GH	CH-PLH	CH-PM
Roughage	4 528	6 000	5 900	5 700	5 400
Cereal grains	1 203	150	150	150	150
Oilseeds	0	0	0	0	0
By-products	161	50	50	50	50
Compound feeds	1 201	400	400	400	400
Others	0	0	0	0	0
TOTAL FEED INTAKE (kg DM/cow/year)	**7 093**	**6 600**	**6 500**	**6 300**	**6 000**
Roughage	64	91	91	90	90
Cereal grains	17	2	2	2	3
Oilseeds	0	0	0	0	0
By-products	2	1	1	1	1
Compound feeds	17	6	6	6	7
Others	0	0	0	0	0
TOTAL (% of total feed intake)	**100**	**100**	**100**	**100**	**100**

COUNTRY	GERMANY		DENMARK	
Feeding system	Crop silage and cereals	Grass silage and cereals	Conventional	Organic
Code	DE-CSC	DE-GSC	DK-CON	DK-ORG
Roughage	4 813	4 641	5 021	5 296
Cereal grains	0	0	263	758
Oilseeds	0	0	0	0
By-products	780	753	1 094	18
Compound feeds	1 093	1 054	1 008	1 114
Others	0	0	0	0
TOTAL FEED INTAKE (kg DM/cow/year)	**6 686**	**6 448**	**7 386**	**7 186**
Roughage	72	72	68	74
Cereal grains	0	0	4	11
Oilseeds	0	0	0	0
By-products	12	12	15	0
Compound feeds	16	16	14	16
Others	0	0	0	0
TOTAL (% of total feed intake)	**100**	**100**	**100**	**100**

COUNTRY	FRANCE				
Feeding system	Mountain & Piedmont grassland	Lowland grassland	Lowland 10–30% maize	Lowland > 30% maize	Mountain & Piedmont with maize
Code	FR-MPG	FR-LG	FR-L1030M	FR-L30M	FR-MPM
Roughage	4 908	4 636	5 338	5 417	5 267
Cereal grains	494	506	278	262	600
Oilseeds	6	2	30	9	10
By-products	208	258	504	706	584
Compound feeds	659	716	463	666	380
Others	0	0	0	0	0
TOTAL FEED INTAKE (kg DM/cow/year)	**6 275**	**6 118**	**6 613**	**7 060**	**6 841**
Roughage	78	76	81	77	77
Cereal grains	8	8	4	4	9
Oilseeds	0	0	0	0	0
By-products	3	4	8	10	9
Compound feeds	11	12	7	9	6
Others	0	0	0	0	0
TOTAL (% of total feed intake)	**100**	**100**	**100**	**100**	**100**

COUNTRY	UNITED KINGDOM			ISRAEL
Feeding system	Grazed	Mixed	Housed	TMR
Code	UK-GRZ	UK-MIX	UK-HOU	IL-TMR
Roughage	5 619	5 525	5 145	2 891
Cereal grains	62	108	197	2 365
Oilseeds	24	60	107	219
By-products	470	653	766	3 241
Compound feeds	159	208	515	44
Others	0	0	0	0
TOTAL FEED INTAKE (kg DM/cow/year)	**6 334**	**6 554**	**6 730**	**8 760**
Roughage	89	84	76	33
Cereal grains	1	2	3	27
Oilseeds	0	1	2	3
By-products	7	10	11	37
Compound feeds	3	3	8	1
Others	0	0	0	0
TOTAL (% of total feed intake)	**100**	**100**	**100**	**100**

COUNTRY	INDIA				
Feeding system	Dry fodder + cattle feed + concentrates	Dry fodder + green fodder + cattle feed + concentrates	Green fodder + cattle feed + concentrates	Silage + dry fodder + concentrates	Silage + cattle fodder + concentrates
Code	IN-DF+CF+C	IN-DF+GF+CF+C	IN-GF+CF+C	IN-S+DF+C	IN-S+CF+C
Roughage	2 440	2 986	1 738	2 952	2 380
Cereal grains	329	0	110	0	0
Oilseeds	0	0	0	0	0
By-products	730	546	1 575	2 373	215
Compound feeds	704	275	350	0	2 628
Others	0	0	0	0	0
TOTAL FEED INTAKE (kg DM/cow/year)	**4 203**	**3 807**	**3 773**	**5 325**	**5 223**
Roughage	58	78	46	55	46
Cereal grains	8	0	3	0	0
Oilseeds	0	0	0	0	0
By-products	17	14	42	45	4
Compound feeds	17	7	9	0	50
Others	0	0	0	0	0
TOTAL (% of total feed intake)	**100**	**100**	**100**	**100**	**100**

4

COMPOSITION OF FEEDING BASKETS WORLDWIDE AN APPROACH USED BY THE FOOD AND AGRICULTURE ORGANIZATION

Food and Agriculture Organization of the United Nations

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4.1. INTRODUCTION

Feed is the foundation of livestock production systems. The nature or type of feed and its nutritive value, in particular the digestibility, determine the extent of animal production, productivity and release of environmental pollutants from livestock production systems. Availability of information on feeding baskets (main ingredients and their levels in diets) of different animal species in livestock production systems is a prerequisite for estimating the environmental impact of the livestock sector; for developing diets and feeding strategies to reduce the carbon footprint; for enhancing animal productivity, health and welfare; and for increasing the quality and safety of animal products. The information generated also helps in establishing the extent of food–feed competition and in developing strategies to reduce this competition. FAO has undertaken a global project *Greenhouse gas emissions from animal food*

chains, aiming at refining and disaggregating the quantification of greenhouse gas emissions that has been reported in *Livestock's long shadow* (FAO, 2006). The information generated through the present study is also intended to be used in making estimates of greenhouse gas emissions for milk, meat, eggs, manure and traction in different livestock production systems.

4.2. METHODOLOGY USED

A survey was conducted during July and August 2010 to map world feed baskets.

A questionnaire was developed (see Annex 1), which sought information on the main components of diets of ruminant animals, aggregating at the national level. It asked for the shares of roughage, concentrates, by-products, cereals and compound feed in the rations of the following animal species at different production and physiological stages:

- Cattle (local, lactating dairy cows; local, non-lactating dairy cows; improved, lactating dairy cows; improved, non-lactating dairy cows; suckler cows; replacement animals; draught animals; fattening animals)
- Buffaloes (local, lactating dairy buffaloes; local, non-lactating dairy buffaloes; improved, lactating dairy buffaloes; improved, non-lactating dairy buffaloes; suckler buffaloes; replacement animals; draught animals; fattening animals)
- Sheep (lactating dairy sheep; non-lactating dairy sheep; reproductive adult sheep; replacement animals; fattening animals)
- Goats (lactating dairy goats; non-lactating dairy goats; reproductive adult goats; replacement animals; fattening animals)

For the purpose of this survey, **local animals** were defined as native animals and **improved animals** as those improved through selection or cross-breeding.

The questionnaire was sent to 812 animal nutrition experts. In total, 75 replies from 43 countries were received (see Annex 2 for distribution of the respondents).

The information obtained was analysed and only data related to dairy animals are presented here.

Definitions

Feeding basket: The main components of the animal diet and their proportion in that diet.

By-products: Agro-industrial by-products, for example dry grain by-products (e.g. brans), wet grain by-products (e.g. brewer's grains), pulps (e.g. beet, citrus), cakes/meal (e.g. cottonseed cake, groundnut cake, soymeal, rapeseed meal).

Compound feed: Ready-mixed concentrate feed produced by the feed industry.

Concentrate: Feed produced on-farm from ingredients such as grains, by-products, minerals and vitamins.

Note: Compound feed and concentrates do not contain any roughage component of the diet.

Replacement animals: Female and male young animals kept for replacing the reproductive dairy and meat herds.

Fattening animals: Female and male animals from the dairy herd (surplus animals) and animals kept solely for meat purpose. These are usually younger animals that are slaughtered before reaching adult weight. In some places, intensive fattening is carried out and in others not.

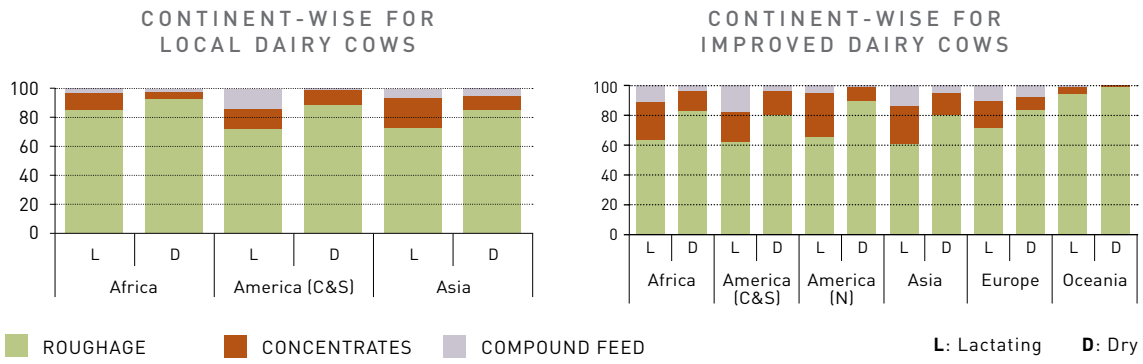
4.3. RESULTS

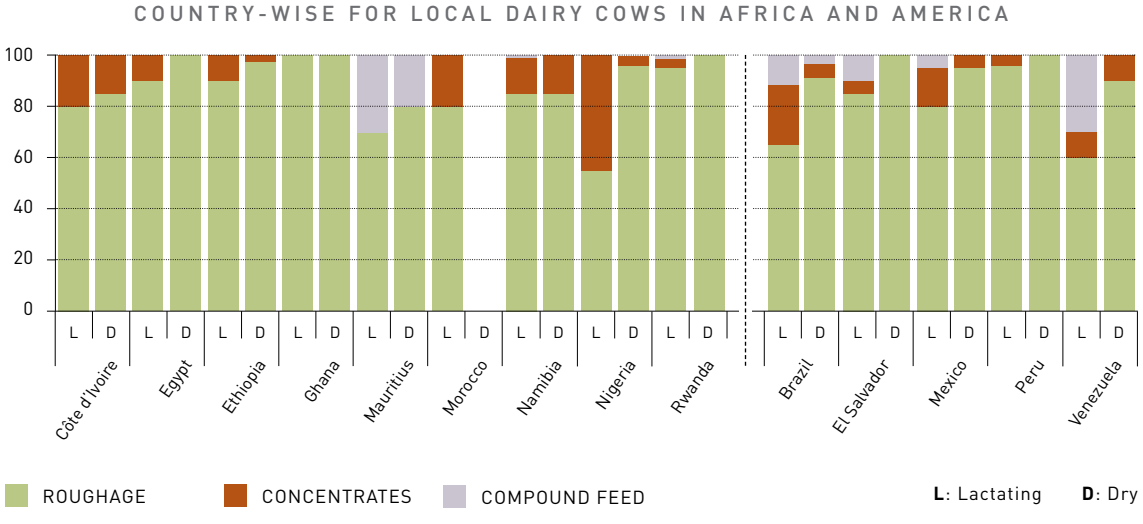
The feeding baskets are presented according to animal species in the order: cattle, buffaloes, sheep and goats. For each animal species, the data are presented in graphical form, first continent-wise and then country-wise. Because roughage and concentrates were the two main components of the feeding basket, information on constituents and their percentage in each of these components is also provided in graphical form. This is followed by salient points for each animal species.

4.3.1. MAPPING OF CATTLE FEEDING BASKETS

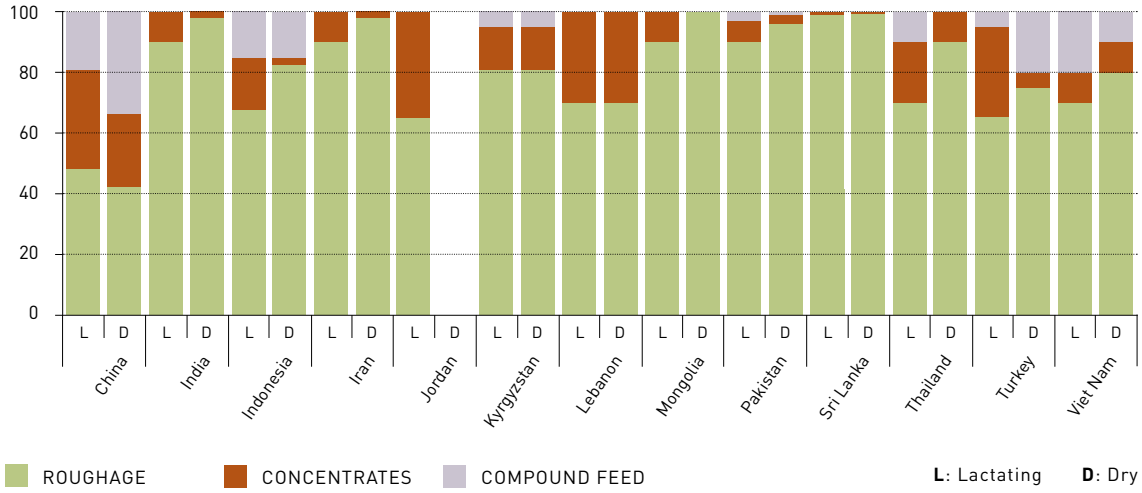
Dairy cattle

Feed basket composition (% DM)



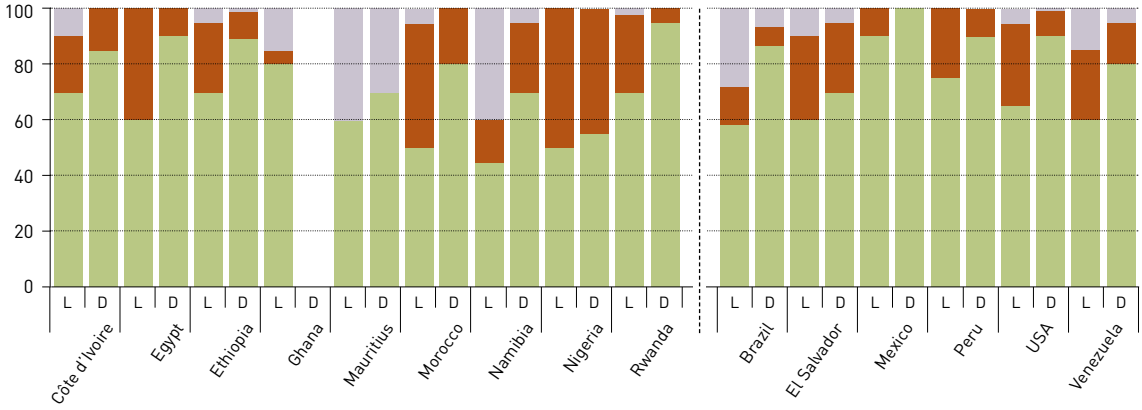


COUNTRY-WISE FOR LOCAL DAIRY COWS IN ASIA



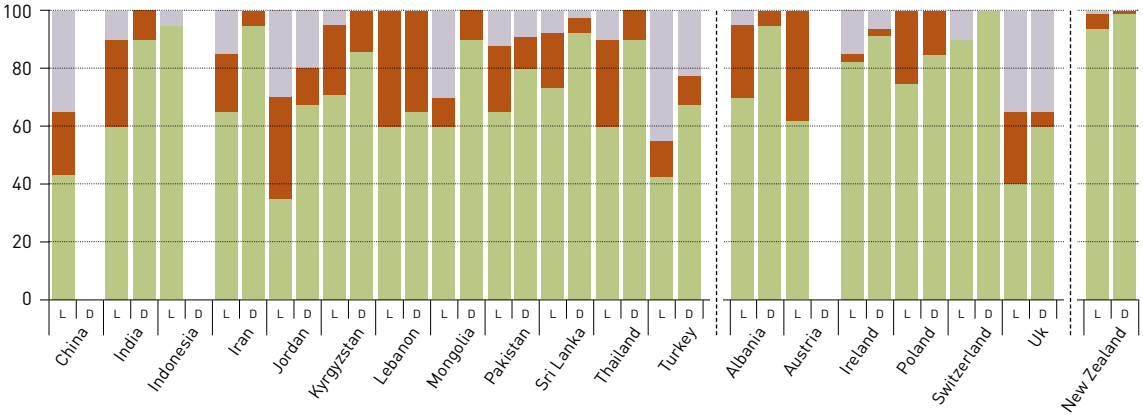
ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

COUNTRY-WISE FOR IMPROVED DAIRY COWS IN AFRICA AND AMERICA



ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

COUNTRY-WISE FOR IMPROVED DAIRY COWS IN ASIA, EUROPE AND NEW ZEALAND

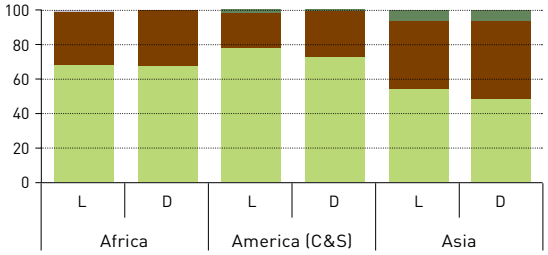


ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

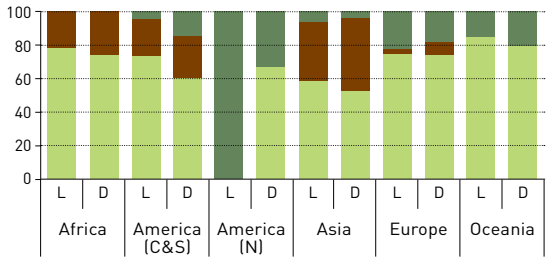
Dairy cattle

Composition of roughage (% DM)

CONTINENT-WISE FOR LOCAL DAIRY COWS

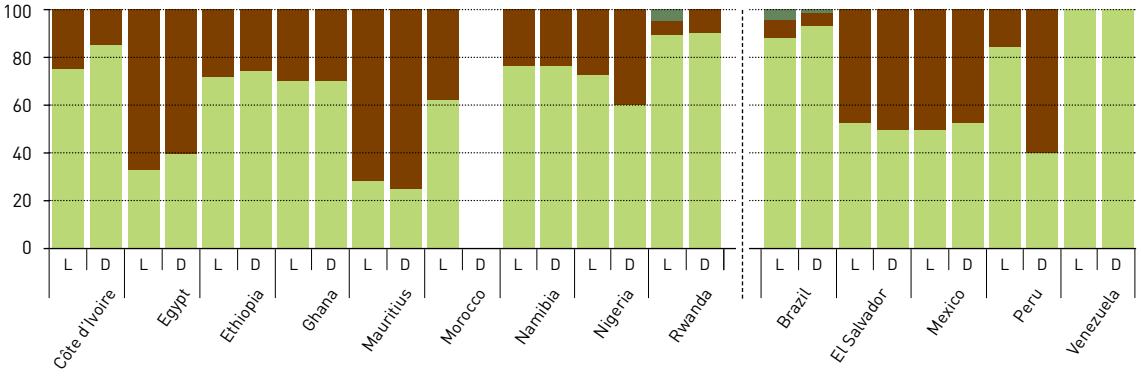


CONTINENT-WISE FOR IMPROVED DAIRY COWS



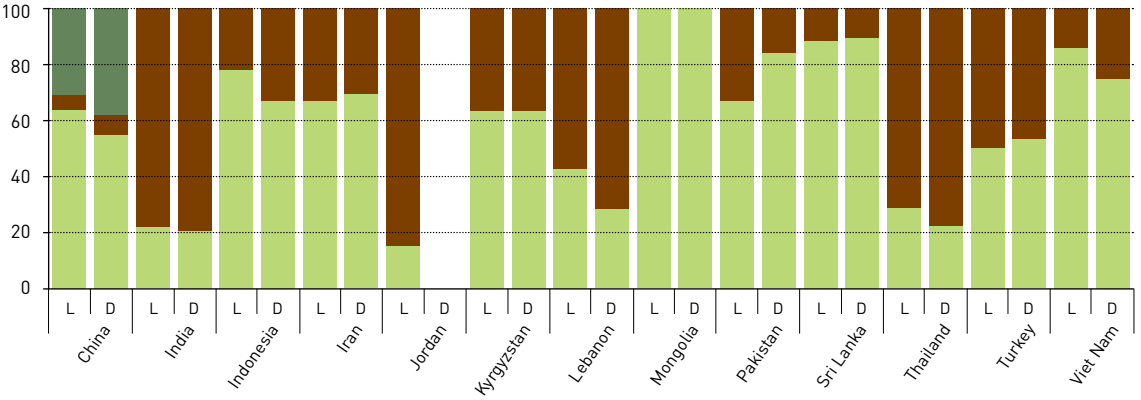
GRASS CROP RESIDUES OTHER ROUGHAGE **L**: Lactating **D**: Dry

COUNTRY-WISE FOR LOCAL DAIRY COWS IN AFRICA, CENTRAL AMERICA AND SOUTH AMERICA



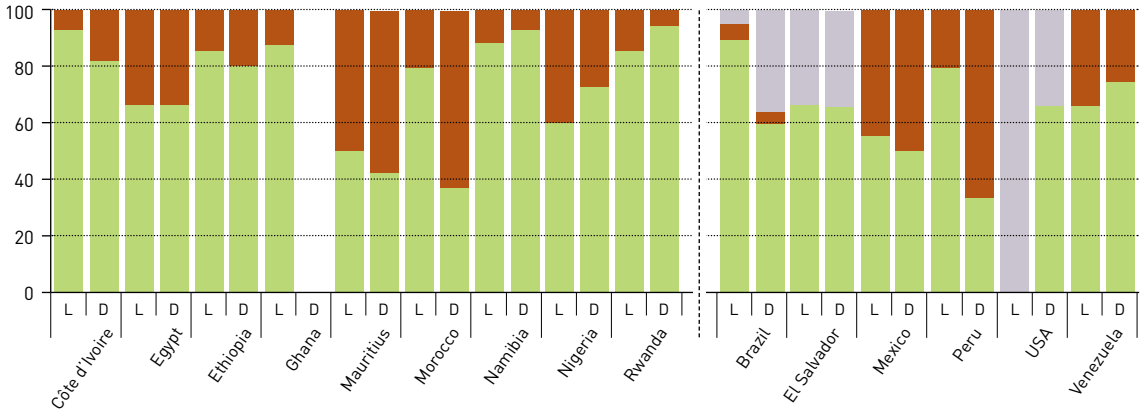
GRASS CROP RESIDUES OTHER ROUGHAGE **L**: Lactating **D**: Dry

COUNTRY-WISE FOR LOCAL DAIRY COWS IN ASIA



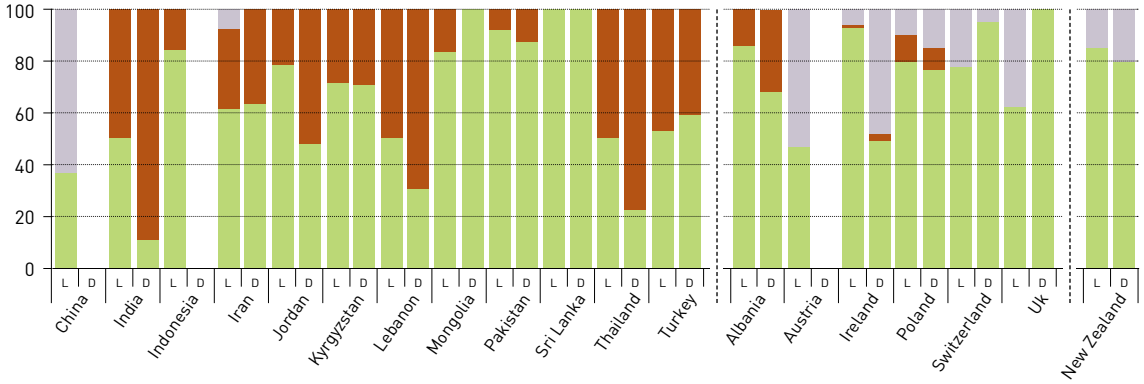
GRASS CROP RESIDUES OTHER ROUGHAGE **L**: Lactating **D**: Dry

COUNTRY-WISE FOR IMPROVED DAIRY COWS IN AFRICA AND AMERICA



ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

COUNTRY-WISE FOR IMPROVED DAIRY COWS IN ASIA, EUROPE AND NEW ZEALAND

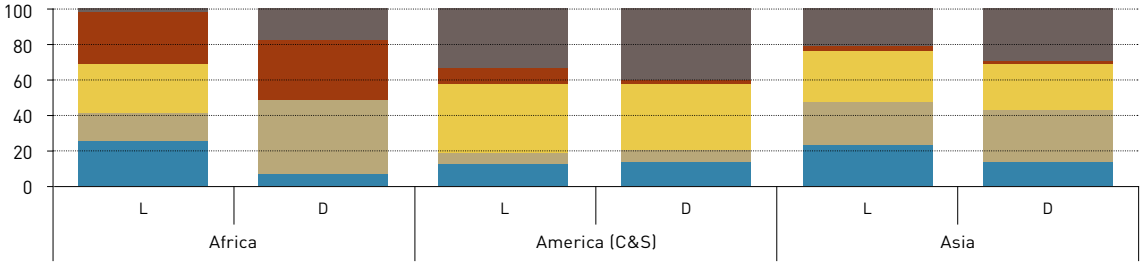


ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

Dairy cattle

Composition of concentrates (% DM)

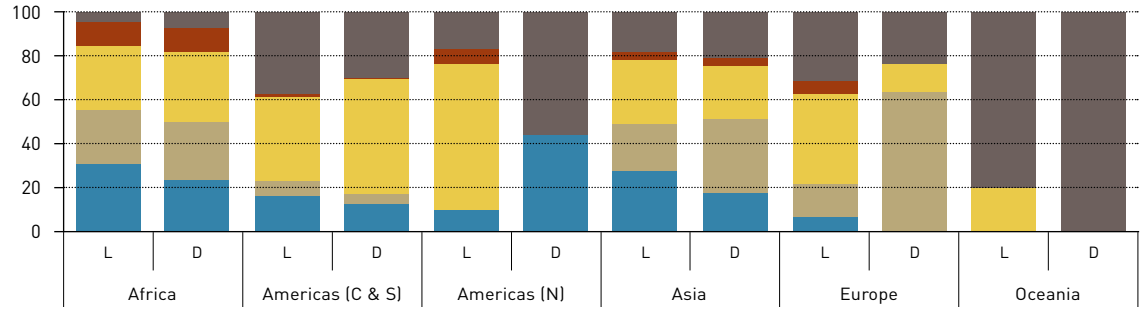
CONTINENT-WISE FOR LOCAL DAIRY COWS



CAKES & MEALS BRANS CEREALS OTHER CONCENTRATES MISCELLANOUS

L: Lactating **D**: Dry

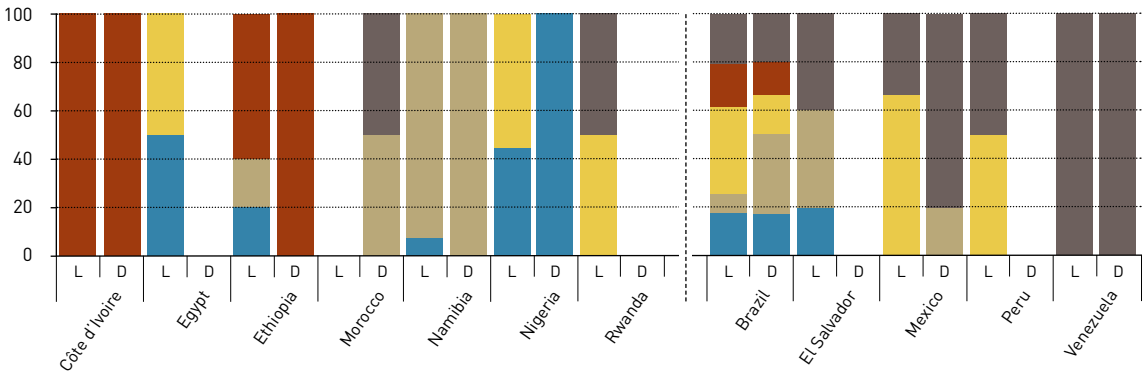
CONTINENT-WISE FOR IMPROVED DAIRY COWS



CAKES & MEALS BRANS CEREALS OTHER CONCENTRATES MISCELLANOUS

L: Lactating **D**: Dry

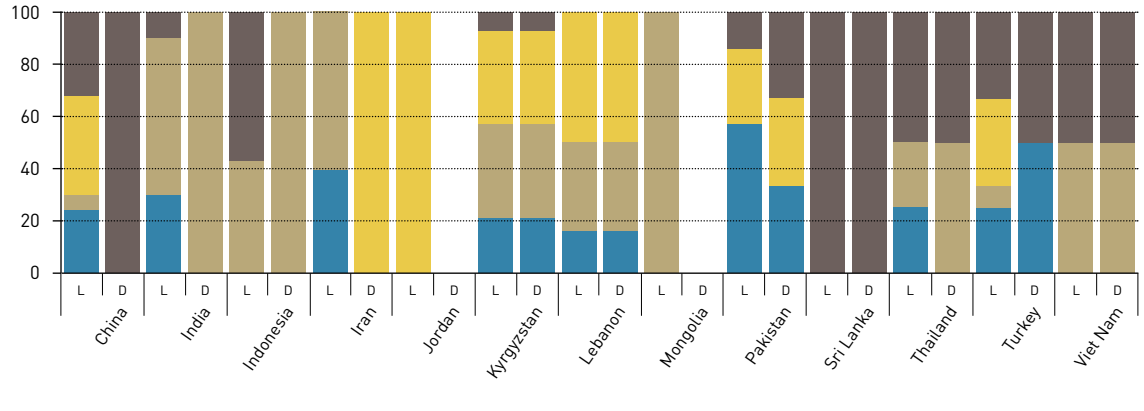
COUNTRY-WISE FOR LOCAL DAIRY COWS IN AFRICA, CENTRAL AMERICA AND SOUTH AMERICA



CAKES & MEALS BRANS CEREALS OTHER CONCENTRATES MISCELLANOUS

L: Lactating **D**: Dry

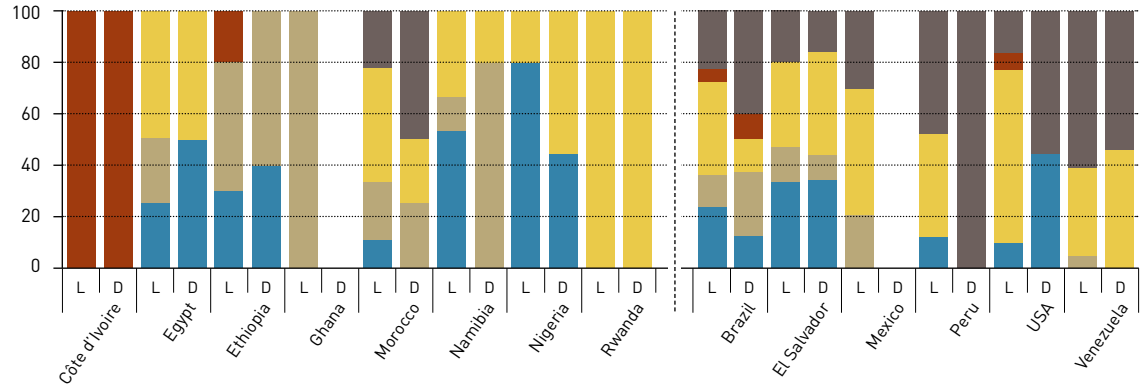
COUNTRY-WISE FOR LOCAL DAIRY COWS IN ASIA



CAKES & MEALS BRANS CEREALS OTHER CONCENTRATES MISCELLANOUS

L: Lactating **D**: Dry

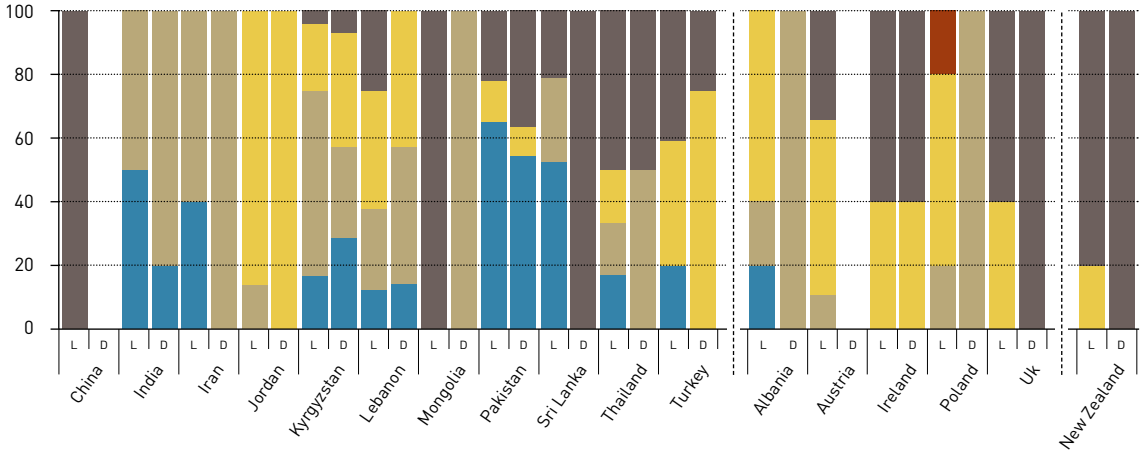
COUNTRY-WISE FOR IMPROVED DAIRY COWS IN AFRICA AND AMERICA



CAKES & MEALS BRANS CEREALS OTHER CONCENTRATES MISCELLANOUS

L: Lactating **D**: Dry

COUNTRY-WISE FOR IMPROVED DAIRY COWS IN ASIA, EUROPE AND NEW ZEALAND



CAKES & MEALS BRANS CEREALS OTHER CONCENTRATES MISCELLANOUS

L: Lactating **D**: Dry

Salient points

Continent-wise

Feeding basket composition: Local dairy cows received a substantial amount (72–93 percent) of roughage. The concentrate use in the diet of lactating animals was almost twice that for dry animals. The contribution of compound feed was very low in all continents except in the Americas where the diets of lactating animals included 13 percent (almost equivalent to the use of concentrates); for Africa the contribution of compound feed was about 2 percent and about 5 percent for Asia.

Improved lactating cows received higher amounts of concentrates and compound feeds than the local cows. Also, the use of concentrates and compound feed, in general, was higher for improved animals than for local animals. For improved cows, dry animals received more roughage than lactating ones. Concentrate use in the diets of lactating cows ranged from 5 percent (New Zealand) to 30 percent (North America). Compound feed was not fed to dry animals in New Zealand and only at 1 percent to dry animals in North America; for lactating animals in other continents, the use of compound feed varied from 10 to 20 percent. In all parts of the world (except New Zealand), on average, the contribution of compound feed in the diets was about half that of the concentrates.

Composition of roughage: Local dairy cows received mostly grass-based roughage (about two-thirds grasses in the roughage) in Africa and Central and South America. In Asia the roughage was composed of crop residues and grasses in almost 1 : 1 ratio.

Roughage composition of the diets for improved dairy cows in Africa, Central and South America, Europe and Oceania (New Zealand) was predominantly grass-based. The proportion of crop residues in the roughage was highest in Asia (35 and 43 percent for lactating and dry cows, respectively).

Composition of concentrates: For local dairy cows, the cereal levels in the concentrates were 28 percent in Africa and Asia and 39 percent in Central and South America for lactating cows. Another important component was cakes/meals, which contributed about 25 percent in both Africa and Asia for lactating animals. A substantial portion of bran was used in the concentrates for lactating and dry animals in Asia (about 25 percent) and for dry animals in Africa (42 percent).

Cereal levels in the concentrates fed to lactating improved dairy cows were 30, 39 and 30 percent in Africa, Central and South America and Asia, respectively. Other major diet components in Africa were bran (25 percent for lactating cows and 26 percent for dry cows) and cakes/meals (30 percent for lactating cows and 24 percent for dry cows). In Asia, the levels of different constituents (lactating and dry animals, respectively) in concentrates were: cakes/meals (27 and 18 percent), bran (21 and 33 percent), cereals (30 and 24 percent) and miscellaneous feedstuffs (18 and 21 percent).

For both local and improved cows in Central and South America, miscellaneous feedstuffs formed a substantial part of the concentrates (25–40 percent).

Country-wise

Feeding basket composition: For local dairy cows, feed baskets were exclusively roughage-based in Egypt (for dry animals), Ghana (for both categories of animals) and Rwanda (for dry animals). Concentrates were fed to some extent in most countries in Africa, use for lactating animals being higher than for dry animals. The highest share of concentrates in the diet was in Nigeria for lactating cows (45 percent). Compound feed was fed in considerable amounts in Mauritius (30 and 20 percent for lactating and dry animals, respectively; availability of compound feed at a subsidized price was reported). In Central and South America, concentrates were part of the feed basket of lactating animals and contents ranged from 4 percent in Peru to 23 percent in Brazil. The proportion of compound feed was highest in Venezuela (30 percent). No compound feed was used in Peru. In other countries, use was higher for lactating animals than for dry animals. In Asia, the feed basket of lactating cows contained concentrates but the levels varied from low (e.g. Sri Lanka 1 percent, Pakistan 7 percent) to substantial (China 33 percent, Jordan 35 percent and Lebanon 30 percent). Compound feed was used in the diet of lactating animals in some countries (China 19 percent, Indonesia 15 percent and Viet Nam 20 percent).

For improved dairy cows, the use of concentrates in the diet of lactating cows in Africa was: Ghana (5 percent), Côte d'Ivoire (20 percent), Rwanda (28 percent), Egypt (40 percent) and Nigeria (50 percent). The use of compound feed in African countries was highest for Mauritius followed by Namibia. Compound feed was not a part of the diets in Egypt and Nigeria. In the Americas, the use of concentrates in the diets of lactating cows was: Mexico (10 percent), Brazil (13 percent), Peru (25 percent), Venezuela (25 percent), El Salvador (30 percent) and the United States (30 percent). Compound feed was not a part of the diets in Mexico and Peru, although its use was highest in the diets of lactating animals in Brazil (28 percent). In Asia, concentrates were fed to some extent to lactating cows in all countries (except Indonesia), from 10 percent in Mongolia to 40 percent in Lebanon. The use of compound feed in the diet of lactating animals was highest in Turkey (45 percent) followed by China (35 percent) and Jordan and Mongolia (30 percent for both countries). In Europe, the use of concentrates in the diets of lactating cows was 25 percent in Albania, Poland and the United Kingdom, and 38 percent in Austria. The use of compound feed was highest in the United Kingdom (35 percent). No compound feed was fed in Poland. In New Zealand the use of compound feed and concentrates was very low.

For all countries and for both the categories of animals, as expected, the use of roughage was higher and that of concentrates lower in dry animals than in lactating animals.

Composition of roughage: For local dairy cows in Africa, the roughage components were largely grass-based, with the exception of Egypt and Mauritius for which lactating and dry cows, respectively, received a substantial amount of crop residues (67 and 60 percent; 71 and 75 percent). In Central and South America, the roughage component was largely grass-based (about 90 and 100 percent respectively) in Brazil and Venezuela. Crop residues formed a substantial part of the roughage in El Salvador and Mexico (about 50 percent) and Peru (16 and 60 percent for lactating and dry animals). In Asia, in China, Indonesia, Iran, Kyrgyzstan,

Mongolia, Pakistan, Sri Lanka and Viet Nam the roughage portion comprised grasses, whereas crop residues formed the major component (> 50 percent) of the roughage in India, Jordan, Lebanon and Thailand.

For improved dairy cows in Africa, the roughage comprised mainly grasses (> 50 percent), except in Mauritius and Morocco where crop residues had a higher share. For all countries in Central and South America, the roughage was mainly (> 50 percent) composed of grasses. In most Asian countries, the roughage was predominantly grass-based. For both the categories of animals in India, Lebanon, Thailand and Turkey and for dry animals in Jordan, crop residues had a larger share. In most countries in Europe, a higher portion of roughage was composed of grasses; however, the contribution of other roughage was substantial in Austria and the United Kingdom (53 and 38 percent for lactating cows) and in Ireland (48 percent for dry cows). This other roughage also included silage.

Composition of concentrates: For local cows in Africa, cereals formed a substantial part of the concentrates in some countries for lactating animals: 50 percent in Egypt and Rwanda and 56 percent in Nigeria. Bran was a major component of the concentrates in Namibia (93 and 100 percent for lactating and dry cows) and Morocco (50 percent for dry cows). The concentrates were exclusively composed of other concentrates in Côte d'Ivoire. In Central and South America cereals were used in the concentrates to the extent of: 37 and 17 percent for lactating and dry cows in Brazil, 67 percent for lactating cows in Mexico and 50 percent in Peru. In Venezuela, 100 percent of the concentrates was composed of miscellaneous feedstuffs. In Asia, the shares of cereals in the concentrates were 38 and 33 percent for lactating animals in China and Turkey, respectively; 100 percent for dry cows in Iran; 100 percent for lactating cows in Jordan; and about 35, 50 and 30 percent, respectively, in Kyrgyzstan, Lebanon and Pakistan. Bran formed a substantial part of the concentrates in India, Indonesia, Mongolia and Viet Nam. Miscellaneous feedstuffs were also a major component of the concentrates in China (100 percent for dry animals), Sri Lanka (100 percent for both dry and lactating animals), Thailand and Viet Nam (50 percent for both dry and lactating animals) and Turkey (33 and 50 percent for lactating and dry animals).

For improved cows in Africa, the concentrates in Côte d'Ivoire were exclusively constituted of other concentrates and in Rwanda exclusively of cereals. Cereals were also present in considerable amounts in the concentrates in Egypt, Morocco and Nigeria. Bran was the only component of the concentrate in Ghana and its level in the diet of dry animals in Namibia was also high (80 percent). Bran was also present in the concentrates of both lactating and dry animals in Ethiopia (about 55 percent) and Morocco (about 24 percent). Except for the Cote d' Ivoire, Ghana and Rwanda, cakes/meals were fed in all the African countries investigated. In the Americas, bran was not a part of the concentrates in Peru and the United States, and its level was very low in Venezuela; in other countries the level of bran in the concentrates ranged from 10 to 25 percent. Miscellaneous feedstuffs formed a substantial part of the concentrates in Peru, the United States, Venezuela and Brazil. The contribution of cakes/meals to the concentrates was also substantial in almost all the Central and South American countries. In Asia, the level

of cereals in the concentrates was highest for Jordan (86 and 100 percent for lactating and dry animals) followed by Turkey, Lebanon and Kyrgyzstan. Other Asian countries that incorporated cereals in the concentrates were Pakistan and Thailand. Bran was of importance for almost all the countries in Asia. The concentrates were composed of 100 percent miscellaneous feedstuffs in the diets of lactating animals in China and Mongolia. In Europe, the share of cereals in the concentrates was substantial in Albania, Austria, Ireland, Poland and the United Kingdom. Bran was present in considerable amounts in the concentrates in Albania and Poland. The miscellaneous feedstuffs formed a major component of the concentrates in the United Kingdom and Ireland (60–100 percent). The level of miscellaneous feedstuffs was also very high in the concentrates prepared in New Zealand.

Note: Feed components used in cattle diets are given in Table 4.1.

Table 4.1. FEED COMPONENTS USED IN DIETS OF CATTLE, AS MENTIONED BY THE RESPONDENTS

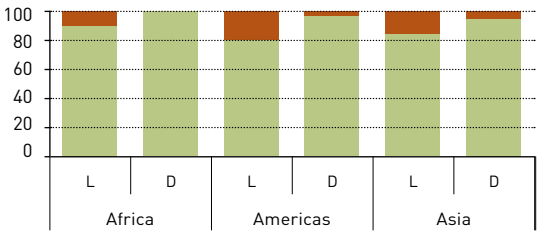
ROUGHAGE			CONCENTRATES			OTHER CONCENTRATES	MISCELLANEOUS
Grasses	Crop residues	Other roughage	Cakes/ meals	Cereals	Bran		
Alfalfa hay, alfalfa cut (fresh grass), grass (fresh, hay, grazing), oat hay, hay (not specified), green fodder, brassica, ryegrass hay, Napier grass, oat (fresh)	Cereal straw, corn stover, crop residues (not specified), wheat straw, oat hay, sorghum residue	Maize silage, alfalfa silage, fodder beets, grass silage, oat silage, ryegrass silage, sugar cane tops, Napier grass, pastures, turnip fodder	African palm meal, rapeseed meal, coconut cake, coconut meal, cottonseed cake, cottonseed meal, fish meal, groundnut cake, mustard cake, sunflower cake, maize cakes, soybean meal, rapeseed meal, palm kernel meal, sesame cake	Sorghum, barley, wheat, broken rice, broken rice/ sorghum/ maize, corn (maize) grain, ground wheat, grain oats, barley, millet, cereals (not specified), oat, rice, triticale, wheat, wet grain corn	Bran (unspecified) pellet, bran raps, bran/husk (undefined), maize bran, mani bran, millet bran, pulse bran, rape bran, rice bran, sorghum bran, soya bran, wheat bran	By-products (not specified)	Beer residues, sugar pulp, beet pulp, beer butt, sugar beet pulp, brewer grains, brewer malt, brewer grain silage, broad-bean, cassava chip, cassava peels, cereal by-products (including maize gluten feed), chicken pea powder paste, chicory pulp, citrus pulp, corn distillers grains, corn gluten flour mill residues, gram husk, kitchen wastes, lupine, molasses, palm kernel extract, poultry manure and litter, soybean, roasted soybean, root crops, soymeal, soy flour, molasses (not specified), tofu waste, urea, wet or dried distillers grains with solubles, broken pulses, tapioca waste, wheat middling

4.3.2. MAPPING OF BUFFALO FEEDING BASKETS

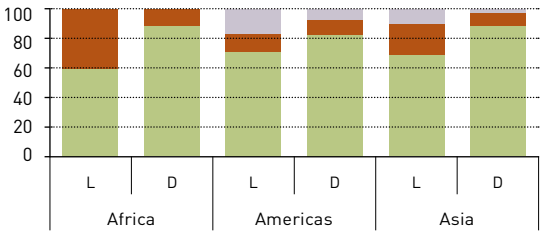
Dairy buffaloes

Feed basket composition (% DM)

CONTINENT-WISE FOR LOCAL DAIRY BUFFALOES

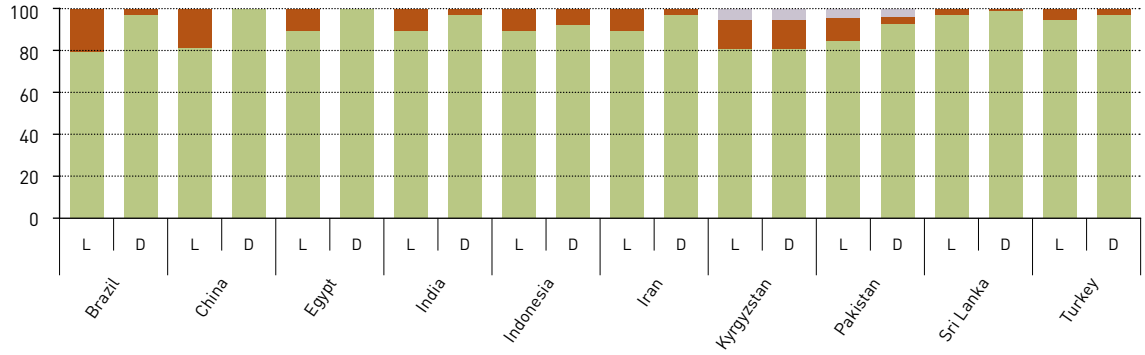


CONTINENT-WISE FOR IMPROVED DAIRY BUFFALOES



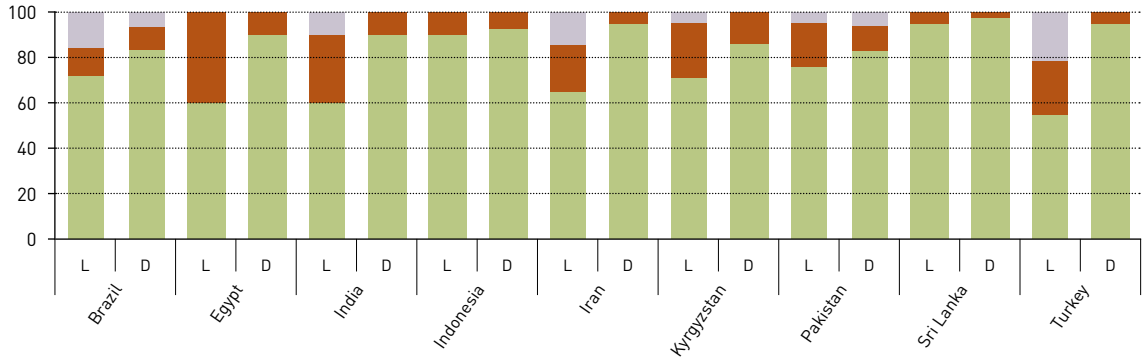
ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

COUNTRY-WISE FOR LOCAL DAIRY BUFFALOES



ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

COUNTRY-WISE FOR IMPROVED DAIRY BUFFALOES

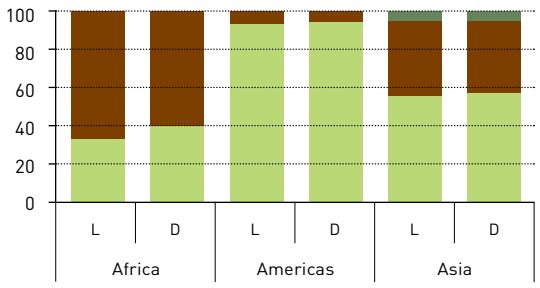


ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

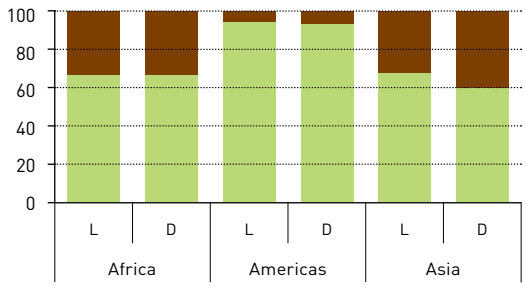
Dairy buffaloes

Composition of roughage (% DM)

CONTINENT-WISE FOR LOCAL DAIRY BUFFALOES

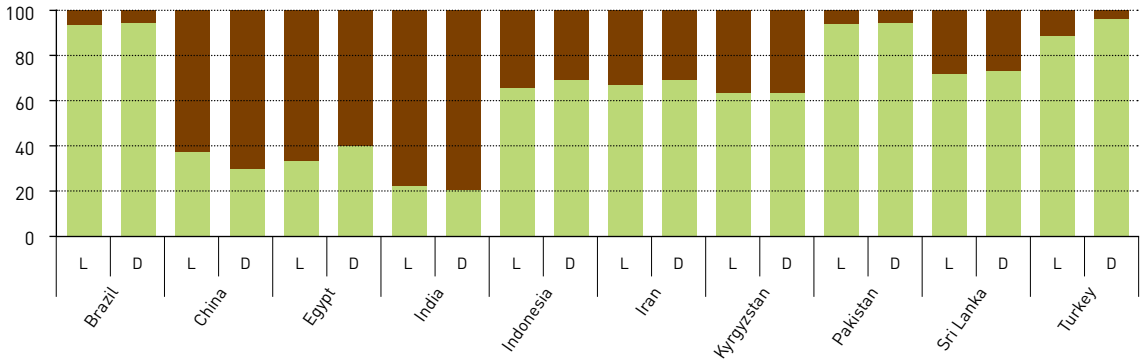


CONTINENT-WISE FOR IMPROVED DAIRY BUFFALOES



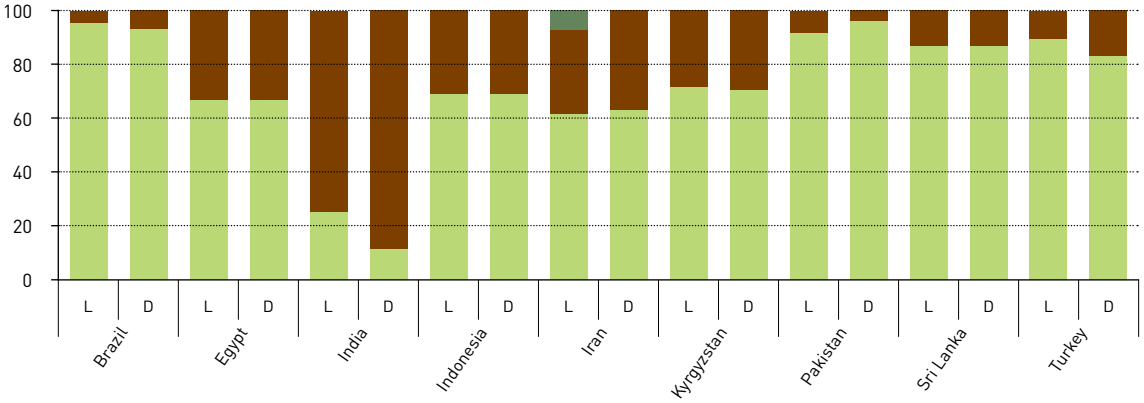
GRASS CROP RESIDUES OTHER ROUGHAGE **L**: Lactating **D**: Dry

COUNTRY-WISE FOR LOCAL DAIRY BUFFALOES



GRASS CROP RESIDUES OTHER ROUGHAGE **L**: Lactating **D**: Dry

COUNTRY-WISE FOR IMPROVED DAIRY BUFFALOES

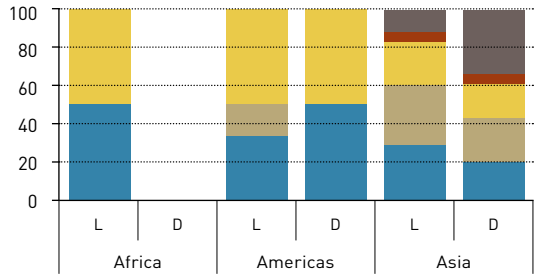


GRASS CROP RESIDUES OTHER ROUGHAGE **L**: Lactating **D**: Dry

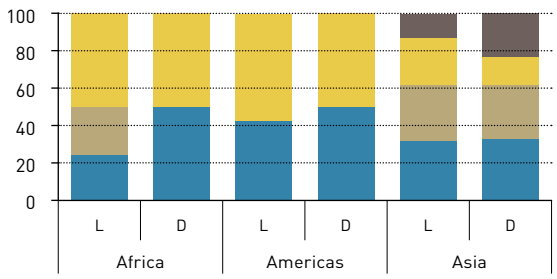
Dairy buffaloes

Composition of concentrates (% DM)

CONTINENT-WISE FOR LOCAL DAIRY BUFFALOES



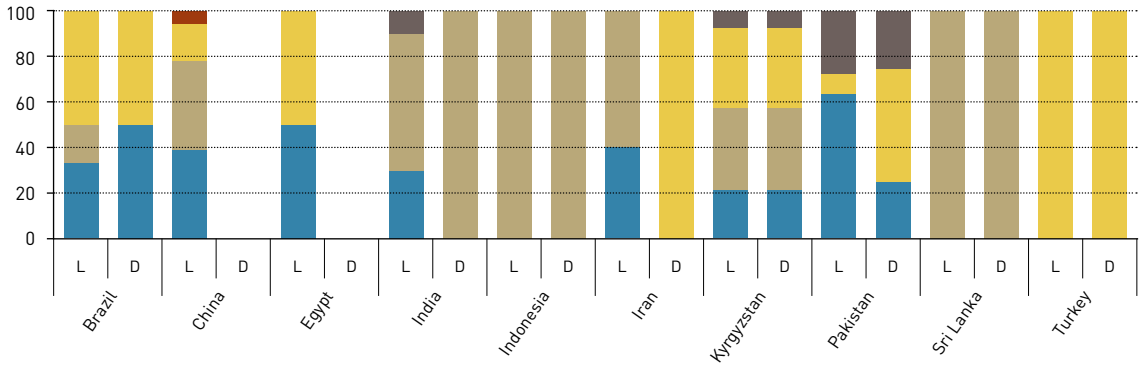
CONTINENT-WISE FOR IMPROVED DAIRY BUFFALOES



CAKES & MEALS BRANS CEREALS OTHER CONCENTRATES MISCELLANOUS

L: Lactating **D**: Dry

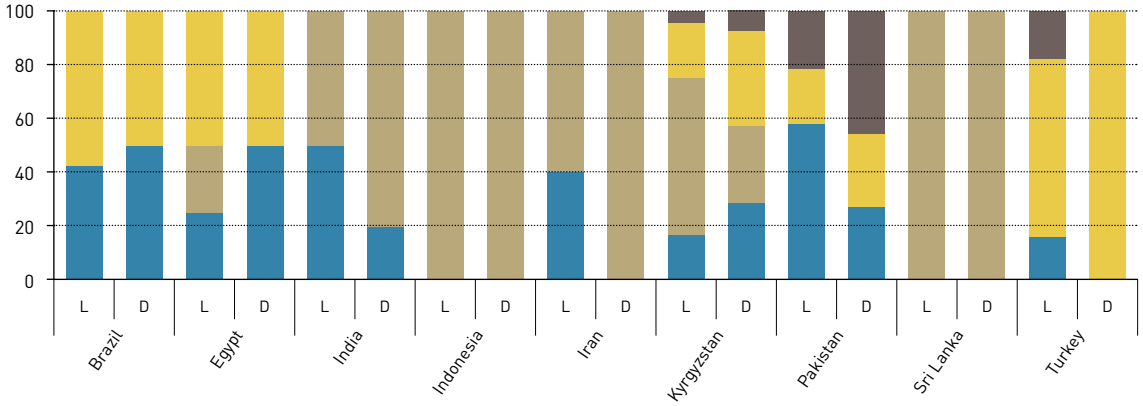
COUNTRY-WISE FOR LOCAL DAIRY BUFFALOES



CAKES & MEALS BRANS CEREALS OTHER CONCENTRATES MISCELLANOUS

L: Lactating **D**: Dry

COUNTRY-WISE FOR IMPROVED DAIRY BUFFALOES



CAKES & MEALS BRANS CEREALS OTHER CONCENTRATES MISCELLANOUS

L: Lactating **D**: Dry

Salient points

Continent-wise

Feed basket composition: In all continents, roughage use was highest for both dry and lactating local dairy buffaloes (dry 95–100 percent; lactating 80–90 percent), the other component being concentrates.

Improved dairy buffaloes received higher amounts of concentrates than the local animals. In the Americas (Brazil) and Asia, compound feed was also a part of the feed basket; in the former (taking both dry and lactating animals into consideration) the use of compound feed and concentrate feed were almost similar whereas in Asia the use of compound feed was about one third that of concentrate feed.

Composition of roughage: For local animals, the roughage fraction was composed mainly of crop residues (60 and 67 percent for lactating and dry animals) in Africa (Egypt). In the Americas (Brazil), grasses were the major part (about 95 percent for both lactating and dry animals) and in Asia grasses formed the major component (about 55 percent), followed by crop residues (about 40 percent) for both dry and lactating animals.

For improved animals (both dry and lactating), the contribution of grasses was higher than crop residues in the roughage fraction: 60–68 percent in Asia, 67 percent in Africa (Egypt) and 95 percent in the Americas (Brazil).

Composition of concentrates: For local dairy buffaloes in Africa (Egypt), 50 percent cereals and 50 percent of cakes/meals made up the concentrate diets for lactating animals. In the Americas (Brazil), concentrates for lactating animals contained 50 percent cereals, 33 percent cakes/meals and 17 percent bran, whereas dry animals received 50 percent cereals and 50 percent cakes/meals. Concentrates for lactating and dry animals, respectively, in Asia consisted of cakes/meals (29 and 19 percent), bran (31 and 24 percent), cereals (23 and 18 percent) and miscellaneous feedstuffs and other concentrates together (17 and 39 percent).

For improved animals, in Africa (Egypt) concentrates consisted of 50 percent cereals for both lactating and dry animals. The level of cakes/meals was higher for dry animals (50 versus 25 percent) and for lactating animals the remaining 25 percent of concentrates was bran. For lactating and dry animals, respectively, the concentrates in the Americas (Brazil) contained cereals (57 and 50 percent) and cakes/meals (43 and 50 percent); in Asia, the contents were cakes/meals (32 and 33 percent), bran (30 and 29 percent), cereals (25 and 15 percent) and miscellaneous feedstuffs (13 and 23 percent).

Note: For the Americas and Africa only one country each are discussed, Brazil and Egypt, respectively.

Country-wise

Feed basket composition: Local dairy buffaloes received mostly roughage in all countries. In most Asian countries except Kyrgyzstan, the dry animals received a diet composed almost exclusively of roughage, whereas lactating animals were given concentrates in addition to roughage (amount of concentrates were: China 18 percent; India, Indonesia and Iran 10 percent; Pakistan 11 percent; Sri Lanka and Turkey < 6 percent). The only countries that fed compound feed were Kyrgyzstan and Pakistan. For both lactating and dry animals, use of compound feed was about 5 percent in Kyrgyzstan and about 4 percent in Pakistan. The proportion of concentrates used for both types of animals in Kyrgyzstan was about 15 percent.

Improved animals received more concentrates and compound feed than local animals. Lactating animals in Asia received between 5 percent (Sri Lanka) and 30 percent (India) of concentrates, and the compound feed used varied between about 5 percent (Kyrgyzstan and Pakistan) and 23 percent (Turkey). For lactating animals in Africa (Egypt), 40 percent of the diet was concentrates. In the Americas (Brazil), animals were fed 12 percent concentrates and 17 percent compound feed. In all these countries, the rest of the diet was composed of roughage. More roughage was fed to dry animals than lactating animals.

Composition of roughage: For both lactating and dry local dairy buffaloes in India and China, roughage comprised mainly crop residues (about 80 and 67 percent, respectively), and in the rest of the Asian countries grasses were the main component of roughage (63 percent for Kyrgyzstan to 95 percent for Pakistan). In the Americas (Brazil), grasses were the major component of the roughage (about 95 percent) and in Africa (Egypt), similar to India and China, crop residues formed the major component of the roughage.

Improved lactating animals received from 62 percent (Iran) to 96 percent (Brazil) grass-based roughage. Only in India did the share of crop residues exceed that of grass-based roughage (75 and 89 percent in lactating and dry animals, respectively). In Africa (Egypt) for improved animals, unlike local animals, the contribution of grasses was higher in the roughage component.

Composition of concentrates: For local dairy buffaloes, the levels of cereals in the concentrates of both lactating and dry animals in Brazil, Kyrgyzstan and Turkey were 50, 36 and 100 percent, respectively. In China and Egypt, concentrates were not fed to dry animals but for lactating animals cereals constituted 17 and 50 percent, respectively, of the concentrates. Although for dry animals in Iran and Pakistan the contribution of cereals in concentrates was higher (100 and 50 percent, respectively), the total amount of concentrates in the diets was very low (< 4 percent). Bran constituted an important part of the concentrates in India (60 and 100 percent in lactating and dry animals); Indonesia, Kyrgyzstan and Sri Lanka (100, 36 and 100 percent, respectively, for both types of animals); and Iran (60 percent for lactating animals). Cakes/meals were also used in the concentrates in Brazil, China, Egypt, India, Iran, Kyrgyzstan and Pakistan, with the largest share in Pakistan (64 percent for lactating animals).

The concentrate compositions for improved dairy buffaloes were characterized by various proportions of cereals (lactating and dry animals, respectively): Brazil (57 and 50 percent),

Egypt (50 and 50 percent), Kyrgyzstan (21 and 36 percent), Pakistan (21 and 27 percent) and Turkey (67 and 100 percent). For some of the countries (Indonesia and Sri Lanka for both types of animals and Iran for dry animals), the concentrates were composed entirely of bran. Bran also formed a significant part of the concentrates in Egypt (25 percent for lactating animals), India (50 and 80 percent for lactating and dry animals), Iran (60 percent for lactating animals) and Kyrgyzstan (58 and 29 percent for lactating and dry animals). Cakes/meals were used in the concentrates (for lactating and dry animals, respectively) in Brazil (50 and 50 percent), Egypt (25 and 50 percent), India (50 and 20 percent), Iran (40 and 0 percent), Kyrgyzstan (17 and 29 percent), Pakistan (58 and 27 percent) and Turkey (16 and 0 percent).

Note: Feed components used in buffalo diets are given in Table 4.2.

Table 4.2. FEED COMPONENTS USED IN DIETS OF BUFFALOES, AS MENTIONED BY THE RESPONDENTS

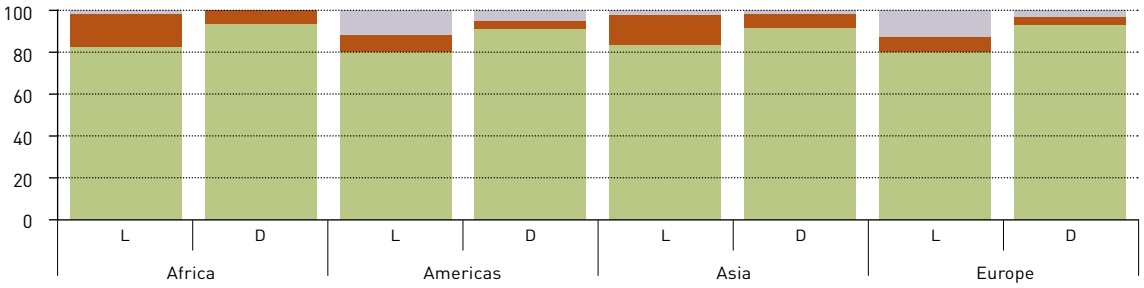
ROUGHAGE			CONCENTRATES			OTHER CONCENTRATES	MISCELLANEOUS
Grasses	Crop residues	Other roughage	Cakes/ meals	Cereals	Bran		
Hays (not specified), grass (fresh, hay), green fodder, mixed fodder	Crop residues (not specified), wheat straw, rice straw, rice chaff	Corn silage, silage (not specified)	Cakes (not specified), cottonseed meal, cottonseed cake, groundnut cake, mustard cake, sunflower cake, maize oil cakes, rapeseed meal, sesame cake, soybean meal, sunflower meal, sunflower pellet, sesame cake	Broken rice, maize/ corn, rice, barley, millet, wheat, sorghum, cracked wheat, cereals (not specified)	Bran and husks (undefined), rice bran, wheat bran, rice bran	By-products (not specified)	Beet pulp, cassava chip, chicken pea powder paste, cotton seeds, flour mill residues, gram husk, kitchen waste, root crops, tofu waste, broken pulses, tapioca waste

4.3.3. MAPPING OF SHEEP FEEDING BASKETS

Dairy sheep

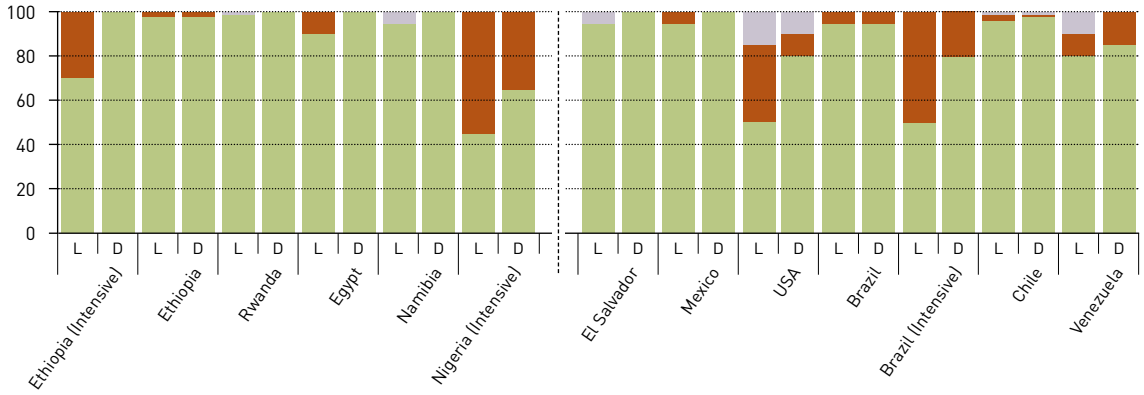
Feed basket composition (% DM)

CONTINENT-WISE



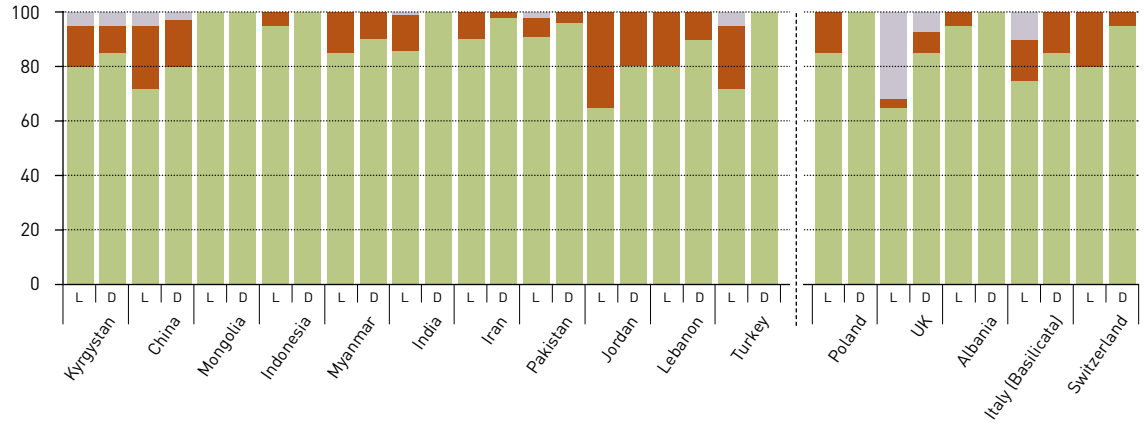
ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

COUNTRY-WISE FOR AFRICA AND AMERICAS



ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

COUNTRY-WISE FOR ASIA AND EUROPE

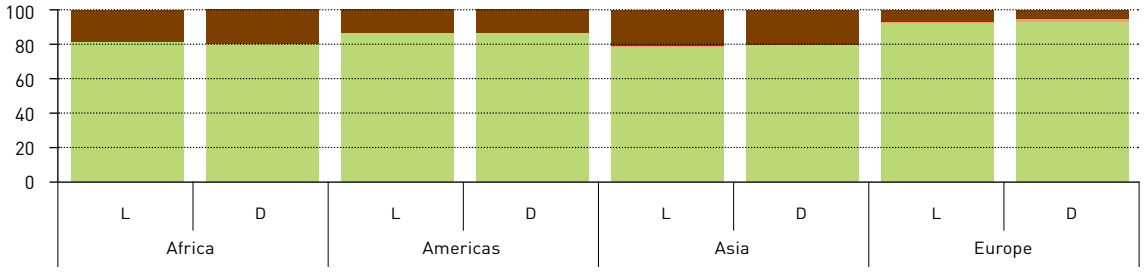


ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

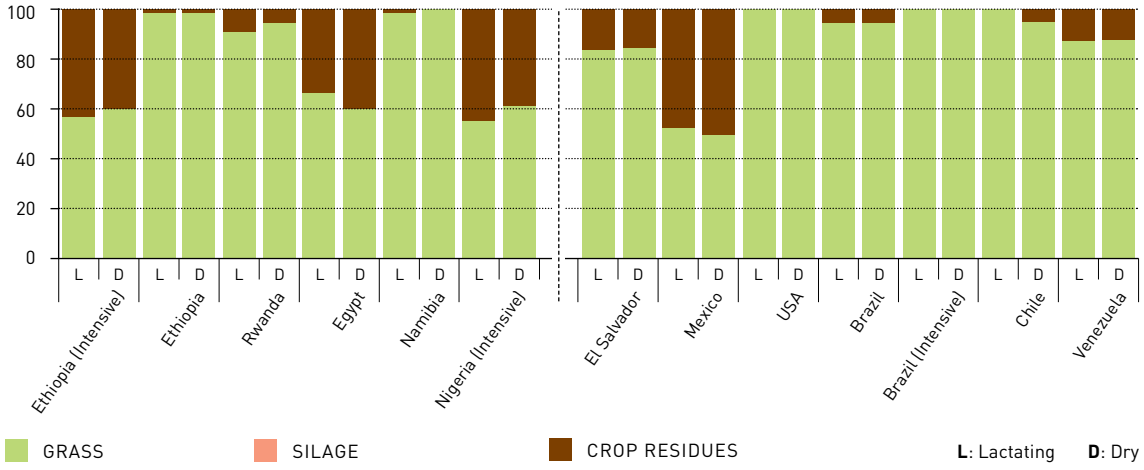
Dairy sheep

Composition of roughage (% DM)

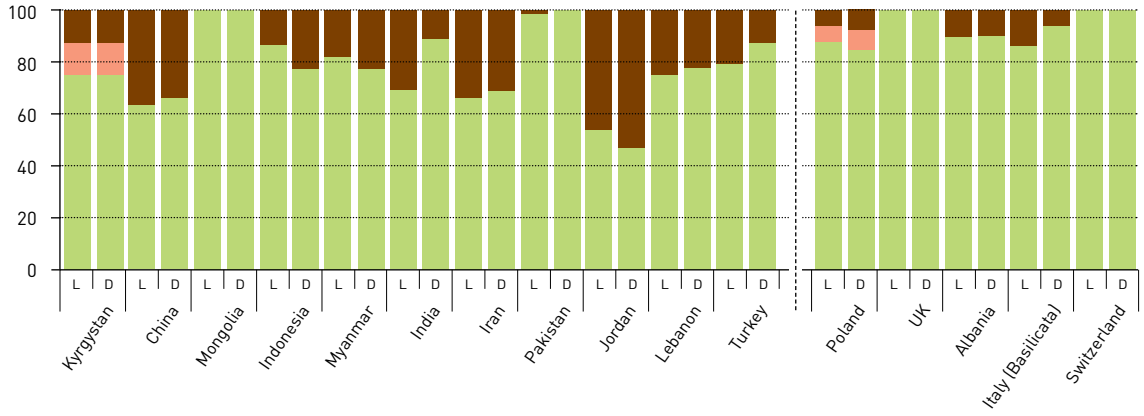
CONTINENT-WISE



COUNTRY-WISE FOR AFRICA AND AMERICAS



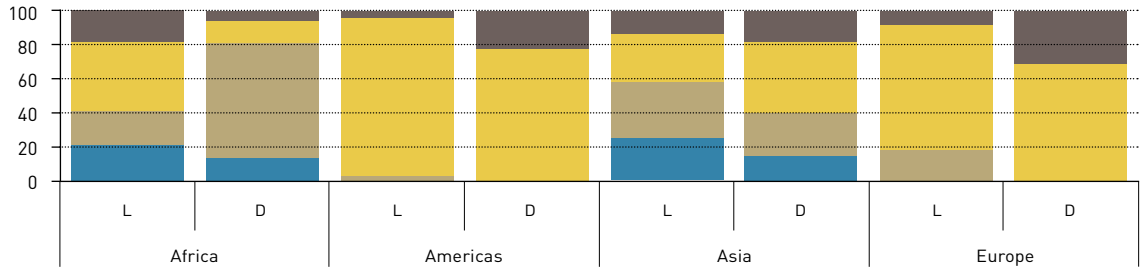
COUNTRY-WISE FOR ASIA AND EUROPE



Dairy sheep

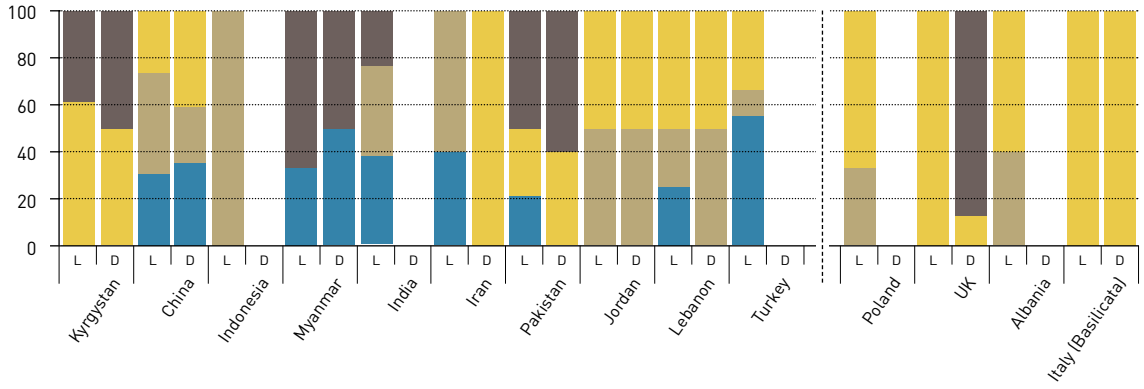
Composition of concentrates (% DM)

CONTINENT-WISE



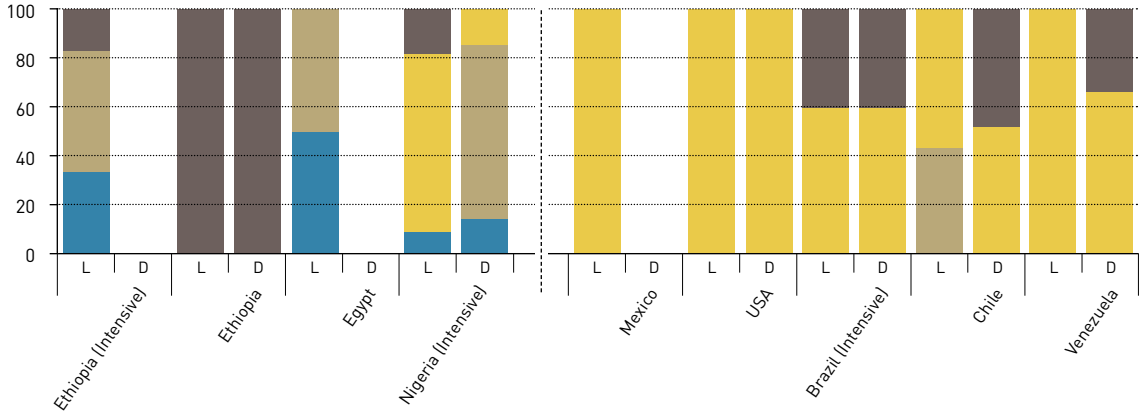
CAKES & MEALS BRANS CEREALS MISCELLANOUS **L**: Lactating **D**: Dry

COUNTRY-WISE FOR ASIA AND EUROPE



CAKES & MEALS BRANS CEREALS MISCELLANOUS **L**: Lactating **D**: Dry

COUNTRY-WISE FOR AFRICA AND AMERICAS



CAKES & MEALS BRANS CEREALS MISCELLANOUS **L**: Lactating **D**: Dry

Salient points

Continent-wise

Feed basket composition: In Africa and Asia, lactating sheep were fed mainly roughage (80–84 percent), the use of other components being concentrates (14–16 percent) and compound feed (about 4 percent). Dry sheep received 90 percent roughage and the rest concentrates.

In the Americas and Europe, the feed basket composition was similar: lactating sheep received about 80 percent roughage, 15 percent compound feed and 5 percent concentrates, and dry sheep were fed nearly 92 percent roughage, 5 percent concentrates and 3 percent compound feed.

Composition of roughage: In lactating sheep diets, the roughage was predominantly composed of grasses (fresh or hay), ranging from 80 percent in Africa and Asia and 84 percent in the Americas to 94 percent in Europe, the rest being crop residues. Silage (about 1 percent) was also a part of the roughage in Asia and Europe for lactating animals. Dry sheep received mainly grasses (80–95 percent) and crop residues in all continents, except Europe where a low level (1 percent) of silage was a part of the roughage.

Composition of concentrates: For lactating sheep in the Americas, the concentrates were predominantly cereals (> 90 percent), the rest being bran; dry sheep received about 76 percent cereals, the rest being miscellaneous feedstuffs. In Europe, lactating sheep, received about 18 percent bran in addition to cereals (about 74 percent), whereas dry sheep in Americas received concentrates that had a higher proportion of cereals than in Europe.

In Asia and Africa, the concentrates in lactating sheep were constituted of 20–28 percent bran, 30–40 percent cereals and 20–26 percent oilseed cakes/meals. The concentrates for dry sheep in Africa were composed of a large part of bran (68 percent) followed by cereals and cakes/meals in almost equal amounts. In Asia, the concentrates were composed of 42 percent cereals, 23 percent bran, 18 percent miscellaneous feedstuffs and 13 percent cakes/meals.

Country-wise

Feed basket composition: In almost all investigated countries in Africa, lactating sheep were fed roughage (> 90 percent) with small amounts of concentrates (Ethiopia) and compound feed (Namibia); dry sheep received almost 100 percent roughage. In intensive systems in Ethiopia and Nigeria, lactating sheep received a substantial amount of concentrates (30–55 percent) and the rest roughage. Dry sheep were given almost 100 percent roughage in Ethiopia (intensive), whereas in Nigeria (intensive) 35 percent concentrates were also fed.

In Asia with the exception of Kyrgyzstan and China, dry sheep were fed mainly roughage, whereas lactating sheep received in addition to roughage substantial amounts of concentrates (Jordan 35 percent, Lebanon 20 percent, Myanmar 16 percent, India 15 percent, Iran 10 percent and Indonesia 5 percent). In Kyrgyzstan, both lactating and dry sheep were fed 10–15 percent concentrates, 10 percent crop residues and the rest (> 80 percent) was roughage. Lactating

sheep in China used 23 percent concentrates and 5 percent crop residues; dry sheep received less concentrates and more roughage than lactating animals.

In the Americas, lactating sheep in Brazil (intensive) were fed roughage and compound feed in the proportion 1 : 1, whereas this ratio for dry sheep was 4 : 1. In the normal Brazilian sheep raising system, use of roughage and concentrates was about 95 and 5 percent, respectively, for both lactating and dry animals. For dry animals in El Salvador, Chile and Mexico, the diets were entirely composed of roughage, and in Venezuela roughage was 82 percent and the rest was concentrates. In these four countries, the roughage content was lower (5–20 percent) for lactating sheep than for dry animals and the rest of the diet was either composed of concentrates, compound feed or a mixture of concentrates and compound feed. Lactating animals in the United States received 50 percent roughage, 35 percent concentrates and 15 percent compound feed; dry animals received a higher share of roughage (80 percent) and lower shares of concentrates and compound feed.

In European countries, lactating sheep received a substantial amount of roughage (70–95 percent) and the amount of compound feed was highest for the United Kingdom, followed by Switzerland and Italy. For all countries in Europe, dry sheep received a higher share of roughage and lower shares of concentrates and compound feed than lactating sheep.

Composition of roughage: In most countries in Africa, the Americas and Asia, the roughage in the diets of both lactating and dry sheep was composed of grasses (fresh and hay), varying from 50 to 100 percent, and crop residues (15–50 percent). Silage (about 15 percent) was a part of the roughage for both groups of sheep only in Kyrgyzstan (about 15 percent) in Asia and only in Poland in Europe (5–8 percent).

Composition of concentrates: In Africa, the concentrates for lactating sheep in Ethiopia (intensive) comprised 50 percent bran, 33 percent cakes/meals and the rest was miscellaneous feedstuffs; no concentrates were fed to dry sheep. In Nigeria (intensive), the concentrates for lactating sheep were composed mainly of cereals (72 percent), whereas the concentrates for dry sheep contained 70 percent bran, the balance being cakes/meals and cereals in almost equal amounts. In Asia, the amount of components that formed the concentrates was variable: in Indonesia, 100 percent bran for lactating animals; in Jordan, equal proportion of cereals and bran for both lactating and dry sheep; and in India, cakes/meals and bran in almost the same proportion (38 percent) and the rest miscellaneous feedstuffs. In Kyrgyzstan, the concentrates contained cakes/meal and miscellaneous feedstuffs but no cereals, whereas in Myanmar the concentrates contained cereals but no cakes/meals. In Pakistan, the concentrates for lactating animals were formed of almost 50 percent miscellaneous feedstuffs and an equal proportion of cereals and cakes/meals (25 percent each); for dry animals the concentrates were formed mainly of miscellaneous feedstuffs (69 percent), the rest being cereals. The concentrates in Iran for lactating sheep contained bran (60 percent) and cakes/meals (40 percent), whereas for dry animals this fraction was composed of 100 percent cereals. No supplement was fed to dry animals in India and Indonesia.

In the Americas, concentrates in the United States comprised 100 percent cereals for lactating and dry sheep; in Brazil (intensive) 60 percent cereals and the rest miscellaneous feed components for both lactating and dry sheep; in Venezuela 100 and 68 percent cereals for lactating and dry animals, respectively, and the rest miscellaneous feedstuffs; in Chile about 57 percent cereals and the rest bran for lactating sheep, and 50 percent cereals and 50 percent miscellaneous feedstuffs for dry sheep; and in Mexico 100 percent cereals for lactating sheep.

In Europe, the concentrates were composed mainly of cereals: in Italy 100 percent for both lactating and dry sheep; in Albania 60 percent and in Poland 40 percent cereals for lactating animals and the rest bran; in the United Kingdom, cereals were used exclusively for lactating sheep, whereas dry sheep received 88 percent miscellaneous feedstuffs and the rest cereals.

Note: Feed components used in sheep diet are given in Table 4.3.

Table 4.3. FEED COMPONENTS USED IN DIETS OF SHEEP (AND GOATS), AS MENTIONED BY THE RESPONDENTS

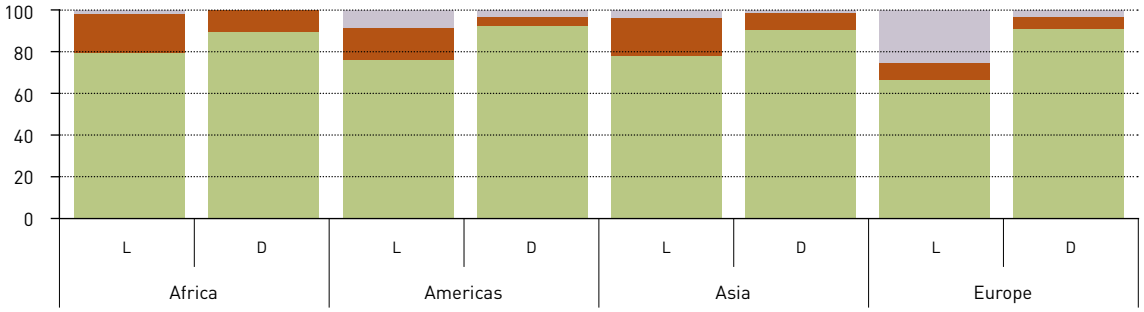
ROUGHAGE			CONCENTRATES			
Grasses	Crop residues	Silages	Oilseed Cakes/meals	Cereals	Bran	Miscellaneous
Alfalfa hay, alfalfa cut (fresh grass), grass (fresh, hay, grazing), oat hay, shrubs (not specified), tree leaves	Corn cob, corn stover, wheat straw, bean straw, crop residues (rice, maize, cottonseed)	Maize silage, alfalfa silage	Copra cake, cottonseed cake, cottonseed meal, flour meals, groundnut cake, maize oil cake, mustard cake, soybean meal, rapeseed meal, palm kernel meal, sesame cake, soycake, sunflower meal, sunflower cake, linseed cake	Wheat, ground wheat, cereals (not specified), barley, broken sorghum/ maize, guinea corn, millet (bajra), yellow corn, white corn, maize, oat, sorghum, triticale	Bran (not specified), maize bran, colza bran, rice bran, wheat bran, beans bran, lentil bran	Cereal by-products (including maize gluten feed), beet pulp, brewery products, distiller's and brewer's products, corn gluten, cassava peels, beet, vegetable marrows (?), citrus pulp, gram husk, bean husk, lentil husk, soybean husk, kitchen waste, household leftovers, cane molasses, poultry litter, broken pulses, legumes, peeled almonds

4.3.4. MAPPING OF GOAT FEEDING BASKETS

Dairy goats

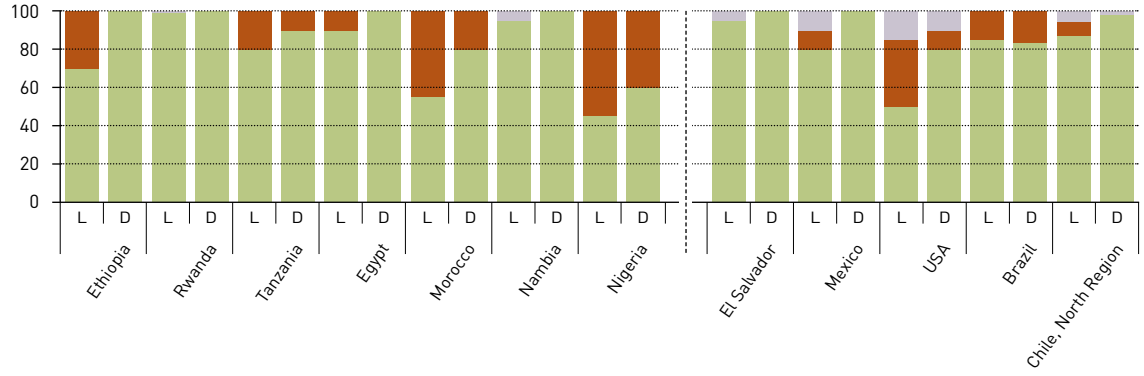
Feed basket composition (% DM)

CONTINENT-WISE



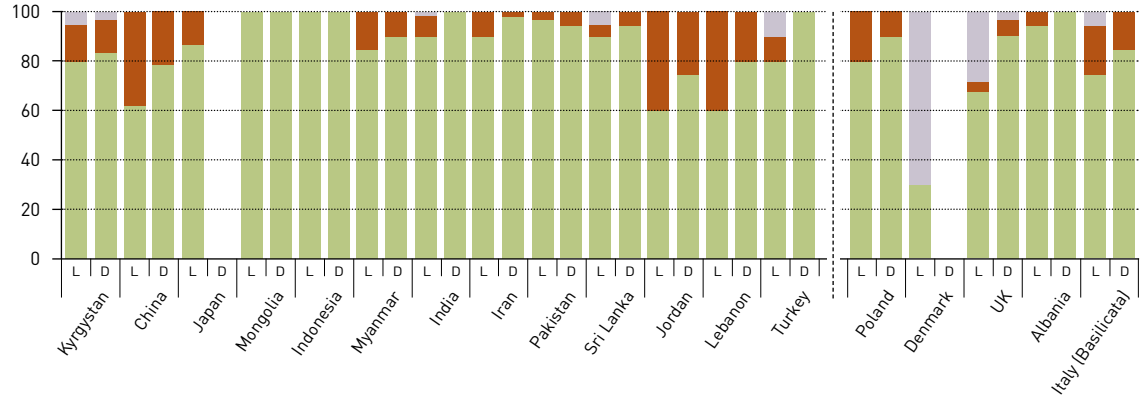
ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

COUNTRY-WISE FOR AFRICA AND AMERICAS



ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

COUNTRY-WISE FOR ASIA AND EUROPE

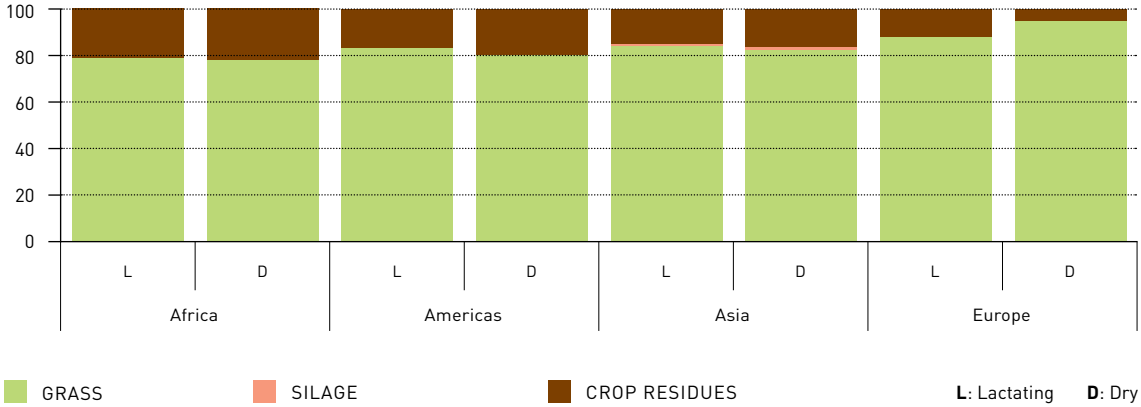


ROUGHAGE CONCENTRATES COMPOUND FEED **L**: Lactating **D**: Dry

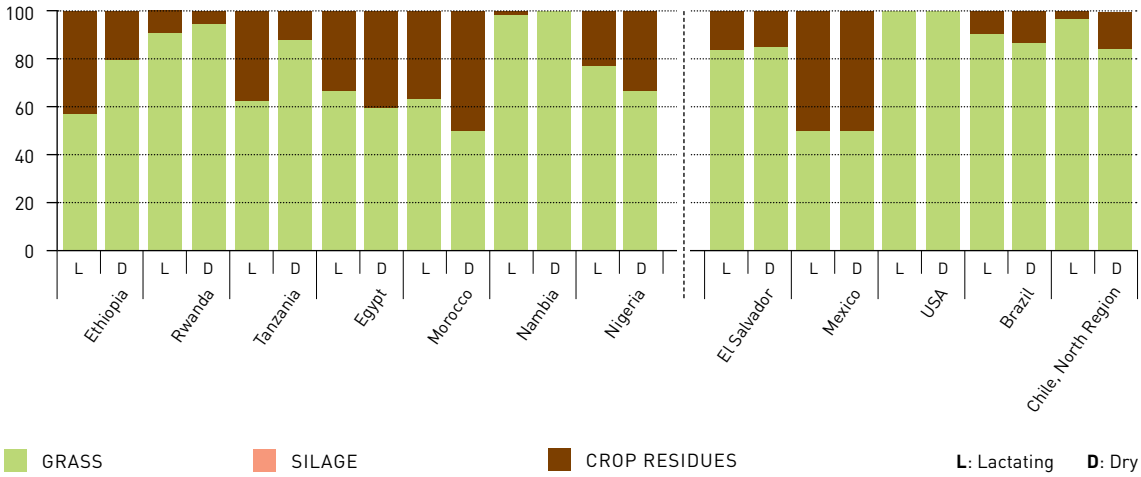
Dairy goats

Composition of roughage (% DM)

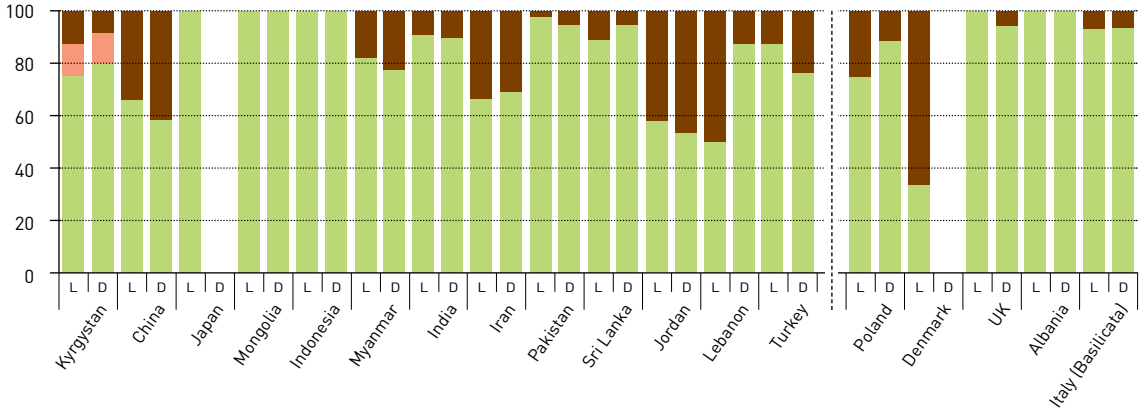
CONTINENT-WISE



COUNTRY-WISE FOR AFRICA AND AMERICAS



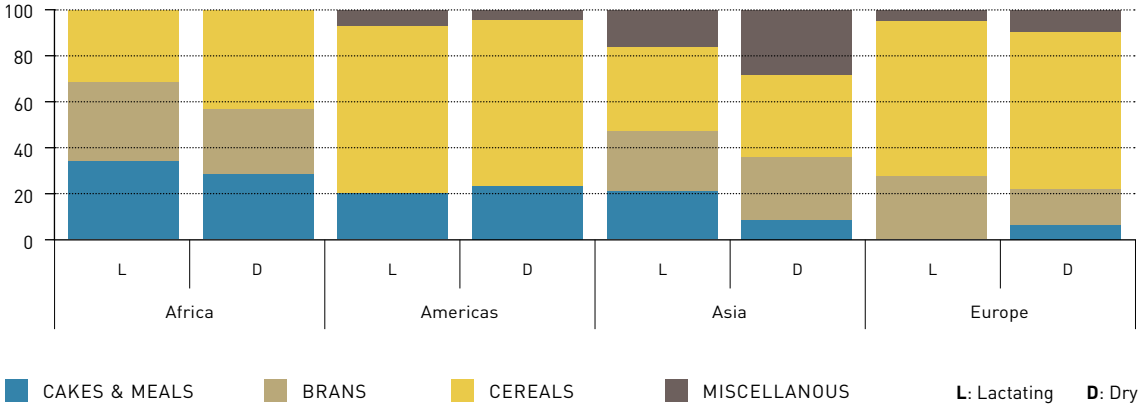
COUNTRY-WISE FOR ASIA AND EUROPE



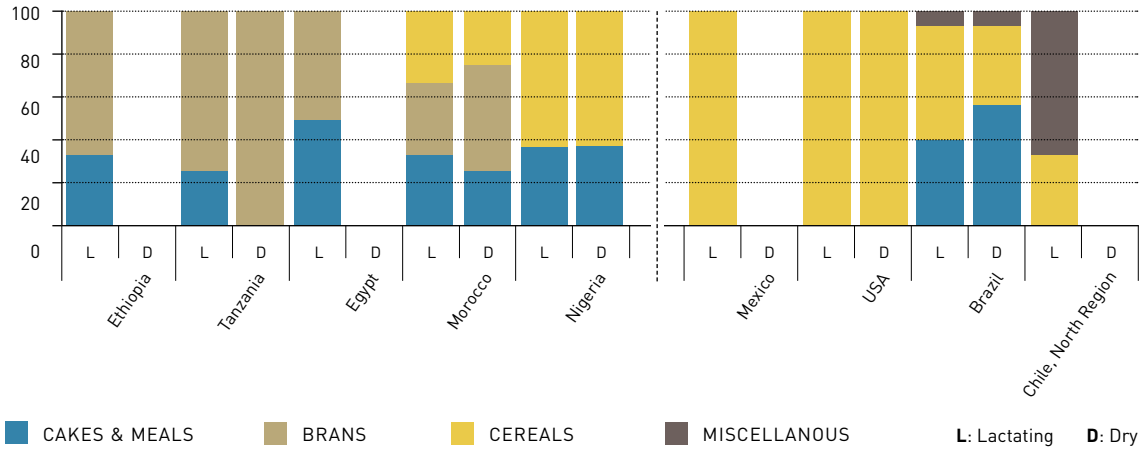
Dairy goats

Composition of concentrates (% DM)

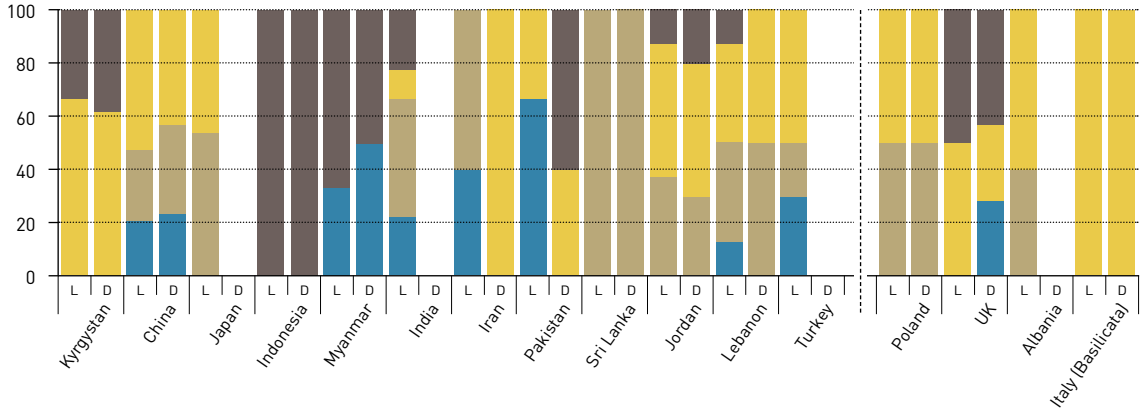
CONTINENT-WISE



COUNTRY-WISE FOR AFRICA AND AMERICAS



COUNTRY-WISE FOR ASIA AND EUROPE



Salient points

Continent-wise

Feed basket composition: In Africa and Asia, lactating goats received mainly roughage (about 80 percent), the rest being concentrates, and in Asia some compound feed was used (3 percent). Dry goats in Africa and Asia received 90 percent roughage and the rest concentrates.

Use of roughage and concentrates for lactating goats in the Americas was about 75 and 15 percent, respectively, and the balance was compound feed. For dry goats in the Americas, the use of roughage was > 90 percent and that of compound feed about 2 percent. The rest was concentrates.

In Europe, for lactating goats the share of compound feed was highest (25 percent) and that of concentrates was 10 percent, the rest being roughage. The feed basket for dry goats in Europe was similar to that for dry goats in the Americas.

Composition of roughage: In all continents, both for lactating and dry goats, the roughage was composed mainly of grasses, fresh or as hay (> 80 percent), the rest being crop residues. The level of grasses in the roughage was slightly higher for lactating than for dry animals in all continents, with the exception of Europe, where dry animals received > 95 percent grass in the roughage.

Composition of concentrates: In Africa, the concentrates for lactating goats were composed of cakes/meals, cereals and bran in almost equal amounts, whereas the concentrates for dry animals had a slightly higher proportion of cereals and slightly less cakes/meals and bran. It should be noted that the diet of lactating goats contained twice as much concentrates as that of dry animals.

In Asia, the concentrates for lactating goats contained a higher amount of cakes/meals than for dry goats (21 versus 8 percent), but the cereals and bran levels were almost the same for both categories of animals. Lower cakes/meals levels in the concentrates for dry goats were compensated by higher amounts of miscellaneous feedstuffs.

In the Americas for both the categories of goats, the concentrates consisted predominantly of cereals (about 73 percent), followed by cakes/meals (about 20 percent), the rest being miscellaneous feedstuffs; bran was not a part of the concentrates.

In Europe, for both lactating and dry goats the concentrates contained about 70 percent cereals; the level of bran was higher for lactating animals (28 versus 15 percent). Cakes/meals were not a part of the concentrates for lactating animals but a small amount of cakes/meals was included in the concentrates of dry animals.

Country-wise

Feed basket composition: In Africa, both lactating and dry goats received mainly roughage and concentrates; only lactating animals in Namibia were fed a small amount of compound feed (< 5 percent) in addition to roughage and concentrates. The diets of dry goats in Ethiopia,

Rwanda, Egypt and Namibia and of lactating goats in Rwanda were composed entirely of roughage. For lactating goats in Nigeria, Morocco, Ethiopia, Tanzania and Egypt, concentrate used ranged from 10 to 55 percent (highest being in Nigeria and lowest in Egypt).

In Mongolia and Indonesia, both lactating and dry goats were fed 100 percent roughage, whereas in the other Asian countries investigated diets also consisted of concentrates in addition to roughage. In Kyrgyzstan, Turkey, India and Sri Lanka lactating goats also received some compound feed (1–10 percent) and concentrates (5–15 percent). Dry goats in India and Turkey were fed 100 percent roughage, and in Sri Lanka they received 5 percent concentrates and the rest was roughage.

In the Americas, lactating goats in El Salvador received 95 percent roughage and 5 percent compound feed, whereas dry goats were fed entirely on roughage. Brazil fed both the categories of goats with diets containing about 85 percent roughage and 15 percent concentrates. In Mexico and Chile (northern region), lactating goats received concentrates (10 and 8 percent, respectively) and some compound feed (10 and 5 percent, respectively); dry goats in Mexico received 100 percent roughage and in Chile 1 percent compound feed was used together with roughage. In the United States, lactating and dry goats received roughage, concentrates and compound feed in different percentages (respectively, 50-35-15 percent and 80-10-10 percent).

In Europe, lactating goats in Denmark received 30 percent roughage and 70 percent compound feed. Another country that fed substantial amounts of compound feed (about 28 percent) to lactating animals was the United Kingdom. In the other countries investigated, lactating goats received 70–90 percent roughage, < 20 percent concentrates and a low level of compound feed (< 8 percent). Dry goats received 90–100 percent roughage, the rest being concentrates; an exception was the United Kingdom, which also used compound feed (about 3 percent).

Composition of roughage: In most countries in Africa, Asia, the Americas and Europe, the roughage component in the diets of both lactating and dry goats was composed of grasses (fresh or hay), varying from 53 to 100 percent, and crop residues (the rest). No silage was fed to any of the categories of animals, except in Kyrgyzstan, where about 13 percent was fed to both lactating and dry goats. In Namibia, the roughage component was entirely grasses for both categories of animals, with a small supplement of crop residues (1 percent) to lactating animals.

Composition of concentrates: In Africa, in Rwanda and Namibia, goats were not supplied with concentrates; in Ethiopia the concentrates in diets of lactating goats were composed of bran and cakes/meals in the ratio 3 : 1, whereas this ratio for Egypt and Tanzania was 1 : 1 and 4 : 1, respectively. Morocco fed lactating goats concentrates that contained the same amounts of bran, cereals and cakes/meals (33 percent each); dry goats received more bran (about 50 percent) and the rest was made up of cakes/meals and cereals (25 percent each). In Tanzania, the concentrates for dry goats contained 100 percent bran and for lactating goats the content was about 25 percent cakes/meals and 75 percent bran. The composition of concentrates for both the categories of animals in Nigeria was almost similar: 64 percent cereals, the rest being cakes/meals.

In Asia, dry goats did not receive concentrates in Mongolia. India and Turkey supplied concentrates only to lactating goats: in India the concentrates consisted of about 40 percent bran, 10 percent cereals and the rest was divided between cakes/meals and miscellaneous feedstuffs; and in Turkey the concentrates contained 50 percent cereals, 30 percent cakes/meals and 20 percent bran. Indonesia fed both categories of goats with concentrates made up of 100 percent miscellaneous feedstuffs. In Kyrgyzstan the concentrates for both the categories of animals contained a substantial amount of cereals (lactating animals 70 percent and dry animals 60 percent) and the rest was miscellaneous feedstuffs. Myanmar supplied concentrates to lactating goats that consisted of miscellaneous feedstuffs (67 percent) supplemented with cakes/meals; the concentrates for dry animals contained these components in the ratio 1 : 1. The concentrates for dry goats in Iran were composed entirely of cereals, whereas those for lactating goats were mainly bran (about 60 percent), the rest being cakes/meals. In China, the concentrates for lactating goats consisted of about 50 percent cereals and the rest was divided between bran and cakes/meals; the concentrates for dry goats had the same components but less cereals (about 40 percent) and more bran (> 30 percent). In Jordan, concentrates containing the same amount of cereals were fed to both lactating and dry goats (about 50 percent) and the content of bran was higher for lactating goats than dry goats (38 versus 30 percent). In Lebanon, the concentrates for dry goats consisted of only cereals and bran in the ratio 1 : 1; lactating goats received bran and cereals in almost the same amounts (about 38 percent) and the rest was divided between cakes/meals and miscellaneous feed components. Turkey supplied only lactating goats with concentrates containing 50 percent cereals, 30 percent cakes/meals and the rest bran.

In the Americas, El Salvador did not supply concentrates to any of the categories of animals. The concentrates in the United States comprised 100 percent cereals for both lactating and dry goats. Mexico only fed lactating goats the concentrates, which were entirely composed of cereals. Chile did not supply concentrates to dry goats, whereas lactating animals received concentrates containing cereals (about 30 percent), the rest being miscellaneous feed components. In Brazil, the quantity of concentrates in diets of lactating and dry goats was almost the same (about 16 percent), but the concentrates for lactating goats contained more cereals (about 53 percent) and a substantial amount of cakes/meals (40 percent), whereas those for dry animals contained less cereals (about 38 percent) and more cakes/meals (56 percent).

In Europe, Denmark did not supply concentrates to lactating goats, which instead received compound feed. In the United Kingdom, the concentrates for lactating goats were constituted of cereals and miscellaneous feedstuffs in 1 : 1 ratio; dry goats received concentrates containing about 43 percent miscellaneous feedstuffs, with the rest divided equally between cakes/meals and cereals. In Albania, dry goats were not fed concentrates but lactating goats received concentrates containing about 40 percent bran and about 60 percent cereals. In Italy, concentrates were fed to both categories of goats and contained 100 percent cereals. The concentrates in Poland were composed of cereals and bran in the ratio 1 : 1 for both lactating and dry goats.

Notes: Feed components used in the diet for goats were the same as for sheep and are reported in Table 4.3. For Denmark and Japan, data on feed basket composition for dry goats were not provided.

4.4. DISCUSSION

This study has compiled and analysed a large amount of data on feeding baskets for major domestic animal species. By feeding baskets, we mean the main components of, and their proportion in, the animal diet. Although appreciating the regional variations within a country and variations even within a region, the experts completing the questionnaire were asked to provide national-level information for a particular animal species. Also, the analyses are based on best estimates provided by the experts (respondents) and, hence, an element of subjectivity cannot be ruled out. Therefore, the data presented in this report provide gross country-level information and have limited applicability in making management decisions to improve efficiency or profitability at the farm level. Nevertheless, the gross information generated through the present study serves the purpose of the analyses done at the national level and some examples of such analyses are provided in the "Introduction" (Section 4.1) to this study. In addition, the conclusions drawn at the continent level should be used and extrapolated with caution because, for some continents, data were not available from a large number of countries.

Information on the diversity of the feeding systems has been captured in the IDF part (Section 3) and information on the feeding systems in a representative farm in various countries is given by the IFCN part (Section 5). Both these sections deal with data largely limited to cattle; whereas the data in this FAO study provide information on buffaloes, goats and sheep in addition to cattle. World maps of the feeding basket generated using the FAO data (presented in Section 2.2) are for improved dairy cattle and buffaloes, sheep and goats, both at lactating and dry stages.

Putting together the data on feeding baskets of cattle presented in this part (FAO; Section 4) with the information on feeding systems at the national level and at the representative farm level presented in the other parts of this report could provide a better understanding of the dynamics of feed ingredient use and its impact on animal productivity and the environment in a country. Information on the feed ingredients used, their proportions in various feeding systems characterized for cattle and their contribution to total milk production (IDF; Section 3) could also enable generation of the feeding basket at the national level, which in theory should be similar to those presented in the present study (FAO; Section 4).

The approaches used by FAO for the generation of feeding baskets and that used by IFCN for a representative farm in a country do not provide information on types of feeding systems. On the other hand, the approach used by IDF does give this information; however, for most countries a systematic approach based on field-level data collection and analysis for characterization of feeding system is lacking. Also, similar to the approach used by FAO, the results on characterization of feeding systems by the IDF approach have an element of subjectivity. Further systematic research on characterization and mapping of animal feeding systems using sound field-based approaches at a country level is urgently needed. This is important especially considering that development and use of sustainable strategies for enhancing livestock production depend on the availability of information on feeding baskets, feeding systems and the chemical composition of feedstuffs (Makkar and Ankers, 2014). The

quality of chemical composition data originating from feed analysis laboratories has been questioned because of a lack of integration of quality control approaches in the methods used for analysis of chemical composition of feedstuffs. Furthermore, to make livestock agriculture competitive and resource-use efficient and to develop effective strategies to decrease the carbon footprint or to manipulate animal product composition and quality, reliable information on the quantity of available feed resources in a region or a country is vital. These issues have been addressed by FAO with the development of the manuals *Quality assurance for animal feed analysis laboratories* (FAO, 2011) and *Conducting national feed assessments* (FAO, 2012).

Using a consultative approach, feeding systems have been defined recently and guidelines developed to characterize feeding systems based on the field data and feeding practices. These guidelines are being used in Latin America, Africa and Asia. For Asian countries, the guidelines and information generated using these guidelines were discussed at the FAO-APHCA (Animal Production and Health Commission for Asia and the Pacific) Regional Workshop on "Animal Feed Resources and their Management in the Asia-Pacific Region", 13–15 August 2013; and for the Near East countries at the FAO-ICARDA (International Centre for Agriculture for Dry Areas) Regional Workshop on "Animal Feed Resources and their Management in Near East and North Africa", 24–26 March 2014. Detailed information on the prevalent feeding systems will be available in the proceedings of the workshop at the end of 2014.

Acknowledgement

We thank the respondents who provided us with the information. Without their help this work would not have been possible. Maps in Section 2 ("Mapping of animal feeding systems") were produced by Ms. Alessandra Falcucci, FAO. Her help is gratefully acknowledged. We also thank Mr. Pierre Gerber from FAO for his suggestions and support.

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ANNEX 1

THE QUESTIONNAIRE

Description of terms such as "by-products", "compound feed", "concentrate", "replacement animals" and "fattening animals" used in this questionnaire are given in the "Methodology used" section (Section 4.2).

Cattle

Country: _____

Relative contribution of feedstuffs (on dry matter basis) to the diet, taking into consideration the population in the entire country		CATTLE							
		Local dairy cows, lactating	Local dairy cows, non-lactating	Improved (cross-bred) dairy cows, lactating	Improved (cross-bred) dairy cows, non-lactating	Suckler cows (beef cows; not milked but the milk of these cows goes to the calf)	Replacement animals	Draught animals	Fattening animals
Roughage	A	%	%	%	%	%	%	%	%
	Grass (fresh, hay)	%	%	%	%	%	%	%	%
	Crop residues	%	%	%	%	%	%	%	%
By-products	B	%	%	%	%	%	%	%	%
	1.	%	%	%	%	%	%	%	%
	2.	%	%	%	%	%	%	%	%
	3.	%	%	%	%	%	%	%	%
Cereals	C	%	%	%	%	%	%	%	%
	1.	%	%	%	%	%	%	%	%
	2.	%	%	%	%	%	%	%	%
	3.	%	%	%	%	%	%	%	%
Compound feed	D	%	%	%	%	%	%	%	%
Sum: A+B+C+D		100%	100%	100%	100%	100%	100%	100%	100%

Comments: _____

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Buffaloes

Country: ______________________________

Relative contribution of feedstuffs (on dry matter basis) to the diet, taking into consideration the population in the entire country		BUFFALOES							
		Local dairy buffaloes, lactating	Local dairy buffaloes, non-lactating	Improved dairy buffaloes, lactating	Improved dairy buffaloes, non-lactating	Suckler buffaloes (not milked but the milk of these cows goes to the calf)	Replacement animals	Draught animals	Fattening animals
Roughage	A	%	%	%	%	%	%	%	%
		%	%	%	%	%	%	%	%
		%	%	%	%	%	%	%	%
By-products	B	%	%	%	%	%	%	%	%
	1	%	%	%	%	%	%	%	%
	2	%	%	%	%	%	%	%	%
	3	%	%	%	%	%	%	%	%
Cereals	C	%	%	%	%	%	%	%	%
	1	%	%	%	%	%	%	%	%
	2	%	%	%	%	%	%	%	%
	3	%	%	%	%	%	%	%	%
Compound feed	D	%	%	%	%	%	%	%	%
Sum: A+B+C+D		100%	100%	100%	100%	100%	100%	100%	100%

Comments: ____

Sheep

Country: ______________________________

Relative contribution of feedstuffs (on dry matter basis) to the diet, taking into consideration the population in the entire country		SHEEP				
		Dairy sheep, lactating	Dairy sheep, non-lactating	Reproductive adult sheep (non-dairy)	Replacement animals	Fattening animals
Roughage	A	%	%	%	%	%
		%	%	%	%	%
		%	%	%	%	%
By-products	B	%	%	%	%	%
	1.	%	%	%	%	%
	2.	%	%	%	%	%
	3.	%	%	%	%	%
Cereals	C	%	%	%	%	%
	1.	%	%	%	%	%
	2.	%	%	%	%	%
	3.	%	%	%	%	%
Compound feed	D	%	%	%	%	%
Sum: A+B+C+D		100%	100%	100%	100%	100%

Comments: ____

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Goats

Country: ______________________________

Relative contribution of feedstuffs (on dry matter basis) to the diet, taking into consideration the population in the entire country		GOATS				
		Dairy goats, lactating	Dairy goats, non-lactating	Reproductive adult goats (non-dairy)	Replacement animals	Fattening animals
Roughage	A	%	%	%	%	%
		%	%	%	%	%
		%	%	%	%	%
By-products	B	%	%	%	%	%
	1.	%	%	%	%	%
	2.	%	%	%	%	%
	3.	%	%	%	%	%
Cereals	C	%	%	%	%	%
	1.	%	%	%	%	%
	2.	%	%	%	%	%
	3.	%	%	%	%	%
Compound feed	D	%	%	%	%	%
Sum: A+B+C+D		100%	100%	100%	100%	100%

Comments: ____

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ANNEX 2

DISTRIBUTION OF RESPONDENTS IN DIFFERENT COUNTRIES AND CONTINENTS

Table A2.1. REGION- AND COUNTRY-WISE DISTRIBUTION OF CONTRIBUTIONS

REGION	COUNTRY [NUMBER OF CONTRIBUTORS]	TOTAL NUMBER OF COUNTRIES	TOTAL NUMBER OF CONTRIBUTORS
Africa, total	Côte d'Ivoire [1], Ethiopia [2], Egypt [1], Ghana [1], Mauritius [1], Morocco [1], Namibia [1], Nigeria [1], Rwanda [1], Tanzania [1]	10	11
Central America	El Salvador [1], Mexico [2]	2	3
South America	Brazil [5], Peru [3], Venezuela [2], Chile [1]	4	11
North America	USA [3]	1	3
America, total		7	17
Central Asia	Kyrgyzstan [1]	1	1
Eastern Asia	China [4], Mongolia [1], Japan [1]	3	6
Southeastern Asia	Indonesia [2], Myanmar [1], Thailand [1], Viet Nam [1]	4	5
Southern Asia	India [12], Iran [1], Pakistan [2], Sri Lanka [2]	4	17
Western Asia	Jordan [2], Lebanon [1], Turkey [2]	3	5
Asia, total		15	34
Eastern Europe	Poland [1]	1	1
Northern Europe	Denmark [1], Ireland [2], UK [2]	3	5
Southern Europe	Albania [1], Italy [1], Spain [1]	3	3
Western Europe	Austria [1], Belgium [1], Switzerland [1]	3	3
Europe, total		10	12
Oceania	New Zealand [1]	1	1
Total		43	75

» 75 individuals or groups from 43 countries provided all the information asked for in the questionnaire. Filled-in questionnaires containing incomplete information were not included in the analysis.

» From Asia, 34 contributions from 15 countries; Africa, 11 contributions from 10 countries; Europe, 12 contributions from 10 countries; Americas, 17 contributions from 7 countries; and Oceania, 1 contribution from 1 country were included in the analysis.

Animal-species-based region- and country-wise distribution of contributions is given below.

Table A2.2a. **CATTLE**

CONTINENT	REGION	COUNTRY [NUMBERS OF CONTRIBUTORS]	TOTAL NUMBER OF COUNTRIES	TOTAL NUMBER OF CONTRIBUTORS
Africa	Eastern	Ethiopia [2], Mauritius [1], Rwanda [1], Tanzania [1]	4	5
	Northern	Egypt [1], Morocco [1]	2	2
	Southern	Namibia [1]	1	1
	Western	Côte d'Ivoire [1], Ghana [1], Nigeria [1]	3	3
America	Central	El Salvador [1], Mexico [2]	2	3
	North	USA [3]	1	3
	South	Brazil [4], Chile [1], Peru [1], Venezuela [1]	4	7
Asia	Central	Kyrgyzstan [1]	1	1
	Eastern	China [4], Mongolia [1]	2	5
	Southeastern	Indonesia [2], Myanmar [1], Thailand [1], Viet Nam [1]	4	5
	Southern	India [7], Iran [1], Pakistan [2], Sri Lanka [2]	4	12
	Western	Jordan [2], Lebanon [1], Turkey [2]	3	5
Europe	Eastern	Poland [1]	1	1
	Northern	Denmark [1], Ireland [2], UK [2]	3	5
	Southern	Albania [1], Italy [1], Spain [1]	3	3
	Western	Austria [1], Switzerland [1], Belgium [1]	3	3
Oceania	Australia and New Zealand	New Zealand [1]	1	1
Total			**42**	**65**

Table A2.2b. **BUFFALOES**

CONTINENT	REGION	COUNTRY [NUMBERS OF CONTRIBUTORS]	TOTAL NUMBER OF COUNTRIES	TOTAL NUMBER OF CONTRIBUTORS
Africa	Northern	Egypt [1]	1	1
America	South	Brazil [3]	1	3
Asia	Central	Kyrgyzstan [1]	1	1
	Eastern	China [2]	1	2
	Southeastern	Indonesia [2], Myanmar [1], Thailand [1], Viet Nam [1]	4	5
	Southern	India [7], Iran [1], Pakistan [2], Sri Lanka [2]	4	12
	Western	Turkey [2]	1	2
Europe	Southern	Albania [1]	1	1
Total			**14**	**27**

Table A2.2c. **SHEEP**

REGION	COUNTRY [NUMBERS OF CONTRIBUTORS]	TOTAL NUMBER OF COUNTRIES	TOTAL NUMBER OF CONTRIBUTORS
Africa	Côte d'Ivoire [1], Egypt [1], Ethiopia [2], Ghana [1], Morocco [1], Namibia [1], Nigeria [1], Rwanda [1], Tanzania [1]	9	10
Central America	El Salvador [1], Mexico [2]	2	3
South America	Brazil [3], Peru [1], Venezuela [1], Chile [1]	4	6
North America	USA [1]	1	1
Central Asia	Kyrgyzstan [1]	1	1
Eastern Asia	China [4], Mongolia [1]	2	5
Southeastern Asia	Indonesia[2], Myanmar [1], Thailand [1]	3	4
Southern Asia	India [9], Iran, Pakistan [2]	3	12
Western Asia	Jordan [3], Lebanon [1], Turkey [2]	3	6
Eastern Europe	Poland [1]	1	1
Northern Europe	Denmark [1], Ireland [2], UK [2]	3	5
Southern Europe	Albania [1], Italy [1]	2	2
Western Europe	Switzerland [1]	1	1
Total		**35**	**57**

Table A2.2d. **GOATS**

REGION	COUNTRY [NUMBERS OF CONTRIBUTORS]	TOTAL NUMBER OF COUNTRIES	TOTAL NUMBER OF CONTRIBUTORS
Africa	Côte d'Ivoire [1], Egypt [1], Ethiopia [2], Ghana [1], Mauritius [1], Morocco [1], Namibia [1], Nigeria [1], Rwanda [1], Tanzania [1]	10	11
Central America	El Salvador [1], Mexico [1]	2	2
South America	Brazil [3], Chile [1]	2	4
North America	USA [1]	1	1
Central Asia	Kyrgyzstan [1]	1	1
Eastern Asia	China [4], Mongolia [1], Japan [1]	3	6
Southeastern Asia	Indonesia[2], Myanmar [1], Thailand [1], Viet Nam [1]	4	5
Southern Asia	India [9], Iran, Pakistan [2], Sri Lanka [2]	4	14
Western Asia	Jordan [2], Lebanon [1], Turkey [2]	3	5
Eastern Europe	Poland [1]	1	1
Northern Europe	Denmark [1], UK [2]	2	3
Southern Europe	Albania [1], Italy [1], Spain [1]	3	3
Total		**36**	**56**

5

ANALYSIS OF FEEDING SYSTEMS FOR "TYPICAL" FARMS AN APPROACH USED BY IFCN DAIRY RESEARCH NETWORK (IFCN)

Torsten Hemme, Othman Alqaisi, Asaah Ndambi and Dorothee Boelling
IFCN Dairy Research Network

WITH CONTRIBUTIONS FROM RESEARCHERS IN THE IFCN DAIRY RESEARCH NETWORK AND COUNTRY EXPERTS FROM 48 DAIRY REGIONS IN 44 COUNTRIES WORLDWIDE

5.1. INTRODUCTION

With growing world population and declining availability of natural resources, feeding the world is becoming a challenge for global agriculture. Dairy farming has provided a high value protein source, serving the nutritional requirements of the growing population. However, animal feeding currently faces crucial challenges as a result of the recurrent leap in grain prices, which have risen above their historical level in 2008. This price increase has raised the level of competition for feed, land and farm resources to produce the required quantities to feed the animals in order to produce milk and meat. In 2010, the cost of animal feed was estimated at more than 65 percent of the total cost of milk production on dairy farms worldwide. Moreover, understanding dairy feeding practices is becoming more and more important because of their impact on the environment (emissions of greenhouse gases and nutrient balance) and on economics (dairy farming profitability). With these ideas in mind, IFCN, IDF and FAO initiated this project to characterize feeding systems on dairy farms, aiming at understanding the variations between

systems and identifying feeding regimes that will help in improving the farm management system and lead to better use of feed resources.

The main goals of this study are: (1) to describe typical dairy farms and existing dairy feeding systems worldwide and (2) to analyse the impact of feeding practices on feed economics and feed efficiency.

The justification and importance of the study arise from the fact that feed is the major source of emissions of greenhouse gases; the environmental emissions from the livestock sector largely depend on the efficiency of converting feed resources into milk. Therefore, understanding feed efficiency and animal performance on typical dairy farms is of high importance. From an economic point of view, as stated above, feed cost represents a major part of the total cost of milk production.

In the context of current global changes in feed economics and its impact on the cost of milk production, understanding world dairy feeding systems is important. Feeding systems are very versatile; they differ within a country and across countries and regions. The dynamic and changing patterns of feeding have led to the use of different plants as feed resources that can compete with human consumption. This can have an impact on the global price of grain, which is used for both human and animal consumption, and consequently on the availability of food. The IFCN global feed price indicator (calculated from the world market price for a feed composed of 30 percent soybean meal and 70 percent corn) showed an increase of 150 percent between 2006 and 2011. This increase has an impact not only on feeding systems, but also on global food security and particularly so in developing countries. Therefore, this report focuses on describing and analysing feeding systems, as well as the recent trends in feed costs and prices that exist in 44 countries (representing 48 regions worldwide). Data collection for such a unique study was only possible with the help of country experts from the 44 countries, whose support we highly appreciate. The report shows the characteristics of feeding patterns, composition of the diet, feed intake, stocking rate and feed efficiency and their relationship with milk yield on average typical dairy farms. Additionally, a detailed analysis on economic and performance indicators is provided for four selected countries (Germany, Switzerland, Jordan and Argentina). The selected indicators for the current study are believed to be the most interesting because they give a detailed description of the feeding and economic aspects of dairy farming systems globally and simplify our understanding of the complexity of the topic.

5.2. IFCN METHODS AND TYPICAL FARMS ANALYSED

5.2.1. METHODOLOGY

The International Farm Comparison Network (IFCN) is a global network of dairy researchers, companies and other stakeholders of the dairy chain. It is coordinated by the IFCN Dairy Research Center (DRC) based in Kiel, Germany. IFCN is the leading global knowledge organization with regard to the economics of milk production. The *IFCN Dairy Report* has been produced annually since 2000 and provides an overview on milk production worldwide. There are currently more than 85 countries participating in the IFCN global network. As the

majority of costs, resources, emissions and political challenges are caused by milk production, the IFCN focuses its attention on this fundamental segment of the dairy chain. Related topics, such as milk prices and dairy farm economics, also form an important aspect of the research conducted. The IFCN is committed to the integrity of the science involved and the reliability of its results. With feed being the first step in the milk production chain, the IFCN has attached special importance to its characterization in different farming systems. Research activities include farm comparison, dairy chain analysis and dairy region development. IFCN has also developed tools to evaluate the sustainability of milk production in different farming systems, as well as to analyse the cost of milk production. Milk price analysis and dairy policy analysis, and their impact on milk production, also feature high on the IFCN agenda.

The methodology applied for data collection, data analysis and result validation was developed by the IFCN and uses the TIPI-CAL (Technology Impact Policy Impact CALculations model). This model was developed by Hemme (2000) and has since been refined to be applicable on a global scale. This model is an analytical tool for better understanding farming systems and is based on the concept of "typical farms".

A typical farm represents a significant number of dairy farms existing in a region or a country. The typical farm usually provides a certain share of the milk produced in the country. It is established on the basis of a panel of farmers, advisors and researchers who also validate the characteristics of the farm.

Unlike most other economic analytical methods, the IFCN methodology uses a few typical farms to represent production systems. This means that the selection of such farms is a very crucial issue. The typical farm approach has been proven to be scientifically correct, and it gives access to data on all existing costs, creating transparency and international comparability in the arena of costs of agricultural production. This approach produces results that are closer to reality than statistical averages (Hemme, 2000). Farm analysis using the TIPI-CAL model runs through a number of indicators that will be described in the following sections of this study.

IFCN has collected and validated farm data for over 10 years. Data on animal feeding systems have been collected by the worldwide IFCN expert network since 2005. Over the years, IFCN has developed a robust methodology to collect, compile, analyse and present data, information and knowledge about dairy production systems.

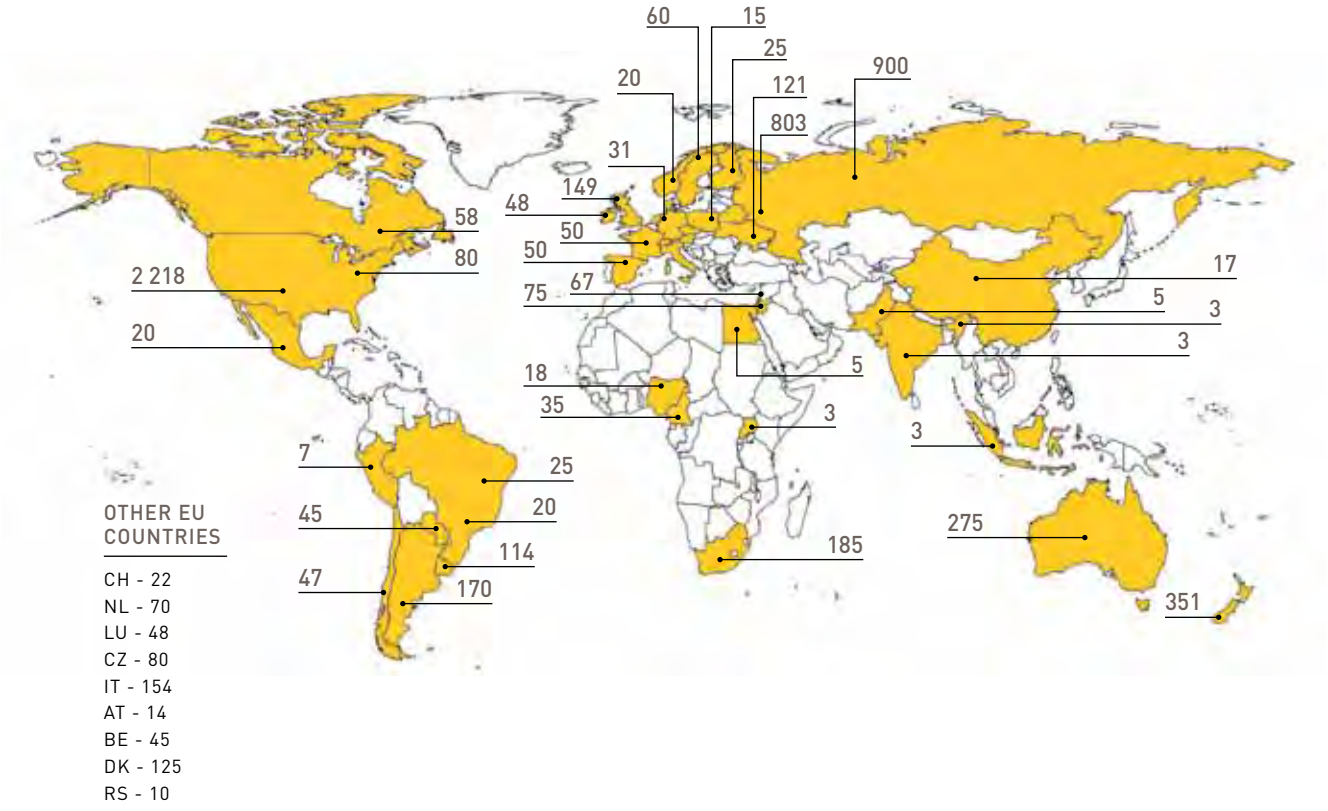
Data from typical dairy farms (around 200–500 variables) were collected via research partners from different countries worldwide. Farm data were inserted into the TIPI-CAL model, which has a sub-module (feed module) combining both physical and economic aspects of feeding systems globally. The model analyses feed efficiency, feed intake data, feed economics, feed prices, efficiency of nutrient use and land productivity on dairy farms (Alqaisi *et al.*, 2011). The results of this study represent average typical dairy farms in 44 countries in 2009.

The countries analysed in this study represent 85 percent of world milk production (cow plus buffalo). The farm types chosen represent 40–60 percent of cows in each country, based on the national farm size statistics of the country. Exceptions are (1) farms in Russia and Ukraine, which have dual milk production systems where very large farms exist alongside very small ones, and (2) farms in the United States, which have a high regional variation in milk production systems.

5.2.2. DESCRIPTION OF DAIRY FARMS ANALYSED

This section of the study shows some background information that describes the typical farms used in the analysis. A short description lists the countries included in the study. The differences in farm size, the share of milk production of a typical farm in relation to the country's milk production and the farming system are highlighted here. Figure 5.1 shows the countries and farms included in the study.

Figure 5.1. TYPICAL AVERAGE-SIZED FARMS USED IN THE STUDY



Numbers in the figure indicate the number of cows per farm on the typical farms analysed
Special cases: in countries where different regions or farming systems were analysed, different average-sized farms were used in the analysis

This part of the study gives background information on the farms analysed and also explains observed tendencies that justify the current situation. In the current report, 48 average-sized farms were analysed, with herd sizes ranging from two cows to greater than 2 000 cows. This variation in farm size is important as it reflects the different feeding systems available in many regions. However, six countries were excluded from the study because of the unreliable quality of the data.

The farm name is identified using the country code followed by a number indicating the number of dairy cows of the respective farm. For example, NO-20 represents a 20-cow farm from Norway. A brief description of average-sized typical farms used in the study is presented below.

NO-20 represents an average-sized farm having Norwegian Red cows in a stanchion barn with pipeline milking system. The farm area comprises 26 ha with 100 percent of the land as grassland. The farm relies strongly on direct payments and also has a cash crop and beef fattening enterprise; the farmer does contractor work for other farmers. Milk average yield is 7 160 kg milk/cow per year.

CH-22 is an average-sized farm having a stanchion barn and pipeline milking system. The dominant breed is Brown Swiss with an average milk yield of 6 310 kg milk/cow per year on 25 ha of land, of which 90 percent is grassland. The farm relies heavily on direct payments. It also has cash crops and other livestock and does contractor work for other farmers.

FI-25 is an average-sized farm with a stanchion barn with a pipeline milking system and has 53 ha with little grassland. The dominant breed is a cross of Ayrshire and Holstein, with an average milk yield of 8 191 kg milk/cow per year. The farm strongly relies on direct payments and has also cash crops and forest land.

AT-14 represents an average-sized farm in the Austrian Alps with a stanchion barn. Simmental cows are dominant and milk yield is 6 200 kg milk/cow per year. The farm consists of 18 ha farmland, of which 70 percent is grassland. The farm heavily depends on direct payments and has also forest land. All of the work on the farm is done by family members.

DE-31S characterises an average-sized farm located in southern Germany, having dual-purpose cows (Simmental) with a milk yield of 6 580 kg milk/cow per year. The cows are kept in a stanchion barn where milking is done via a pipeline system. The farm operates on 39 ha of land (58 percent grassland) and has cash crop returns besides dairying. Additionally, the farmer does contractor work for other farmers. About 96 percent of the work on the farm is done by family members.

DE-90N characterises an average-sized farm in northern Germany, having Holstein Friesian cows with an average milk yield of 8 165 kg milk/cow per year. The cows are kept in a free stall barn where milking is done using a 2 × 6 herringbone parlour. The farm operates on 97 ha of land (46 percent grassland) and has some cash crop returns and fattens its male calves. Besides the family members, a large share of the work is done by young people being trained as farmers on the farm.

NL-70 is an average-sized farm in the Netherlands, the farm operating on 41 ha of land (90 percent grassland) with a free stall barn and a milking parlour. The average milk yield is 8 420 kg milk/cow per year. About 90 percent of the work on the farm is done by family members and major share of forage production work is done by contractors.

BE-45 represents an average-sized farm in Belgium, the farm operating on 40 ha of land (30 percent grassland) and having a free stall barn. The average milk yield of the Holstein Friesian cows on this farm is 7 660 kg milk/cow per year. The farm fattens the male calves on the farm. All of the work on the farm is done by family members.

LU-48 is an average-sized farm located in Luxemburg. It has Holstein Friesian cows with a milk yield of 7 475 kg milk/cow per year. The cows are kept in a free stall barn where milking is done using a milking parlour. The farm operates on 97 ha of land (52 percent grassland). Besides dairy, the farm sells cash crops and fattens beef bulls. About 90 percent of the work is done by family members.

FR-50-W represents an average-sized farm in the western part of France with a free stall barn and a milking parlour. The farm operates on 61 ha (60 percent grassland). From its Holstein cows, it has a milk yield of 7 470 kg milk/cow per year. Besides dairy, the farm also has returns from cash crops. All the work is done by the family members.

ES-50NW is an average-sized farm in northwest Spain (Galicia), having Holstein cows with a milk yield of 9 330 kg milk/cow per year. The cows are kept in a free stall barn and milking is done using a parlour system. The farm operates on 23 ha of land (50 percent grassland). All work on the farm is done by family members.

IT-154 represents an average-sized farm in northern Italy (Lombardy), having Holstein cows with a milk yield of 8 810 kg milk/cow per year. The cows are kept in a free stall barn where milking is done in a parlour system. The farm operates on 72 ha of land that is very fertile and can also be used for cash crops. About 56 percent of the work on the farm is done by family members.

UK-149NW represents an average-sized farm in the United Kingdom, located in the north western part of the country. The Holstein Friesian cows have a milk yield of 7 780 kg milk/cow per year. The farm operates on 130 ha (92 percent grassland); the other part of the land is used for cash crops. Besides dairy, the farm generates returns from fattening beef bulls. About 39 percent of the work is done by family members.

IE-48 reflects an average-sized farm in Ireland with a free stall barn and a milking parlour. The farm operates on 44 ha of grassland. From its Holstein cows and with a seasonal grazing system (supplemented with compound feed), it has a milk yield of 7 000 kg milk/cow per year. About 90 percent of the work is done by family members.

DK-125 represents an average-sized farm located in Denmark; it has Holstein cows with a milk yield of 9 352 kg milk/cow per year. The cows are kept in a free stall barn where milking is done in a parlour. The farm operates on 116 ha of land (10 percent grassland) and has cash crop returns. About 60 percent of the work is done by family members.

SE-60 is an average-sized family farm having a stanchion barn with a pipeline milking system. The farm is located in Sweden and operates on 80 ha with 15 percent grassland. The milk yield of the Holstein Friesian cows is 9 805 kg milk/cow per year. The farm generates returns from selling cash crops (grain). About 90 percent of the work is done by family members.

PL-15 characterises an average-sized family farm in Poland, having a stanchion barn with a pipeline milking system. The milk yield of the cows is 6 830 kg milk/cow per year. The farm operates on 32 ha, which is mainly used to produce forage and grain for the dairy cows. All the farm work is done by family members.

CZ-80 represents a family farm in the Czech Republic that was developed after 1991. The farm keeps Holstein Friesian cows, has a free stall barn and a milk yield of 9 200 kg milk/cow per year. The farm operates on 108 ha of which 10 percent is grassland.

RS-10 is an average-sized family farm in Serbia, having a stanchion barn with a bucket milking system. The farm operates on 15 ha of land and has 50 percent Holstein and 50 percent dual-purpose cows with an average milk yield of 5 680 kg/cow per year. All farm work is done by family members.

UA-121 represents an average-sized farm in the Ukraine in which dairy is only a small segment of the whole farm. It has 1 121 ha of land, grows cash crops and has beef fattening and other livestock such as hogs and sheep. The breed is Ukrainian Red and White, which has a milk yield of 4 000 kg/cow per year. As this is a corporate farm all work is done by employees.

BY-803 represents a traditional corporate farm, which accounts for the greater part of milk in Belarus. The farm operates on 4 900 ha and has a big cash crop activity. The milk yield is 4 430 kg per cow per year. The farm operates in a free stall barn; all work on the farm is done by employees.

RU-900 characterises traditional corporate farms in Russia. For the IFCN analysis, we located this farm in the Krasnodar region. The farm operates on 11 082 ha and cash crops are the major agricultural activity. The milk yield is 5 600 kg/cow per year. The farm operates in a free stall barn with a milking parlour.

IL-67 represents an average-sized "family operated" farm in Israel with a free stall barn and a milking parlour. The farm operates as a feedlot and purchases all its feed. From its Holstein cows and intensive feeding system, the milk yield is 10 362 kg/cow per year. About 56 percent of the work is done by family members.

JO-75 reflects an average-sized feedlot farm with 5 ha of land located in the Al-Duhleel semi-arid area in Jordan. The dominant breed is Holstein Friesian, which produces 6 360 kg milk/cow per year. Cows are milked by a pipeline milking system. The feeding is based on imported

concentrate, and zero grazing is typically practiced. Photo 5.3 shows the feedlot dairy farming system in Jordan. About 20 percent of the work on the farm is done by family members.

EG-5 represents an average-sized household farm in Egypt, keeping water buffaloes with a milk yield of 2 828 kg milk/buffalo per year. Milking is done by hand; the barns are quite simple and located in the backyard of the farm house. The farm operates on half a hectare of irrigated land and uses also part of this land for cash crops.

UG-3 is an average-sized farm from Uganda, having local Ankole breed cows mainly for beef production and dairying as a side business. The cows are milked by hand in a fenced area where they also sleep. One herdsman collects 3–4 such herds every morning for grazing and returns them to the owner in the evenings. The cows have no concentrate supplementation, which explains a milk yield of less than 1 000 kg milk/cow per year.

NG-18 represents an average-sized household farm in northern Nigeria keeping cross-breeds of local cows and Holstein. The farm is a landless production system with a milk yield of 3 050 kg milk/cow per year. Feeding is mainly from grass cut from public areas and additional concentrate supplementation. Milking is done by hand; the barns are quite simple in the backyard of the house.

CM-35 is an average-sized farm in the western highlands of Cameroon, having local Fulani breed cows mainly for beef production, with dairying as a side business. The cows are milked by hand in a fenced area where they also sleep. They usually graze on communal pastures throughout the day and have no concentrate supplementation, which explains a milk yield of less than 1 000 kg milk/cow per year.

ZA-185 is an average-sized farm in the country. As South Africa has such a diversity of farming systems, this farm type represents a feedlot rather than a grazing system and is typical for the Free State (centre of South Africa), which is dry and has less than 500 mm rain per year. The milk yield of the Holstein cows is 6 750 kg milk/cow per year. The farm operates on 397 ha, which is only partly used for producing dairy feed. The major share of work is done by hired employees.

CA-58 represents an average-sized farm in the province Ontario in Canada with 133 ha of land. The cows are Holstein Friesian, kept in a stanchion barn with a milk yield of 7 270 kg milk/cow per year. About 75 percent of the work on the farm is done by family members.

US-80WI is an average-sized family farm having a traditional stanchion barn with a pipeline milking system. Such farms are very typical for the northeast of the United States, this one being located in Wisconsin. The farm operates on 76 ha of land and about 80 percent of the work is done by family members. The milk yield of the Holstein Friesian cows is about 8 960 kg milk/cow per year.

US-2218NY represents a larger type of farm with a free stall barn and a milking carousel. This farm has been set up in the state of New York and the work is mainly done by hired employees. The farm operates on 1 909 ha and produces most of its feed needs on the farm. In addition, this farm creates some returns via cash crops. The milk yield of the Holstein Friesian cows is approximately 10 610 kg milk/cow per year.

MX-20 is an average-sized farm for Mexico and has been set up in the province of Hildalgo. The farm keeps 20 Holstein cows with a milk yield of 4 810 kg milk/cow per year, milked by hand. The farm operates on 4 ha of land, which means most of the feed is bought in. The major share of the work is done by family members.

AR-170 represents an average-sized farm with 200 ha of land, located in the province of Santa Fe in Argentina. The milk yield is 5 160 kg milk/cow per year. Besides grazing, compound feed is provided but no concentrate is given. Milking is done in a parlour. About 20 percent of the work is done by family members.

UY-114 characterises an average-sized farm located in Uruguay with a grazing system and a milk yield of 5 320 kg milk/cow per year. The farm has 213 ha of land. Milking is done in a parlour.

PY-45 is an average-sized farm (Chaco region in Paraguay) with a grazing system and a milk yield of 3 820 kg milk/cow per year. The farm has 72 ha of land and milking is done in a parlour. The cows are not housed. All farm work is done by family members.

CL-47 represents an average-sized grazing farm located in the south of Chile (X. Region). The farm operates on 120 ha and uses a milking parlour. In winter time, the farm has some basic barn facilities. The milk yield is 4 820 kg milk/cow per year as the farm feeds approximately 340 kg of compound feed per cow per year.

BR-20S represents an average-sized farm in the south of Brazil; it is a family farm operating on 18 ha of land. The farm uses a bucket milking machine. The milk yield is 3 980 kg milk/cow per year.

BR-25SE represents an average-sized farm in the southeast of Brazil (Minas Gerais). It is family farm operating on 53 ha of land. The cows are a cross of Gir and Holstein Friesian. Milking is done with a bucket milking machine. Milk yield is 1 460 kg milk/cow per year.

PE-7 reflects an average-sized family farm and is located in the dairy region of Cajamarca at high altitude (3 000 m above sea level) in Peru. The farm operates on a grazing system and has 16 ha of land. The cows are Brown Swiss, have a milk yield of 2 360 kg milk/cow per year and are milked by hand. All the work is done by family members.

IN-3S is an average-sized farm in India, household style with cross-bred cows that produce 2 940 kg milk/cow per year. The feeding system is based on straw, crop residues and compound feed. The family relies strongly on cash crop returns, sales of manure and off-farm income. This farm was chosen to represent feeding systems in India on the maps shown in this report.

IN-3E is an average-sized farm in India (West Bengal), household-style with cross-bred cows that produce 1 390 kg milk/cow per year. The feeding system is based on by-product feeds and concentrate. The family relies strongly on cash crop returns but to a lesser extent compared with farm IN-3S.

PK-5 represents an average-sized household farm in rural areas (Punjab) in Pakistan, keeping 5 Nili Ravi buffaloes and operating on 5 ha of land. The milk yield is 2 100 kg milk/buffalo per year and milking is done by hand. Besides dairy, the farm generates a return from cash crops and beef fattening as well as from selling manure.

BD-2 represents an average-sized household-type farm in Bangladesh with 0.5 ha of land. The feeding system is based on straw and other crop residues. The family relies strongly on cash crop returns, the value of manure and the off-farm income of the husband.

ID-3NG is an average-sized farm located in Indonesia and having Holstein cows that are milked by hand. The farm has less than half a hectare of land with Napier grass. In addition, because of to its location in the high altitude zone (700 m above sea level), the farm has access to forest land from which it harvests natural pastures. Milking is done by hand and the milk yield is about 2 710 kg milk/cow per year. Feeding is mainly imported concentrates, agro-industrial by-products and grass.

CN-17N represents a family farm in China that operates within a dairy garden in the region of Beijing. About 95 percent of the work is done by family members. The farm has no land; all concentrate and roughage are purchased. Milking is done via a central parlour, which is also commonly used by other farmers in these villages. An investor sets up the barn and also the milking centre for about 20 farm units similar to CN-17 and in return gets a share of the milk price received from the milk processor.

AU-275WA represents an average-sized farm located in Western Australia that operates on 160 ha of land. The milk yield is 7 060 kg milk/cow per year, which indicates that besides grazing, a small amount of compound feed is used.

NZ-351 is an average-sized farm in New Zealand, located on North Island. The farm has 128 ha, which is mainly used for grazing. The milk yield of the Holstein-Jersey cross-bred cows is 4 600 kg milk/cow per year. Milking is done by a swing-over parlour. The cows are not housed.

Photo 5.1. HARVESTING CORN STRAW IN NORTHERN CHINA

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Photo 5.2. LARGE-SCALE DAIRY FARMING IN MEXICO – TORREON

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Table 5.1. DESCRIPTION OF THE TYPICAL DAIRY FARMS ANALYSED

TYPICAL FARM	No. OF COWS	MILK YIELD (kg ECM/ cow)	REGION	BREED	TOTAL LAND (ha)	TOTAL LABOUR INPUT (labour units)	FAMILY LABOUR INPUT (% of total labour)
NO-20	20	7 156	Nord-Østerdalen	Norwegian Red	25.9	1.7	89%
CH-22	22	6 305	Hilly area	Brown Swiss	25.0	2.1	82%
FI-25	25	8 191	Päijät-Häme	Ayrshire/ HF	53.7	2.5	99%
AT-14	14	6 204	Styria	Brown Swiss	18.0	1.2	100%
DE-31S	31	6 576	Southern Germany	Simmental	39.3	1.5	96%
DE-90N	92	8 165	Northern Germany	HF	97.0	3.3	45%
NL-70	70	8 416	North Netherlands	HF	41.3	1.2	92%
BE-45	45	7 663	Belgium	HF	40.0	2.5	100%
LU-48	48	7 475	All the country	HF	96.5	1.8	91%
FR-50-W	50	7 466	Western France	HF	61.0	1.9	100%
ES-50NW	50	9 328	Galicia	HF	23.0	1.9	100%
IT-154	154	8 809	Lombardy	HF	72.0	4.3	56%
UK-149NW	149	7 784	NW England	HF	130.0	2.8	39%
IE-48	48	6 998	Southern Ireland	HF	44.0	1.7	91%
DK-125	125	9 352	Jutland	HF	115.8	2.1	59%
SE-60	60	9 805	Skåne, Hörby	HF	80.0	2.0	90%
PL-15	15	6 826	Mazowieckie	HF and local breed	32.0	2.5	100%
CZ-80	80	9 201	Northeast Czech R.	HF	108.0	2.7	67%
RS-10	10	5 675	Vojvodina	HF, Simmental	15.0	2.4	100%
UA-121	121	3 945	Chernihivska	Ukrainian Red and White	1 121.2	76.3	0%
BY-803	803	4 432	All the country	HF	4 897.8	240.1	0%
RU-900	900	5 600	Krasnodar	Ayrshire	11 082.0	407.6	0%
IL-67	67	10 362	All the country	HF	0.4	2.7	56%
JO-75	75	6 358	Al-Dhuleel	HF	5.0	5.4	21%
EG-5	5	2 828	R Behera	Egyptian buffaloes	0.6	2.0	63%
UG-3	3	728	Kayunga	Local Ankole	1.6	1.6	67%
NG-18	18	3 050	Kano	Bunaji x HF crosses	0.2	2.8	51%
CM-35	35	645	Western Highlands	Fulani	40.0	2.2	44%
ZA-185	185	6 754	Free-Sate		397.0	5.2	18%
CA-58	58	7 273	Québec	HF	133.0	1.6	76%
US-80WI	80	8 963	Wisconsin	HF	76.0	3.0	79%
US-2218NY	2218	10 605	Northeast USA	HF	1 909.0	48.5	8%

TYPICAL FARM	No. OF COWS	MILK YIELD (kg ECM/ cow)	REGION	BREED	TOTAL LAND (ha)	TOTAL LABOUR INPUT (labour units)	FAMILY LABOUR INPUT (% of total labour)
MX-20	20	4 812	Hidalgo Mexico	HF	4.0	2.4	46%
AR-170	170	5 158	Sta.Fé-Córdoba	HF	227.0	4.8	20%
UY-114	114	5 322	South Uruguay	HF	213.0	3.6	30%
PY-45	45	3 827	Chaco	HF	72.0	1.9	100%
CL-47	47	4 820	Xª Región	HF & HF x Jersey	120.0	2.4	6%
BR-20S	20	3 981	Santa Catarina	HF	17.5	1.3	100%
BR-25SE	25	1 460	Minas Geráis	Gir (milk) x HF	52.9	0.9	100%
PE-7	7	2 362	Polloc, Cajamarca	Brown Swiss	15.8	1.9	100%
IN-3S	3	2 939	Karnataka	HF cross-breed	3.9	1.9	100%
IN-3E	3	1 390	West Bengal	Jersey cross-breed	0.5	1.4	53%
PK-5	5	2 098	Central Punjab	Nili ravi buffaloes	4.9	4.0	74%
BD-2	2	749	Dinajpur	Local	0.5	0.7	75%
ID-3NG	3	2 707	East Java	HF	0.3	1.2	100%
CN-17N	17	4 653	Northern China	HF	0.0	2.8	95%
AU-275WA	275	7 055	Western Australia	HF	160.0	3.2	53%
NZ-351	351	4 604	Waikato	Cross-bred HF/Jersey	126.1	2.6	42%

Explanations

Farm code: Example: JO-75 represents a 75-cow farm in Jordan

No. of cows: Average number of dairy cows (lactating and dry) per year.

Milk yield: The total volume of milk produced per cow and per calendar year adjusted to energy-corrected milk (ECM) with 4% fat and 3.3% protein.

Labour: Hired and family labour input for the whole farm (1 unit = 2 100 hours)

5.2.3. FARM SIZE AND STOCKING RATE

Farm size represents the average number of adult dairy cows (dry and lactating cows) per year.

The detailed analysis in Table 5.1 covers 48 typical dairy farms from 48 dairy regions and 44 countries of the world. For each of the 48 regions analysed, one average-sized farm has been used.

The average farm size in 2010 was estimated by the IFCN as 2.4 cows per farm globally. The mean farm size on the typical farms studied was estimated at 144 cows per farm. The average farm size varied between 2 218 cows on one of the North American farms and 2 cows on the farm in Bangladesh.

On a regional scale, the variation in size on the European farms ranged between 154 cows on the Italian farm and 14 cows on the Austrian farm. Near East and African farm size varied between 185 cows in South African and 3 cows on the Ugandan farm. This variation was bigger for the North and South American farms as it varied between 2 218 cows in North America and 7 cows in Peru. In Southeast Asia, small-scale farming was traditionally practiced (Hemme and Otte, 2010), with an average farm size of 3 cows in India and 2 cows in Bangladesh; whereas in Oceania, the average farm size was estimated at 351 in New Zealand and 275 in Australia. Details are shown in Figure 5.2.

The exceptions are countries with two distinct milk production systems, where very large farms exist alongside very small ones (Belarus, Ukraine) or large countries with high regional variation in milk production (Germany, Brazil and the United States). In the first group of countries, the level of management was of relevance and, therefore, the average large farms were used in the study. In the latter group of countries, two typical farms were used: the first was an average-sized farm and the second was the large-scale type of typical farm.

The **stocking rate** on an average-sized farm is illustrated in Figure 5.3. Three stocking categories were defined: The first is a farming system with a low stocking rate (less than 1 livestock unit (LU) per hectare), which is predominant on farms with a large land area: examples are the RU-900 and CA-85 farms. The second category is a farming system with an average stocking rate (between 1 and 3 LU/ha). This is common on most farms in Western Europe, the United States and Latin America. On these farms, the land area per cow is smaller, which indicates that the land is either more productive or more feed is purchased. The third category has a high stocking rate (over 3 LU/ha), which is dominant on feedlot farms that are based on a concentrate feeding system and purchase of the majority of their feed. If these farms own pasture land, zero grazing is practiced. Examples for these farms are the CN-17, JO-75 and the MX-20 feedlot farms.

The variation in stocking rate between farms is attributed to the availability of land resources.

Explanations

Farm code: Example: JO-75, which is a 75-cow farm in Jordan (for details see Table 5.1).
Farm size: Indicated by the average number of dairy cows (lactating and dry) per year.
Milk yield: The total volume of milk produced per cow per calendar year adjusted to energy-corrected milk (ECM) with 4% fat and 3.3% protein.
Stocking rate: Represents the average livestock unit (1 LU = 650 kg) per hectare of land of the dairy farm.

Figure 5.2. **FARM SIZE INDICATED BY NUMBER OF COWS PER FARM**

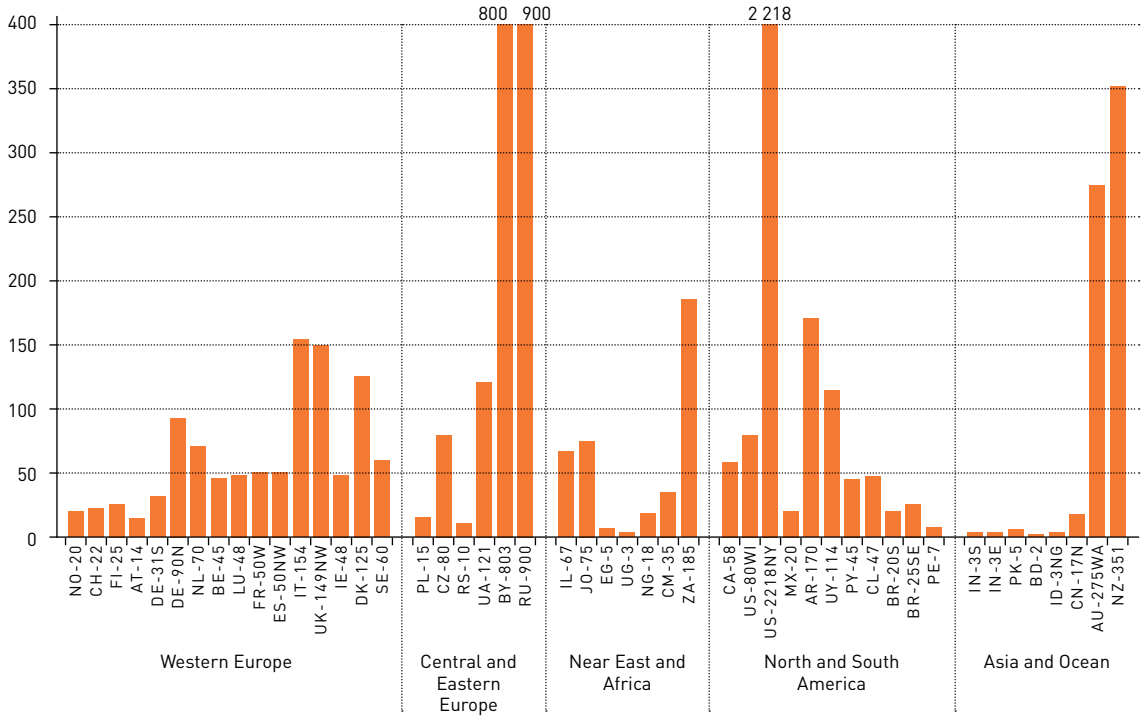
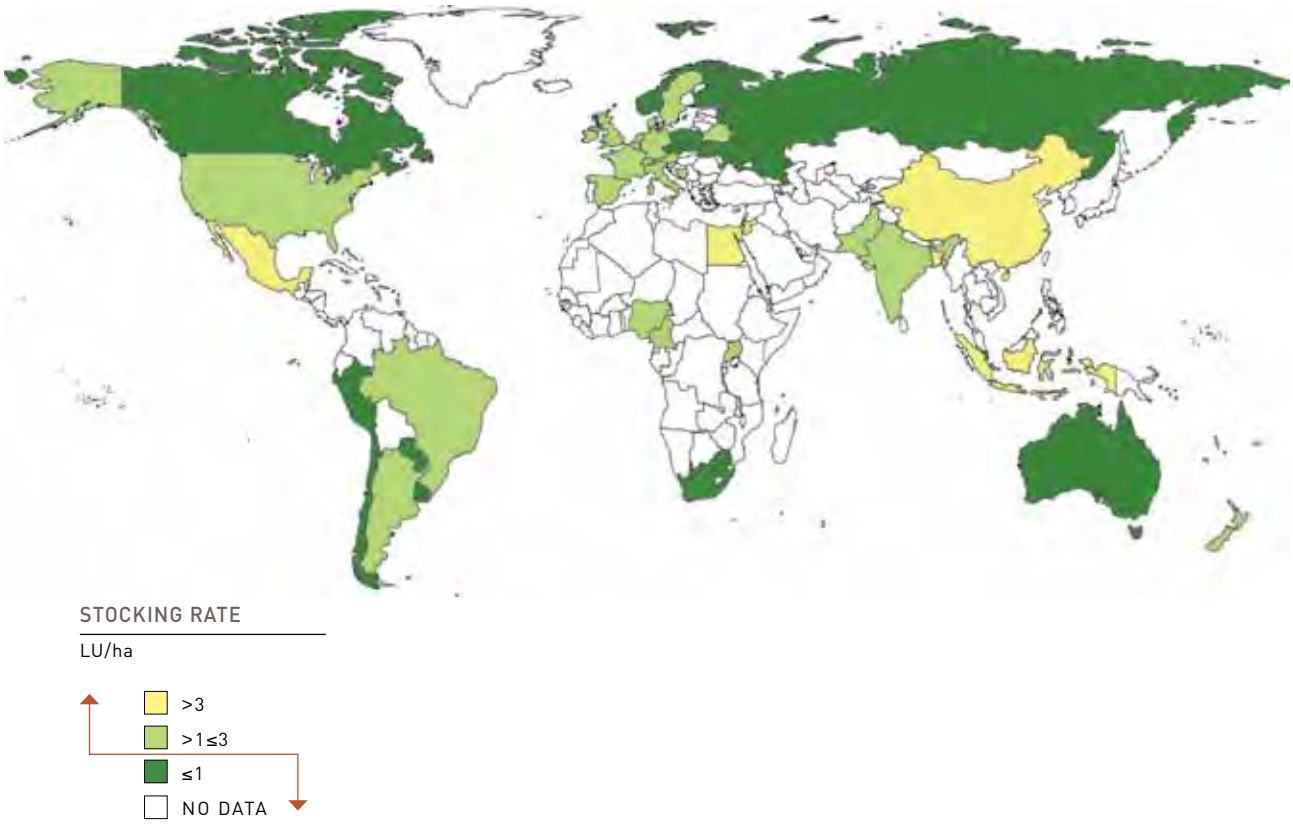


Figure 5.3. **STOCKING RATE ON THE AVERAGE-SIZED TYPICAL FARMS ANALYSED**



5.2.4. MILK YIELD OF TYPICAL DAIRY FARMS

This part of the study discusses the milk yield on typical dairy farms and the factors that impact them. Figure 5.4 gives detailed information on the average milk yield on the farms studied and Figure 5.5 shows the world map of annual milk yield per lactating animal (cows and buffaloes) and divides farms into six categories according to yield.

Average milk yield on all farms analysed was 5 800 kg/cow per year. Milk yield on the typical average-sized farms in this study varied between low milk yields of 650 kg/cow per year in the Cameroonian farm (Ndambi and Hemme, 2009) and more than 11 000 kg/cow per year on the US-2218NY farm in New York. Milk yield was determined by feed ration, breed and farm management.

Generally, about 60 percent of all farms analysed have pure Holstein Friesian cows. Many Holstein Friesian farms are characterized by intensive management and feeding systems, resulting in milk yields of more than 7 000 and up to 11 000 kg/cow per year. This is the case in Western Europe, the United States and Israel.

On the EU farms, milk yield ranged between 6 200 kg on the AT-14 farm and 9 300 kg/cow per year on the ES-60 farm. This level of milk yield was influenced by the genetics of the cows, the quality and nature of the feedstuff offered to the animals and the management.

Another category of milk production shown in Figure 5.5 is a milk yield ranging between 5 000 and 7 000 kg/cow per year, which can be found on average-sized farms located in Argentina, Australia, South Africa and Russia. The level of milk production in this category was influenced by feeding less compound feed because more farm land was allocated for forage production.

In the next category, milk yield on a typical average-sized farm ranged between 3 000 and 5 000 kg/cow per year. Examples of this category are Brazil, China and Nigeria. The main impact on milk yield was influenced by lower feed quality, e.g. feeding straw on the CN-17 farm or elephant grass on NG-18, as well as the effect of breed.

Milk yield levels between 1 000 and 3 000 kg/cow per year were found on Southeast Asian farms located in India, Pakistan and Indonesia. On these farms, the milk yield was influenced by the typical feeding system for that region, which is based on agricultural by-products of low quality, and by the use of local buffalo animals, which are characterized by low milk yield.

The lowest milk yield in the farms studied was obtained on the CM-35, UG-3 and BD-2 farms. On the first two farms, the low milk yield is associated with the dual-purpose production of both milk and beef. Furthermore, cows of local breed raised on these farms are basically fed on elephant grass. On the BD-2 farm, the low milk yield is determined by the small size of the buffalo breed of Dinajpur, which is characterized by low milk yield, as well as by the use of a large proportion of agricultural by-products such as rice straw as feed.

Figure 5.4. MILK YIELD IN 1 000 KG ENERGY-CORRECTED MILK/COW/YEAR

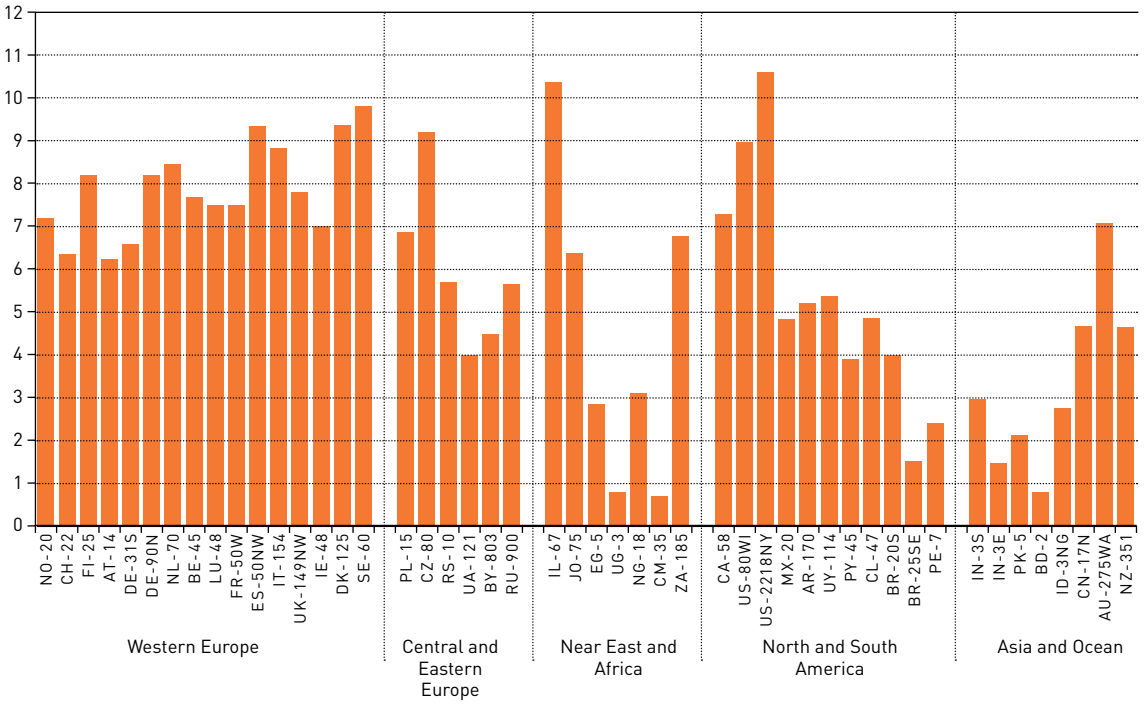
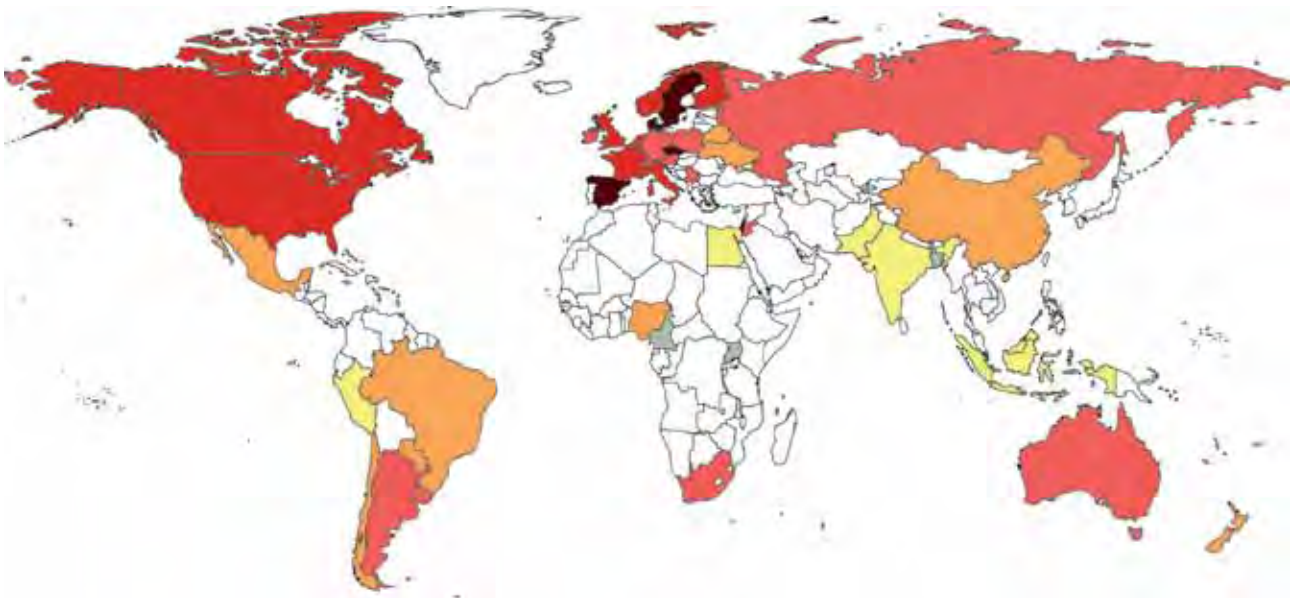


Figure 5.5. MILK YIELD PER COW PER YEAR ON AVERAGE-SIZED TYPICAL FARMS



MILK YIELD OF AVERAGE-SIZED TYPICAL FARM

100 kg ECM kg/cow

- >9
- >7≤9
- >5≤7
- >3≤5
- >1≤3
- ≤1
- NO DATA

5.3. MAPPING AND COMPARISON OF FEEDING SYSTEMS

5.3.1. FEED COMPOSITION

This section describes the feeding systems on the typical average-sized farms used in the study. Dairy feeding systems are globally diverse and differ between countries and farms within a country. For example, feeding systems in India are based on the heterogeneous agro-climatic conditions, topography, availability and other socio-economic factors. There are 20 agro-eco regions and 60 agro-eco sub-regions in India. Each of the agro-eco sub-regions is further subdivided into agro-eco units at district level for long-term land use strategies. The type of feed available for feeding dairy animals depends on the region to which the district belongs and on the particular agro-eco unit. On Indian farms, also including large-scale farms, purchased wheat bran, Ragi straw, cottonseed cake, Bazra straw, Jowar straw and oilseed by-products are the dominant feed items on farms.

However, in order to understand better the existing feeding systems on different farms, Figure 5.6 shows the ration composition (percentage of dry matter intake) for lactating cows on typical dairy farms in 44 countries. The chart shows the IFCN characterization of the most dominant feed items on dairy farms, which include the major groups of concentrates (both processed and non-processed), corn silage, grass, grass silage, hay and other feedstuffs.

On a regional basis, the **EU farms** can be divided into two categories: grass-based feeding systems (including grass silage) and corn-silage-based systems. In countries with either little arable land or a substantial amount of permanent grassland, the feeding system is mainly based on grass and grass silage, e.g. the farms NO-20, CH-22, FI-25 and AT-14 as well as UK-149 and IE-48. On the IE-48 farm, the land is used for grazing; however, little concentrate feed is offered to the cows. On the UK-149NW farm, only little fresh grass was fed, but more grass silage and also a small amount of maize silage were used. On the other EU farms, the major feed components are maize and grass silage. On all farms, concentrate feed is added as supplement to the diet, in different proportions. In most European countries, the ration is made up of less than 30 percent concentrate; only very few countries feed 40 percent or more (Finland, Spain, Serbia and Russia). The diets are mainly based on fresh grass and either maize or grass silage.

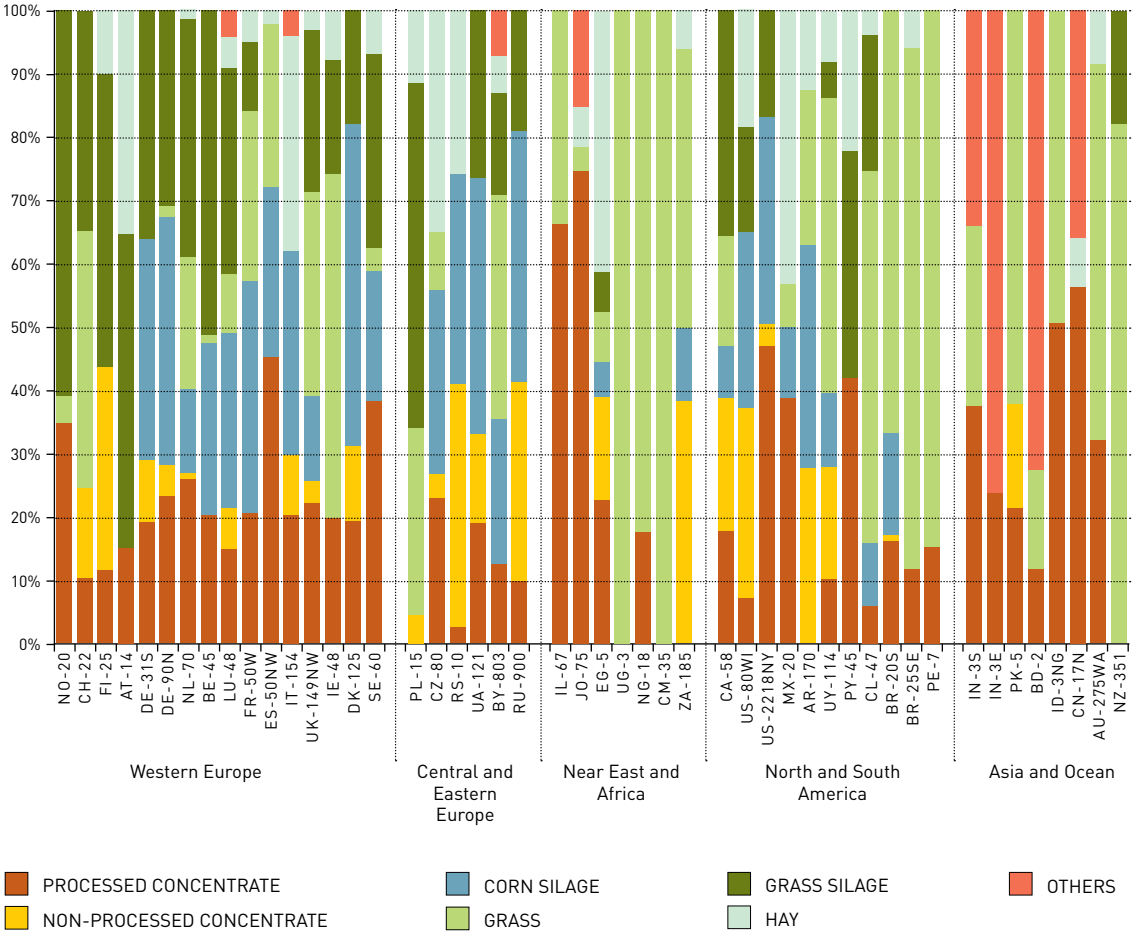
In **northern Africa** and the **Near East** regions, feeding systems can be classified as feedlot systems, dominant on the IL-67 and JO-75 farms, which depend on imported concentrate feeds because of the shortage of water and arable land. Concentrate feeding was the highest among the farms studied and typically exceeded 65 percent of the total ration. In African countries, the feeding system is very different, grazing on pasture being the most common system. The dominance of this system is due to the fact that arable land is used to produce grain for human consumption. Additionally, farming is based on a dual-purpose system; the cows have only a low productivity and therefore are only fed small amounts of concentrates.

Feeding systems are quite similar on the **North American farms**, where about 40 percent of the diet is composed of concentrate feed. The CA-58 farm feeds a large proportion of grass silage whereas US-80WI and US-2218NY farms feed a large proportion of maize silage. This is

dominant because of the availability of arable land used for crop production; additionally, the high level of milk yield requires additional supplements of concentrate feed.

In **Latin America,** grass-based systems are dominant on average-sized farms; a cut-and-carry system was notified on the Brazilian farms; and a grazing system was practiced on the CL-47 farm, where the share of grass exceeded 85 percent of the diet, with the final 10–15 percent being made up of processed concentrate.

Figure 5.6. RATION COMPOSITIONS ON TYPICAL AVERAGE-SIZED FARMS, BASED ON SHARE OF PERCENTAGE DRY MATTER



Explanations

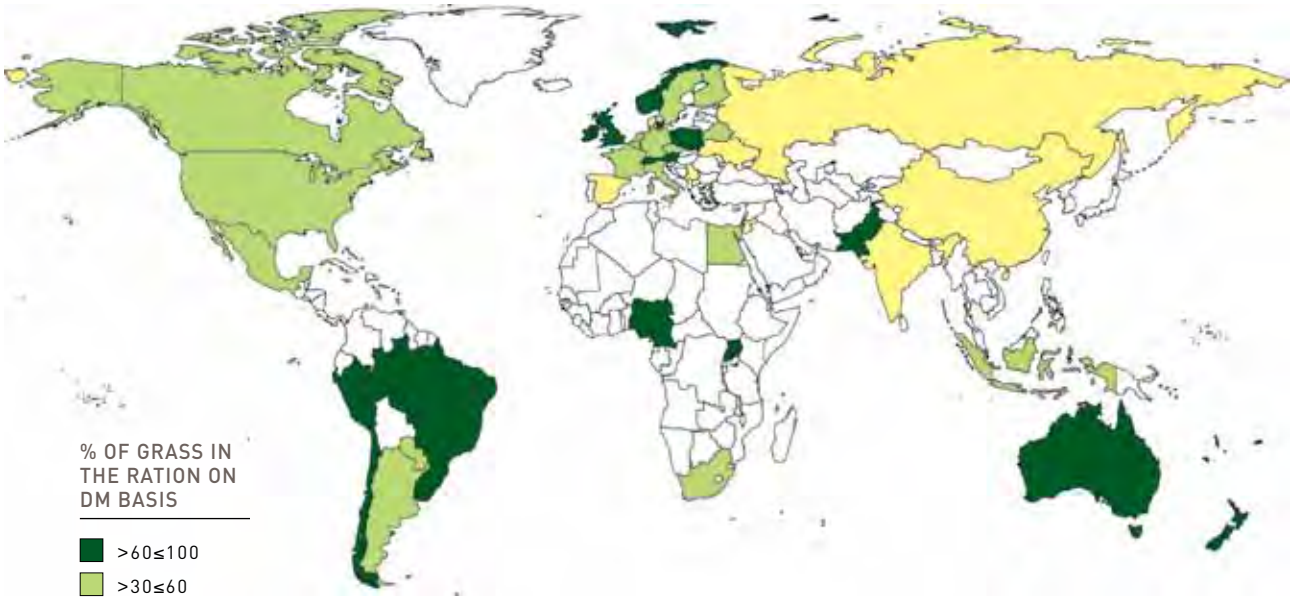
Ration composition: On typical average-sized farms, figures are calculated as follows: the estimated dry matter intake (eDMI) from each single feed item is divided by the total eDMI from the ration.

Share of grass in the diet: Expressed as a percentage of DM, which equals eDMI of grass (all types of fermented grass, dried grass, cut-and-carry and grazing pasture) divided by total eDMI from the ration.

Grass feed: As shown in Figure 5.7, includes all types of fermented grass, dried grass, cut-and-carry and grazing pasture.

Corn silage: Also called maize silage, consisting of cobs, seeds, leaves and stalks of maize plant.

Figure 5.7. SHARE OF GRASS IN THE RATION (PERCENTAGE OF DRY MATTER)



In Latin America, most of the arable land is used to produce cash crops for export purposes, whereas other land, such as the Pampa, is used for grass production and grazing.

The **Southeast Asian farms** have different feeding systems. The ration was composed of low quality concentrate and agricultural by-products and, in addition to that, low quality grass from pasture or cut-and-carry grass for lactating animals. On the CN-17 farm, the feedlot system is dominant as there is no land allocated for crops or grass production. The basic components of the diet are purchased concentrate and whole plant maize straw. On the IN-3S farm, concentrate feed represented 37 percent of the total diet, whereas on the IN-3E farm with a less intensive system, concentrate represented 24 percent of the diet. These two farms only represent small scale farms in India and may not reflect the situation in other farming systems.

In **Oceania,** grazing systems are dominant. On the AU-275AW farm, feeding is based on grass from pasture with a concentrate supplement of 30 percent in the diet, whereas on the NZ-351 farm, no concentrate was fed and the total diet was based on ryegrass from pasture lands (more than 80 percent). This is attributed to the favourable climatic conditions for grass production.

Grass was part of almost all diets and was dominant in many countries in Europe, Africa, Latin America and New Zealand. The intake of grass varied between 10 percent on the Jordanian farm up to 90 percent on the New Zealand farm (sample average was 45 percent).

Within the countries studied, corn silage composes part of the diet in 26 countries: Corn silage is mostly dominant in a large number of countries in the EU and in North and Latin America (all farms sample average was 14 percent). Worldwide, the percentage of corn in the diet ranged between 51 percent on these farms and zero on the African and Southeast Asian farms.

Photo 5.3. **DAIRY IN COLOMBIA ON 3 000 M**

© Torsten Hemme

However, when considering all types of grass (cut-and-carry grass, fermented and dried grasses) as shown in Figure 5.7, the basic components of forage were grass and corn. The share of forage (sample average was 69 percent) among the major feed items are corn, corn silage, grass and grass silage. According to this concept, the share of grass was highest on the SE-60, UK-149, IE-48, BR-25SE, CL-47, CM-35, UG-3, PK-5, AU-275 and NZ-351 farms with a share of more than 60 percent of the diet, whereas moderate grass intake (30–60 percent of the diet) was fed on the FR-50W, DE-90N, US-80WI and CA-58 farms. Meanwhile, little grass (less than 30 percent of the diet) was fed in ES-50W, RU-900, CN-17 and IN-3S farms.

These results indicate that in the majority of countries, the biggest component of the diet is based on different types of grass. It is thus the main feed base for producing milk in the world.

5.3.2. CONCENTRATE FEEDING

In addition to grass feeding, which was discussed in the preceding section, this part of the report discusses concentrate and processed concentrate feeding in different locations. Concentrate feed items represented in this study include all types of grains; cereals; high quality concentrate feed items originating from soybeans, canola or their by-products; and other energy-rich/protein-rich by-products.

Concentrate is the second most important feed after grass. The intake of concentrate ranged between zero on the New Zealand farm and up to 75 percent on feedlot farms (Alqaisi, 2012) in Jordan (sample average was 30 percent) as shown in Figure 5.8.

In the majority of countries, concentrate intake ranged between 20 and 40 percent of the total diet. Generally, the share of concentrate feed in the EU and eastern European farms was

lower than in other regions. Exceptions were found on the ES-50NW and FI-25 farms, where feeding concentrate exceeded 40 percent on dry matter basis.

Concentrate intake was the highest on the JO-75 and IL-67 farms. This is typical for Near East farms as land and water resources are limited. Therefore, the share of concentrate exceeded 65 percent of the total diet on dry matter basis. Other feeding systems characterized by low concentrate inputs are dominant on the African farms, the CL-47 farm and the BR-farm. Little concentrate was typically added to the diet on the African farms and, as explained before, most of the arable lands are used for grain production for human consumption. On these farms, the diet is based more on grass from pasture or the cut-and-carry grass system. Additionally, the low quality of the grass on these farms also contributed to the low milk yield.

One of the determining factors for including concentrate in the diet may be attributed to animal productivity; it is also associated with the availability of arable land to produce crops. On the North American farms, intake of concentrate is high because the genetic potential of the dairy cows is high and, thus, concentrate is needed to fulfil the additional requirements of high yielding dairy cows.

In most of the Southeast Asian countries, low quality concentrate is fed, as this is usually made up of agricultural by-products. On the CN-17 and ID-3NG farms, the share of concentrate in the diet exceeds 50 percent of the total diet on dry matter basis. On these farms, concentrate is usually imported in large quantities. Feeding low quality concentrate feeds was usually associated with low milk yield.

Figure 5.9 shows the share of processed concentrate in the concentrate intake in the diet (percentage of concentrate dry matter). A high share of concentrate feeds is usually processed. The processed concentrate feed represents about 74 percent of concentrate intake on average. Meanwhile, a high share of home grown concentrate was found (> 75 percent) in six countries.

Processed concentrates are processed and formulated at a feed mill. The processed concentrates in the current study also include the high quality concentrate by-product feeds that originate from extraction of oils or other by-products that pass through mechanical processes.

More than 40 percent of the concentrate feeds were processed, this is the case for all EU farms (except PL-15), and Southeast Asian farms including China. In North and South America (except the United States and Argentina) and in Russia, home grown grains were more common. This can be explained by the fact that small areas of land were allocated for crop production on typical farms, producing small quantities of concentrate for dairy cow feeding. The majority of processed concentrate was either purchased from other feed industry enterprises or from industries producing by-products.

Explanations

Concentrate feeds: Includes all types of grains, cereals, high quality concentrate feeds originating from soybeans, canola or their by-products, and other energy-rich/protein-rich by-product feeds and animal by-products (fish meal, blood meal etc.).

Processed concentrates: All concentrates rich in energy and protein feed that pass through an industrial or processing stage (dehydration, heating, grinding, mixing, extraction etc.). This also includes by-products originating from energy-rich/protein feedstuffs that pass through an extraction process.

Figure 5.8. SHARE OF CONCENTRATE IN THE RATION (PERCENTAGE OF DRY MATTER)

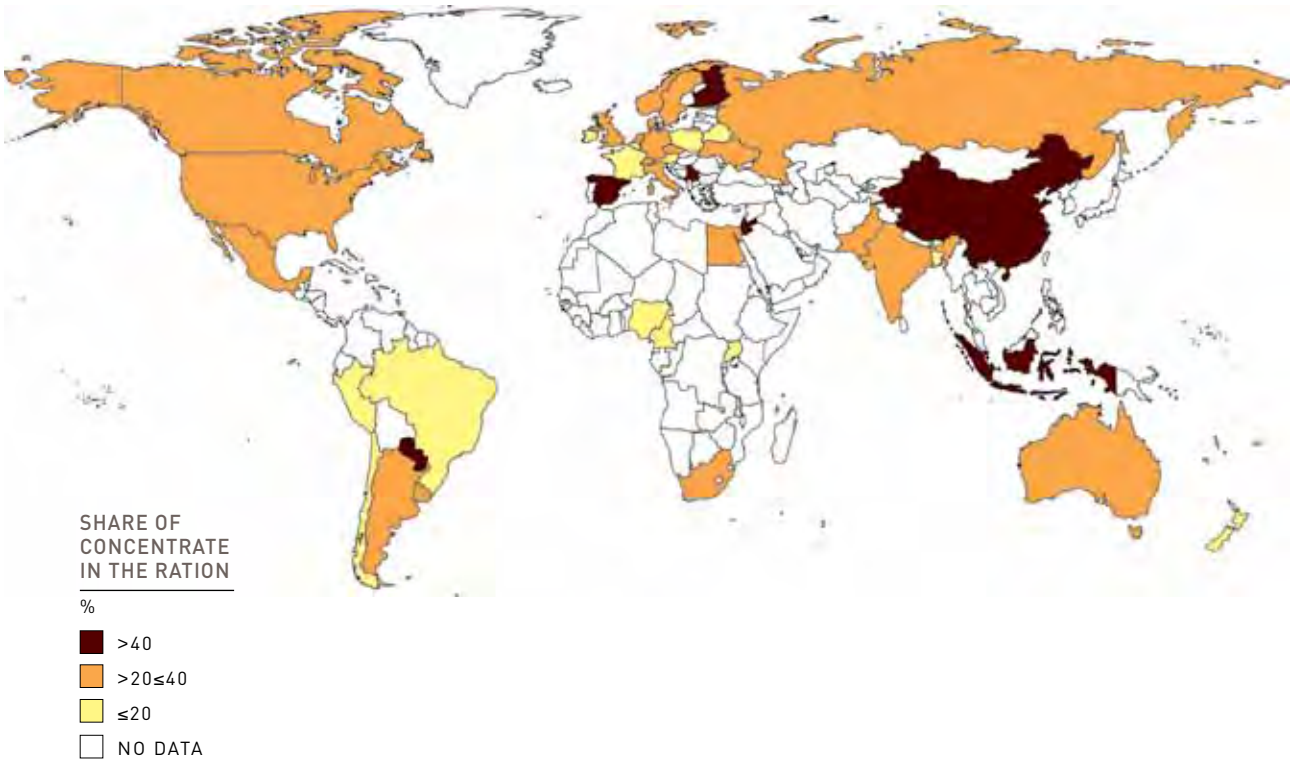
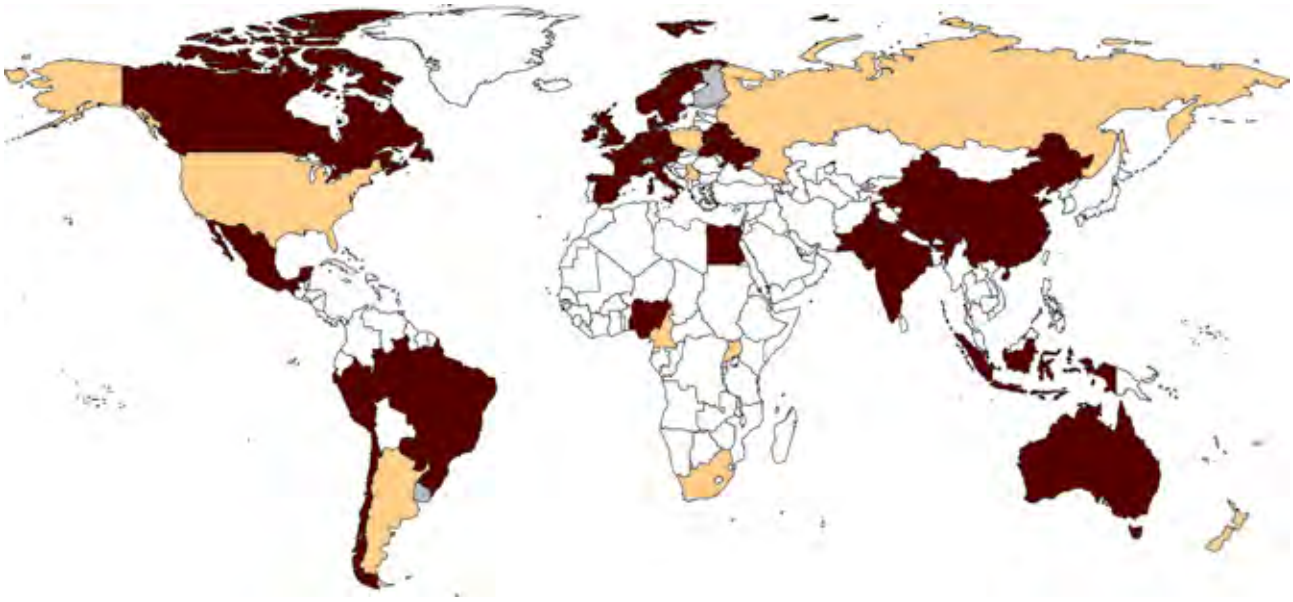


Figure 5.9. SHARE OF PROCESSED CONCENTRATE IN TOTAL CONCENTRATE INTAKE IN THE RATION (PERCENTAGE OF DRY MATTER)



5.3.3. DRY MATTER INTAKE AND FEED EFFICIENCY

In addition to feed intake, **dry matter intake** is one of the major factors determining milk production on dairy farms. It is one of the main drivers for converting feed resources to milk. Figure 5.10 shows the different intake levels for a lactating cow on an average-sized farm. These figures are estimations by our research partners, and the quality of the data were compared with the predicted feed intake based on milk yield ECM, milk protein, milk fat and body weight of the cow.

On the majority of the farms studied, the intake ranged between 15 and 20 kg DM/day. However, intake varied between the high value of 25.6 kg DM/day on the US-2218 farm and the lowest value of 5.5 kg DM/day on the CM-35 farm. This farm has a local cattle breed (Fulani) with low body weight and its emphasis is on beef production.

The level of milk yield was associated with the dry matter intake level: the higher the feed intake, the higher the milk yield, e.g. the feed intake on the US-80WI farm was nearly twice as high as on the IN-3S farm and the milk yield was tripled.

Feed efficiency in the current study is expressed as kilograms milk produced in ECM per kilogram dry matter intake. Using ECM milk has the advantage that the efficiency on different farms can be benchmarked.

Feed efficiency was greater than 1.0 in 27 countries analysed (Figure 5.11). The feed conversion efficiency of lactating cows was the highest (> 1) in the European and North American farms. It ranged between 1.63 in the grain and silage-based feeding systems in Europe and 0.43 in the grass-based feeding systems dominant in Africa (all farms sample average was 1.1 kg ECM milk/kg DM feed).

Feed efficiency was determined by several factors such as breed of the animal, lactation period, level of dry matter intake and feed quality. The efficiency varied between a maximum of 1.63 kg ECM/kg DM intake on DK-125 and SE-60 farms, and a minimum of 0.52 kg ECM/kg DM intake on the BD-2 farm. The ration composition (Figure 5.6) shows that the variation in feeding systems led to such a variation in the results. The low level of BD-2 and UG-3 farms can be related to different reasons. The feeding system on the BD-2 farm is based on low quality/high fibre by-products fed to a local breed characterized by a low milk yield. Similarly, the UG-3 farm is based on low quality pasture grass (elephant grass) and the dominant breed is the local Ankole, which is also characterized by a low milk yield, and the system is beef oriented (as is the case on most farms in this country).

This indicates that there is an opportunity to improve the feed efficiency by improving the quality of the feed offered to the animals, which will result not only in a higher production level, but also mitigate the levels of methane and nutrients emitted to the surrounding environment. The available feed resources in the majority of developing countries with small-scale farming systems are of low quality, resulting in a low feed efficiency and low milk yield. But, in these systems, the cost of milk production is lower compared with the advanced systems in the large-scale farming dominant in developed countries, where the cost of milk production is high but the feed quality is also high, resulting in a higher animal efficiency and milk yield. In this context, the next section will discuss the impact of feed efficiency on milk yield and cost of milk production, as well as the variation in feed cost in different dairy feeding systems.

Figure 5.10. ESTIMATED DRY MATTER INTAKE PER LACTATING COW (kg feed/cow/day)

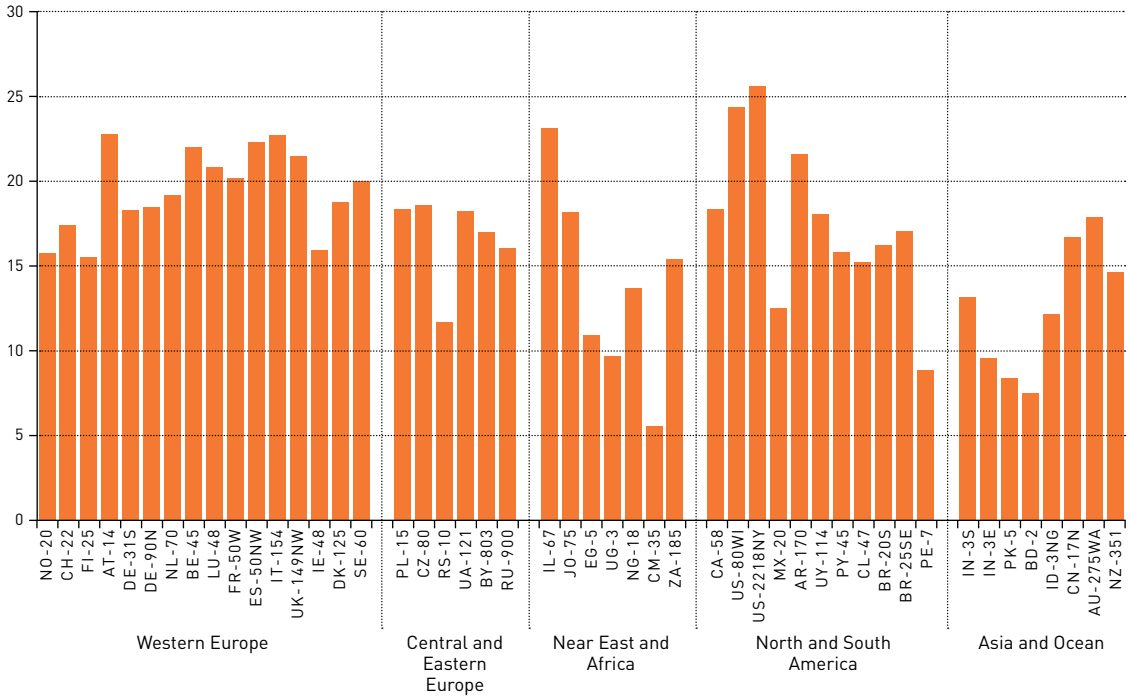
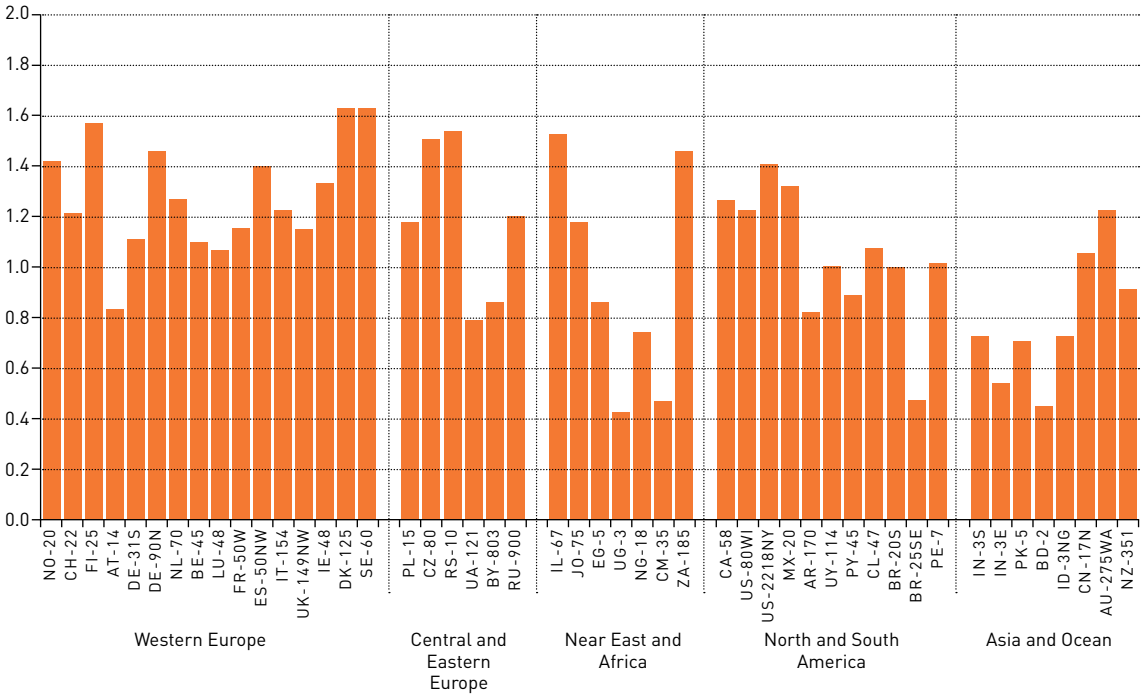


Figure 5.11. ESTIMATED FEED EFFICIENCY FOR A LACTATING COW (kg ECM milk/kg dry matter intake)



Explanations

Estimated dry matter intake (eDMI): Based on data supplied by research partners. The figures represent the average dry matter intake (DMI) of a lactating cow in the herd.

Feed efficiency: Calculated as the average ECM daily milk yield of a lactating cow divided by the daily eDMI.

5.3.4. ECONOMICS OF DAIRY FEEDING SYSTEMS

Feed cost usually has the biggest share in the cost of milk production; therefore analysing feed costs in more depth can improve farm profitability. Figure 5.12 shows the share of feed cost in the total cost of milk production on the average-sized farms for each country. Feed cost in US dollars (US$) to produce100 kg ECM milk was calculated using the Activity Based Costing method where variable costs for feed production and the purchased feed, labour, land used for feed production and other on-farm inputs related to feed were allocated to feed cost with grades from zero (i.e. no machinery used in animal feeding on-farm) to 100 percent (i.e. purchased concentrate). This cost was then divided by the total cost of milk production to get the percentage share of feed cost. Based on the results from the average farms analysed, we clustered the feed cost into three categories: high, average and low share of feed cost in the total cost.

High share of feed cost: This is dominant in farms located in eastern Asia, parts of Latin America and in the Near East, where the share is usually above 70 percent of the total milk production cost. This could be attributed to the amounts of roughage and concentrates purchased, whereas other costs such as labour and machinery are very small and do not play a major role.

Moderate share of feed cost: In this category, at least 50–70 percent of total costs go to feed. The majority of farms in Central and South America, Africa, Oceania and southern parts of Europe belong to this category. The moderate share of feed cost could be related to less purchased feed and use of a higher proportion of feed produced on-farm with lower production costs. Other inputs such as labour and machinery represent a higher portion of the cost of milk production compared with the first category.

Low share of feed cost: With 40–50 percent of total milk production costs, this category is dominant in farms located in northern Asia, Europe and North America. The share of feed cost in this system is lowest compared with the first two categories because the total cost entails higher input prices such as labour, large capital investments and quota cost. In addition, higher costs are attributed to feeding and manure handling costs. The results of this study show that higher feed costs do not mean higher animal performance and, consequently, feed efficiency. However, feed cost is linked strongly to feed prices and the feeding system on-farm.

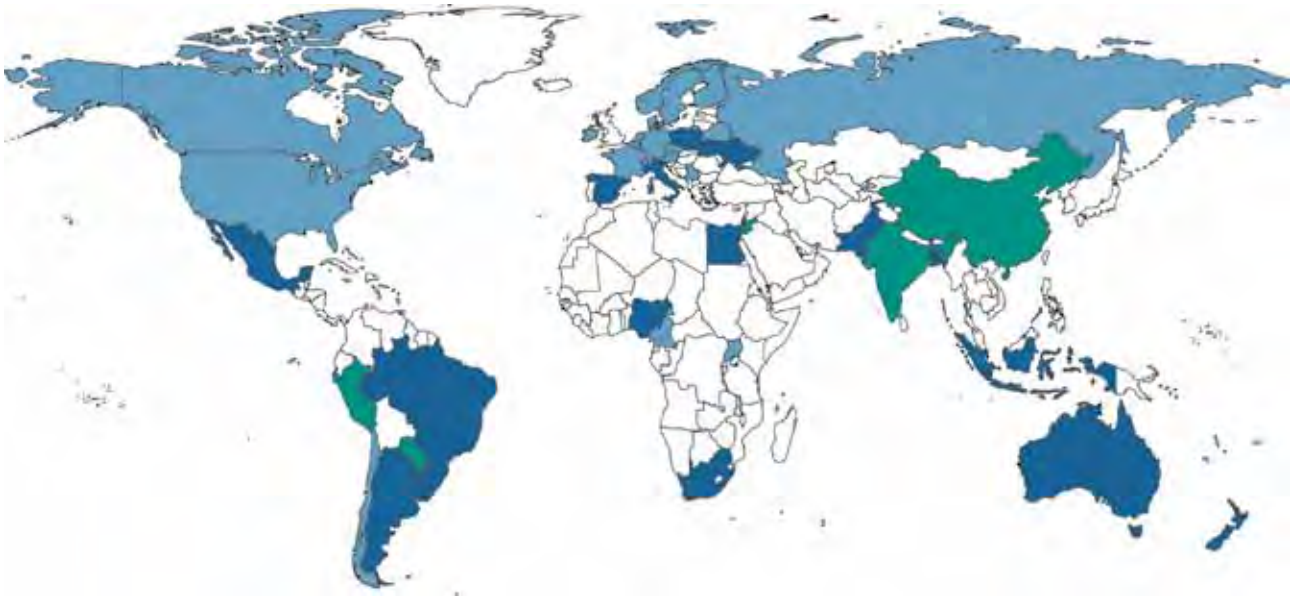
Feed efficiency (FE) and milk yield and the relationship between them in regard to milk yield and their impact on cost of milk production are shown in a regression analysis (see Figure 5.13).

The reasons for the wide variation in feed efficiency were explained in the preceding section. The regression line shows the relation between feed efficiency and milk yield, which reveals a strong positive relationship between the two variables (R^2 = 0.65). The slope shows that an increase in feed efficiency of one unit (0.1) will lead to an increase in the annual milk yield of 750 kg ECM milk at global level. However, animals with a higher feed efficiency produce

more milk, but at what cost? In order to answer this question, two dairy farming systems were compared in terms of feed efficiency and cost of milk production: one European dairy farm with feed efficiency of 1.22 kg ECM/kg DM intake and milk yield of 22.5 kg ECM milk per day, with a high cost of milk production (> 50 US$/100 kg ECM), compared with a Southeast Asian farm with a feed efficiency of only 0.38 kg ECM/kg DM intake and a production of about 2.4 kg ECM milk per day, but with much lower milk production costs (25 US$/100 kg ECM). In high yielding farms, animals are characterized by a higher feed efficiency; nevertheless, the cost of milk production was also higher on those farms.

The results indicate that feed efficiency is one of the major determining factors for increasing milk yield, but it is also a determinant of the cost of milk production. Small-scale dairy farms in Asian countries are characterized by lower feed costs because of the lower feed quality offered to cows (from pasture or agricultural by-products) and produce less milk compared with the European farms that are characterized by higher feed quality, higher feed efficiency and milk yield, but also by higher feed costs.

Figure 5.12. **SHARE OF FEED COST IN TOTAL COST OF MILK PRODUCTION IN 2009**

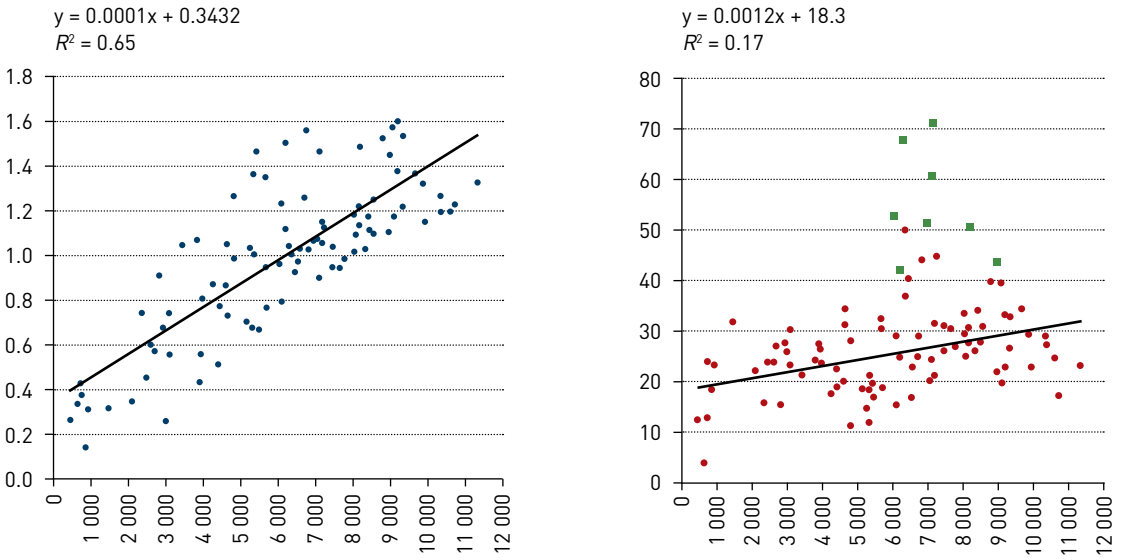


SHARE OF FEED COST IN TOTAL COST

%

- >70
- >50≤70
- ≤50
- NO DATA

Figure 5.13. **MILK YIELD IN RELATION TO FEED EFFICIENCY AND FEED COST**



Explanations

Activity-based costing (ABC): A method for allocating the costs of milk production into different activities. These costs are: labour cost, machinery cost, fuel cost, electricity cost and water cost. These cost items are allocated to the following activities: home-grown feed production, feeding and manure handling, milking, cow handling and, finally, farm management.

5.3.5. DETAILED ANALYSIS OF FEEDING SYSTEMS IN SELECTED COUNTRIES

A detailed analysis of feeding systems is essential in order to understand the variation and the reasons for differences between the systems. This section will discuss the variation in feeding systems in four countries (Germany, Switzerland, Jordan and Argentina) in detail. Results show that feed intake was highest on the Argentinean farm with 21.5 kg DM/day but that feed efficiency (FE) was lowest with 0.76 kg ECM milk/kg DM intake, compared with 18.5 kg DM intake and a feed efficiency of 1.06 on the Swiss farm (see Figures 5.14, 5.15 and 5.16)

Comparing feed costs between the two farms, the total feed cost was about 6 percent lower on the Argentinean farm because the dry matter feed price (DMFP) was 55 percent lower. On the basis of the price of purchased feed, the Argentinean farm had the advantage of lower feed cost by 21 US$ per 100 kg ECM produced from the compound feed compared with the Swiss farm. However, although the feed price was lower on the Argentinean farm, the feed efficiency was also lower by 27 percent compared with the Swiss farm. Feed and manure handling costs were much lower on the Jordanian and the Argentinean farms (11.8 and 11.4 US$/100 kg ECM milk, respectively) compared with the Swiss farm, which had considerably higher costs. DMFP on the Jordanian farms was 442 US$/tonne. Meanwhile, feed efficiency was 1.12, slightly higher than on the Swiss farm and much higher than on the Argentinean farm.

The German farm achieved higher milk yield (22.5 kg ECM milk/day) and higher feed efficiency (1.2) compared with the other farms; the DMFP was 263 US$/tonne DM. Comparing these figures with the Swiss farm, the German farm had 39 percent lower total feed cost.

The energy- and protein-corrected (EPC) concentrate intake was highest on the Jordanian farm, where a mixture of grains represented more than 70 percent of the total ration, with an intake of around 722 g/kg ECM milk produced. This was followed by the Argentinean farm, where concentrate intake represented 30 percent of the total ration, which was around 331 g/kg ECM milk. However, the predicted EPC intake depends on the quality of the actual concentrate fed on the farm. The Jordanian dairy regions are located mainly in areas of semi-arid climate conditions, where water resources are scarce and forage production biomass is very low. Under these conditions, concentrates represent a high proportion of the ration, independently of the feed prices.

Feed efficiency results varied across countries, which could be attributed to different feeding systems, ration quality and the breed of the cows. DMFP and EPC feed prices are new feed price indicators that can be used on dairy farms (Alqaisi *et al.*, 2010). When feed prices are high, it becomes very important to consider the feed efficiency figures and the quality of the feed supplied to the lactating cows, all of which can help to reduce the total feed cost. The relation between feed costs and feed prices is evident in this analysis. IFCN national feed prices will be discussed in the next section, which gives a detailed view of how they developed during the period between 2006 and 2010.

Figure 5.14. **MILK YIELD AND DRY MATTER FEED INTAKE**

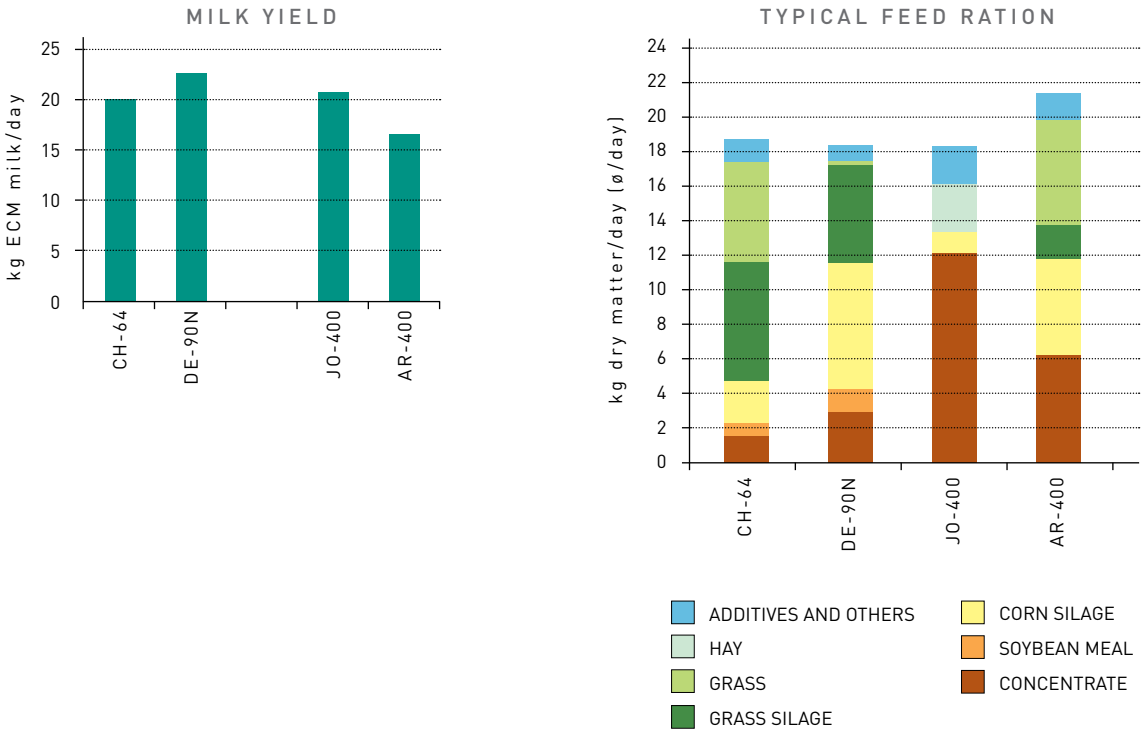


Figure 5.15. **FEED COST AND PRICES**

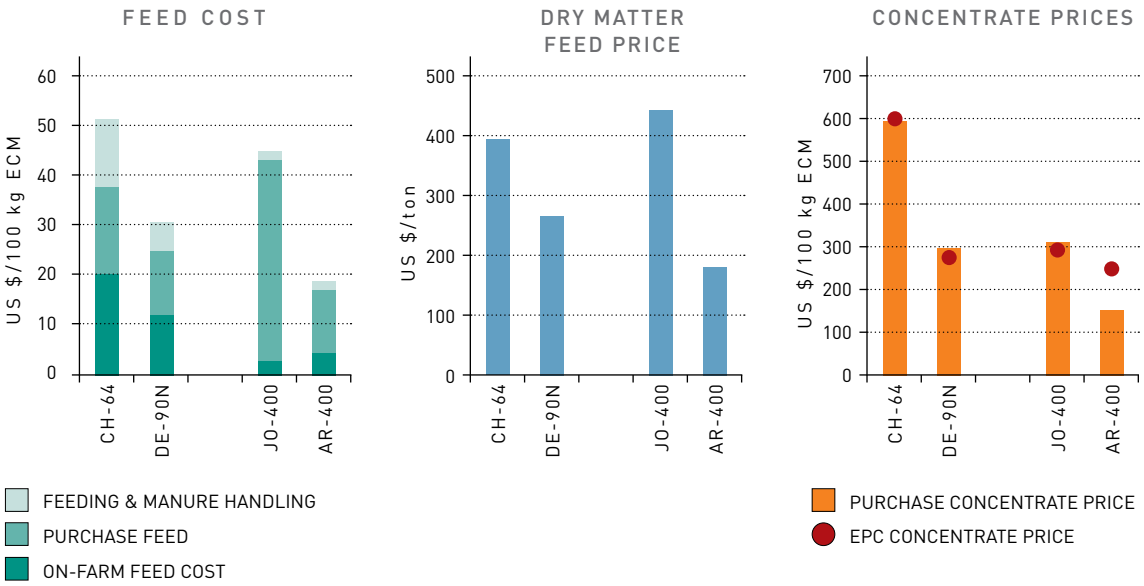
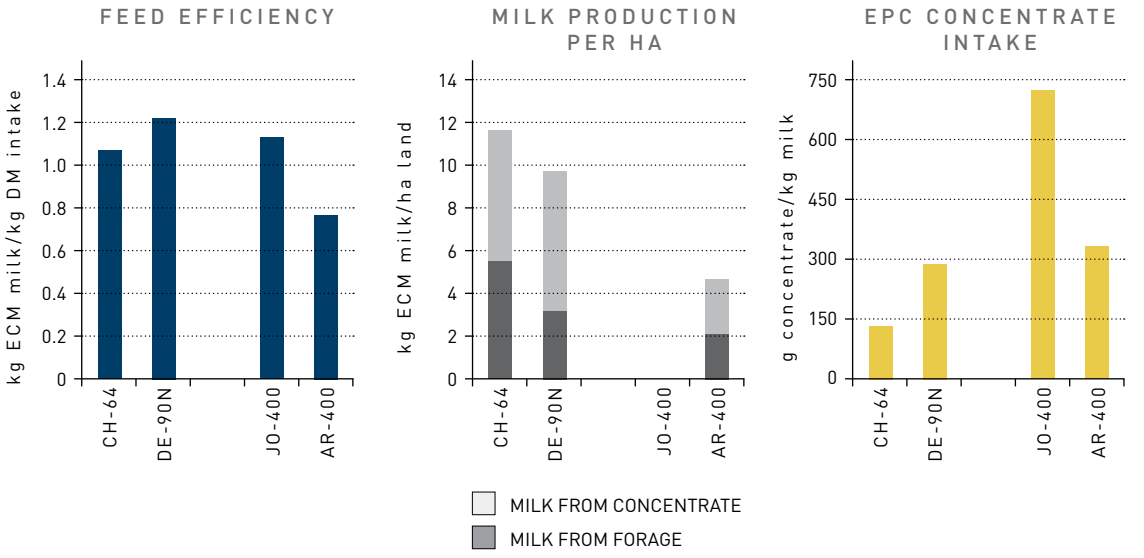


Figure 5.16. **FEED EFFICIENCY AND LAND PRODUCTIVITY**



Explanations

Data sources: Data from year 2009. **Dry matter feed intake:** Data from a typical farm ration, data on daily intake basis (as feed basis, and dry matter intake). **Feed efficiency:** Daily energy-corrected milk (ECM) yield in kg divided by the daily dry matter intake in kg. **Energy and protein corrected concentrate (EPC) price:** Calculated as follows: the EPC conversion factor is calculated as the average of the energy and protein difference between typical and EPC concentrate. The EPC price per tonne concentrate is the EPC conversion factor multiplied by the typical concentrate price. **On-farm dry matter feed price (DMFP)**: The feed efficiency value multiplied by the total feed cost on a typical farm; the results are given in US$ per dry matter tonne of feed. **Predicted EPC concentrate intake per kg milk:** The daily amount of EPC concentrate in kg (as fed) divided by the quantity of milk produced daily in ECM. **Milk production from concentrate per ha land:** Total milk production from (home-grown and purchased) concentrate divided by the total area (ha) allocated to the dairy enterprise. **Milk production from forage per ha:** Total milk production per farm divided by the forage area used for the dairy enterprise minus the milk production per ha from concentrate (home-grown and purchased).

5.3.6. TIME SERIES ANALYSIS OF MILK AND FEED PRICES (2006–2010)

The feed prices in the four countries are presented as a time series between 2006 and 2010, as shown in Figure 5.17. Feed prices have become extremely volatile in recent years. In order to analyse feed prices, two commodities were used to describe trends in global feed prices: soybeans and corn grains. The calculated IFCN feed price indicator is based on 70 percent corn (energy feed) and 30 percent soybean meal (protein feed). The milk : feed price ratio was calculated by dividing the milk price by the feed price. Milk price was calculated on the basis of skim milk powder and butter prices, and data on national milk prices were provided by research partners and then corrected to ECM.

In **Germany**, the average milk price in 2006 was around 34 US$/100 kg ECM and increased substantially in 2008 to 50 US$/100 kg ECM milk, but returned to the level of 2006 in 2009.

Similarly, feed prices increased from 16 US$/100 kg in 2006 to 26 US$/100 kg feed in 2009, i.e. an increase of 35 percent during this period. This was reflected in the milk : feed price ratio, which declined below 1.5 in 2009.

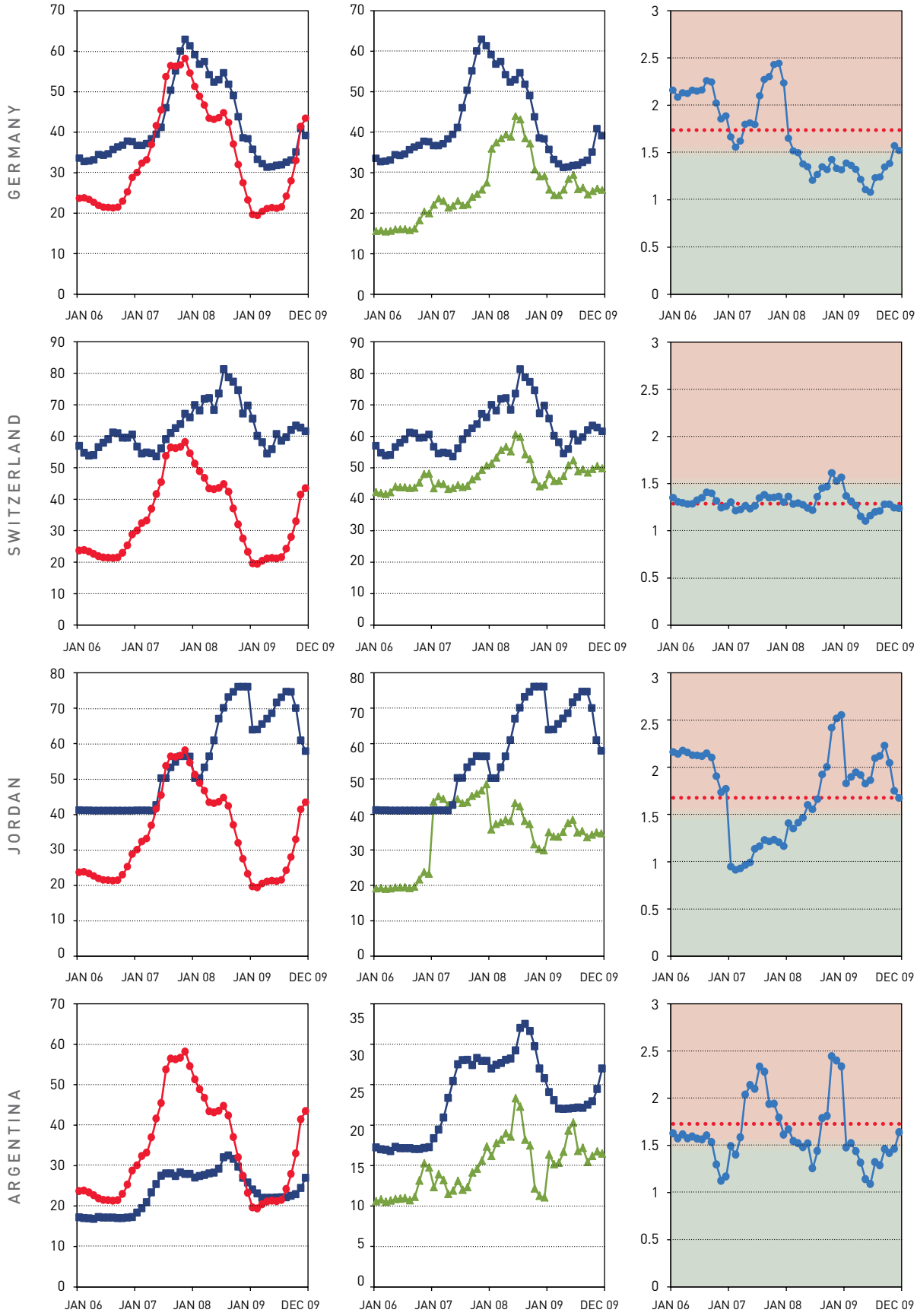
The **Swiss** milk price increased by only 3 percent during the same period, while feed increased by 1 percent. The milk : feed price ratio remained constant at around 1.5.

Compared with world market prices, the national milk price in Germany was 33 percent higher than the world market price in 2006, but it followed the world market price between 2006 and 2009. Therefore, the gap was reduced between the two prices in 2009 and reached 23 percent. Similarly, the Swiss milk price followed the world market price of milk, but with a larger gap than in the German case. In 2006, the national Swiss milk price was 60 percent higher than the world market price for milk. This gap between the two prices remained until 2009, when the national milk price was 56 percent higher than the world milk price.

The **Jordanian** milk and feed prices recorded greater fluctuations compared with the European prices. In 2006, the milk price was 41 US$/100 kg ECM milk and increased to 67 US$/100 kg ECM in 2009, while the feed price increased by 42 percent in the same period. Because of milk and feed price fluctuations, the milk : feed price ratio changed greatly during the same period, for example it varied between < 1 in 2007 to > 2.5 in 2008. Compared with the world market price, the milk price in Jordan was higher, with a big gap between the two prices. In 2006, the national milk price was 44 percent higher than the world market price of milk and in 2009 the gap between the two prices increased up to 61 percent.

In **Argentina**, the milk price showed a similar trend to the European price during 2006–2009. The milk price varied between 17 US$/100 kg ECM in 2006 and 26 US$/100 kg ECM in 2009. During the same period, feed prices increased by 30 percent and ranged between 10 US$/100 kg ECM in 2006 and 16 US$/100 kg ECM in 2009. The milk: feed price ratio was around 1.6 during the same period, but reached above 2.0 in mid-2007 and at the end of 2008. It was mostly influenced by the reduction in feed prices during these periods. The Argentinian milk price showed different patterns compared with the other countries. The national milk price followed the world milk price, but was usually lower; the national price was 36 percent higher than the world milk price in 2006 and reduced to 14 percent in 2009.The recent volatilities in global feed prices, as shown in the preceding paragraphs, indicate that feed price is one of the major determining drivers for the cost of milk production in different farming systems.

Figure 5.17. MILK PRICES, FEED PRICES AND MILK: FEED PRICE RATIO IN FOUR COUNTRIES
(milk and feed prices in US$/100 kg)



5.4. KEY FINDINGS

This study analysed feeding systems in 44 countries, representing 85 percent of world milk production. Key findings are summarized below.

- **Method used:** The IFCN method is based on the "typical farm" approach. A typical farm represents a certain share of milk production in a country. The analysis is based on average-sized typical farms and the feed ration of lactating dairy cows.
- **Strong diversity in farming systems:** Dairy feeding systems are very diverse in terms of (1) farm size, which varied between 2 cows in Bangladesh and 2 218 cows in the United States and (2) the feed items used. Even within a country, every farm has its own specific system. This analysis is a simplification of a very complex reality.
- **Milk yield globally ranges from 650 to 11 000 kg/cow per year:** Milk yield on the typical average-sized farms studied varied between low milk yields of 650 kg/cow per year on the Cameroonian farm, up to more than 11 000 kg/cow per year on a North American farm (sample average was 5 900 kg/cow per year). Milk yield was determined by breed and genetics, feed items and farm management.
- **Forage dominates over concentrates in most feeding systems:** The basic component of forage was grass and maize feeds. The share of forage in the diet on all farms was 69 percent, where the major feeds were maize silage, grass and grass silage.
- **Grass is the main feed base for milk production in the world**: Grass was found in almost all diets and was dominant on European farms, and on African, Latin American and New Zealand farms. The intake of grass varied between 10 percent on the Jordanian farm up to 90 percent on the New Zealand farm (sample average 45 percent).
- **Concentrate is the second most important feed and represents 30 percent of the diet:** Concentrate intake ranged between zero intake on the New Zealand farm up to 75 percent on feedlot farms in Jordan (sample average 30 percent).
- **A high proportion of concentrate feeds is usually processed:** Processed concentrate feeds represented about 74 percent of concentrate intake on average, meanwhile a high share of home grown and non-processed concentrate (> 75 percent) was found in six countries.
- **Maize silage composes part of the diet in 26 countries:** Maize silage was most dominant in a large number of countries in the EU and North and Latin America (all farms sample average was 14 percent). Intake ranged between 51 percent on the farm with the highest share and zero on the African and Southeast Asian farms.
- **Feed efficiency is greater than 1.0 in 27 countries:** The feed conversion efficiency of lactating cows was the highest (> 1) on the EU and North American farms and ranged between 1.63 in the grain and silage-based feeding systems in Europe and 0.43 in grass-based feeding systems dominant in Africa (all farms sample average was 1.1 kg ECM milk/kg DM feed).

Photo 5.4. SILAGE FEEDING SYSTEMS AND EQUIPMENT IN ESTONIA

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» **Feed costs** represented 50–60 percent of the total costs of milk production, driven by feed efficiency but more by the on-farm dry matter feed price.
» **Feed price has increased by 150 percent since 2006:** Feed prices have increased at a high rate, driven by the increases in prices of oil and input (land and fertilizer).
» **Milk** : **feed price ratio is a determining factor for farming systems, feeding systems and feed intensity**: Milk prices and feed prices are not correlated and both are volatile and fluctuating. This could represent a risk factor and the fluctuating milk : feed price ratio may require an adjustment of the feeding system.

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6
CONCLUSION

Animal feeding is the first step in the production of milk and therefore affects the rest of the production chain. Several indicators are available for the characterization of milk production systems in relation to the feeding of animals. The use of simple indicators makes it possible to understand better the feeding systems throughout the world by comparing them. This approach makes it possible, using a global survey, to present the diversity of feeding systems within and among countries, using common criteria for comparison. The ***World Mapping of Animal Feeding Systems in the Dairy Sector*** includes IFCN survey results on dairy cattle feeding systems for 44 countries; the IDF survey results on dairy cattle feeding systems for 15 countries; and the FAO survey results on dairy cattle, water buffalo, sheep and goat feeding systems for 43 countries.

6.1. ANIMAL FEEDING INDICATORS

Geospatial displays of data represent an easy way to demonstrate the diversity of animal feeding approaches. The results of the feeding schemes obtained from the studies of IDF and IFCN are summarized in world maps for dairy cattle. The parameters include stocking rate, average milk yield and the percentages of roughage, concentrate and processed feed utilized (Section 2.1). World maps for the feeding baskets (percentage constituents in feeds) from the FAO study are also presented for the improved dairy cattle and water buffaloes, sheep and goats, both during lactating and dry stages (Section 2.2).

Stocking rate: The stocking rate is defined as the number of animals per hectare of roughage production. This indicator can reflect the capacity of a farm to grow roughage for feeding its animals. In general, higher stocking rates result in lower amounts of roughage produced on the farm per animal, which suggests that the dairy feeding system is more reliant on purchasing roughage to meet animal needs.

Differences in stocking rate are notable for a variety of reasons. Small dairy farm enterprises with only a few lactating animals (such as those observed in China and India) typically have higher stocking densities that reflect the small land holdings per farm delegated for roughage production. Larger dairy enterprises with more lactating cattle (such as those observed in North America and Europe) typically have lower stocking densities, reflecting greater land holdings (owned or leased) for roughage production. A notable exception is New Zealand, where an

improved pasture-based feeding system combined with a large average herd size results in a higher stocking rate.

Average milk yield: The average milk yield represents the mean volume of milk produced per animal per year for the entire herd. Average milk yield is expressed as kilograms of energy-corrected milk (standardized to a fat content of 40 g/l and protein content of 32 g/l) per cow per year.

In general, average milk yield is highest in North America and Western Europe and lowest in Asia and Africa. The main goal of these systems is to maximize the average milk yield per cow. Other systems throughout the world do not always wish to reach the same objective. Average milk yield is a general reflection of the adequacy of the feeding system utilized by the dairy producer. Other factor such as the genetic potential of the animal, environmental conditions and management practices also influence average milk yield.

Percentage of roughage: Percentage of roughage is expressed as the percentage of dry matter intake of roughage to the total feed consumed by an animal on a yearly basis. Most of the time, roughage is produced and consumed by animals on the same farm. In some feeding systems, a substantial portion of the roughage may be purchased. In most feeding systems in this report, roughage represents the major proportion of the feed consumed by the animal. The share of roughage in the total feed intake is of crucial importance for dairy production because most of the time it represents the main feed and thus leads feed efficiency. The percentage of roughage intake may vary according to such factors as availability of the roughage due to geographic and/or climatic factors and availability of alternative or by-product feeds.

Percentage of concentrates: Concentrates are supplements to the roughage part of the diet of the cows and provide energy and protein (typically from grains or oilseeds). Raw materials and processed (compound) feed may be used as concentrates. Percentage of concentrates is expressed as the percentage of dry matter intake of concentrates to the total feed consumed by an animal on a yearly basis. By definition, the percentage of concentrates and roughage represent the totality of feed consumed by the animals (100 percent).

Concentrates may be grown on the farm (grains and oilseeds) or purchased off the farm as raw materials (grains and oilseeds), processed feeds (processed and/or blended feeds) or by-products (distiller's grains, citrus pulp or cottonseed). Different amounts of concentrates are used in feeding systems depending on roughage availability and the farmer's objective regarding milk yield. The percentage of concentrate intake may vary according to such factors as availability of land for on-farm production, geographic and/or climatic factors and availability of alternative or by-product feeds.

Percentage of processed feed: Processed feed is a subcomponent of concentrates and is composed of multiple raw materials, combined by mechanical mixing. The compound feed that results can be granulated or mashes of mixed, non-granulated compound feeds. Percentage

of processed feed is expressed as the percentage of dry matter intake of processed feed to the total feed consumed by an animal on a yearly basis.

In some aspects, it possible to distinguish between concentrates produced and consumed directly on-farm and those having undergone an industrial transformation before being purchased by a farmer. The processing of ingredients off-farm sometimes makes it difficult to have precise knowledge of the final composition of processed feeds. The percentage of processed feed intake may vary according to such factors as availability of land for on-farm production of concentrates, geographic and/or climatic factors influencing roughage production and availability of alternative or by-product feeds.

6.2. COUNTRY-LEVEL DATA

Developed countries: Developed countries generally have animal feeding systems adapted for large-scale (herd size) higher-yielding dairy cows that are concentrated in confinement production systems (either seasonally or year-round). There is a greater reliance on both stored forage and purchased grains and concentrate. In North America and Europe, milk yield typically exceeds 7 000 kg energy-corrected milk per cow per year. Roughage typically is 60–80 percent of the diet for dairy cows, with concentrate constituting the remaining 20–40 percent of the diet.

However, it is easy to find feeding systems in developed countries that that do not fit into that broad generalization. Animal feeding systems for dairy cattle in New Zealand are predominately pasture-based with a low reliance on purchased grains and concentrate (typically less than 10 percent of the diet) even though the average herd size is relatively large compared with most other developed countries. Animal feeding systems for dairy cattle in Japan, where land availability to grow roughage is more limited, have diets that are typically less than 40 percent roughage and more than 60 percent concentrate.

Developing countries: Developing countries show greater variability in animal feeding systems ranging from systems with high reliance on roughage to high reliance on concentrates. In South America and South Africa, milk yield typically reaches 7 000 kg energy-corrected milk per cow per year whereas in Southeast Asia and India most production is less than 3 000 kg energy-corrected milk per cow per year. For South America (similar to developed countries), roughage comprises more than 60 percent of the diet for dairy cows, with concentrate constituting less than 40 percent of the diet. In contrast, for China and Southeast Asia, roughage generally makes up less than 60 percent of the diet for dairy cows, with concentrate constituting more than 40 percent of the diet.

However, that broad generalization misses the important delineation between the roughage sources. For example, animal feeding systems for dairy cows in Venezuela rely almost entirely on grass for the roughage source whereas systems in Thailand rely substantially on crop residues (cereal straw, corn stover, etc.). Additionally, developing countries are more likely to have animal feeding systems adapted for small-scale (herd size) water buffalo, sheep and

goat production systems, where locally produced roughage represents the major source of feed utilized. However, that broad generalization again misses an important delineation – that between the roughage source and concentrate use. For example, animal feeding systems for dairy goats in Indonesia rely almost entirely on roughage whereas up to 40 percent of the feed utilized in systems in Jordan and Lebanon is from concentrates.

6.3. FINDINGS BY APPROACH

International Dairy Federation: The IDF method is based on an expert survey of dairy feeding practices in IDF member countries. This approach describes the diversity of feeding systems within a given country on the basis of data obtained from national experts in dairy feeding practices that are pertinent and specific to those countries. The results of the feeding scheme survey (stocking rate, milk yield, percentages of roughage, concentrates and processed feed, feed efficiency etc.) are paired with demographic data on the size and scope of the dairy industry structure in participating countries. The feeding systems are presented by country in a concise factsheet format. Some of the findings of the IDF approach include:

» Milk fat content is more variable than milk protein content: Milk fat and milk protein composition varied from 37 to 48 g/l and 31 to 38 g/l, respectively.
» Roughage intake is indicative of overall intake of feed: In general, increased annual consumption of roughage resulted in increased overall feed intake.
» By-product feed use is highly variable: By-product feed use ranged from 0 to 45 percent of the total feed intake. Feeding by-product feeds was most prominent in intensive systems (Israel and South Korea) that consumed more than 8 000 kg of dry matter per animal per year.

Food and Agriculture Organization: The FAO method is based on an expert survey distributed to animal nutrition experts. The data are presented in a feeding basket approach that indicates the percentage of the diet supplied by roughage, concentrate and compound feed. The results of the feeding schemes are presented for improved and local cattle, improved and local buffaloes, sheep and goats in participating countries. Some of the findings of the FAO approach include:

» Crop residues are an important part of the diet for cows in Asia: Roughage for local dairy cows was composed of crop residues and grasses in almost 1 : 1 ratio; the proportion of crop residues in the roughage was 35 percent and 43 percent for improved lactating and dry cows, respectively. The use of compound feed in Asia and Africa was very low (up to 5 percent).
» Improved dairy buffaloes receive more concentrates and compound feed than local animals: Local dairy buffaloes received mostly roughage in all countries. Crop residues were an important source of roughage for both improved and local dairy buffaloes in India. The use of compound feed for cattle was low in Asia.
» For both cattle and buffaloes in Asia and Africa, the use of home-made concentrate is higher than the use of compound feed.

» Lactating sheep diets worldwide include similar proportions of roughage, concentrate and compound feed: Lactating sheep received approximately 80 percent roughage, 15 percent compound feed and 5 percent concentrates. In most countries in Africa, the Americas and Asia, the roughage in the diets of both lactating and dry sheep was composed of grasses (fresh and hay).
» Lactating goat diets are composed mostly of roughage: In Africa and Asia, lactating goats were fed mainly roughage (80 percent), the rest being concentrates, and in Asia some compound feed was supplied (3 percent). Use of roughage and concentrates for lactating goats in the Americas was approximately 75 percent and 15 percent, respectively, and the balance was compound feed. In Europe, the share of compound feed in the diet of lactating goats was highest (25 percent) and that of concentrates was 10 percent.
» In most developing countries, milk is produced from crop residues, grasses and agro-industrial by-products: Apart from some countries (e.g. Jordan, Lebanon, Egypt, Morocco, Turkey, Nigeria, Rawanda) in the developing world, low levels of cereals were used in the diets of dairy animals, suggesting that a human-edible animal product of high quality (milk) was produced from human-inedible feed resources by the dairy sector in most developing countries.

International Farm Comparison Network: The IFCN method is based on the "typical farm" approach, giving a descriptive analysis of feeding systems, milk yields, land use and labour. A typical farm represents a certain share of milk production in a country. This approach was also used to analyse feed costs, feed prices and feed efficiency. Some of the findings from the IFCN approach include:

» Forage dominates over concentrates in most feeding systems: The basic component of forage was grass and maize feeds. The share of forage in the diet on all farms was 69 percent, the major feeds being maize silage, grass and grass silage.
» Grass is the main feed base for milk production in the world: Grass was found in almost all diets and was dominant on European farms and on African, Latin American and New Zealand farms. The intake of grass varied between 10 percent on the Jordanian farm up to 90 percent on the New Zealand farm (sample average 45 percent).
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» Feed efficiency is higher than 1.0 in 27 countries: Feed conversion efficiency of lactating cows was the highest (> 1) on the EU and North American farms and ranged between 1.63

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» Feed price has increased by 150 percent since 2006: Feed prices increased at a high rate and were driven by the increase in prices of oil and input (land and fertilizer).

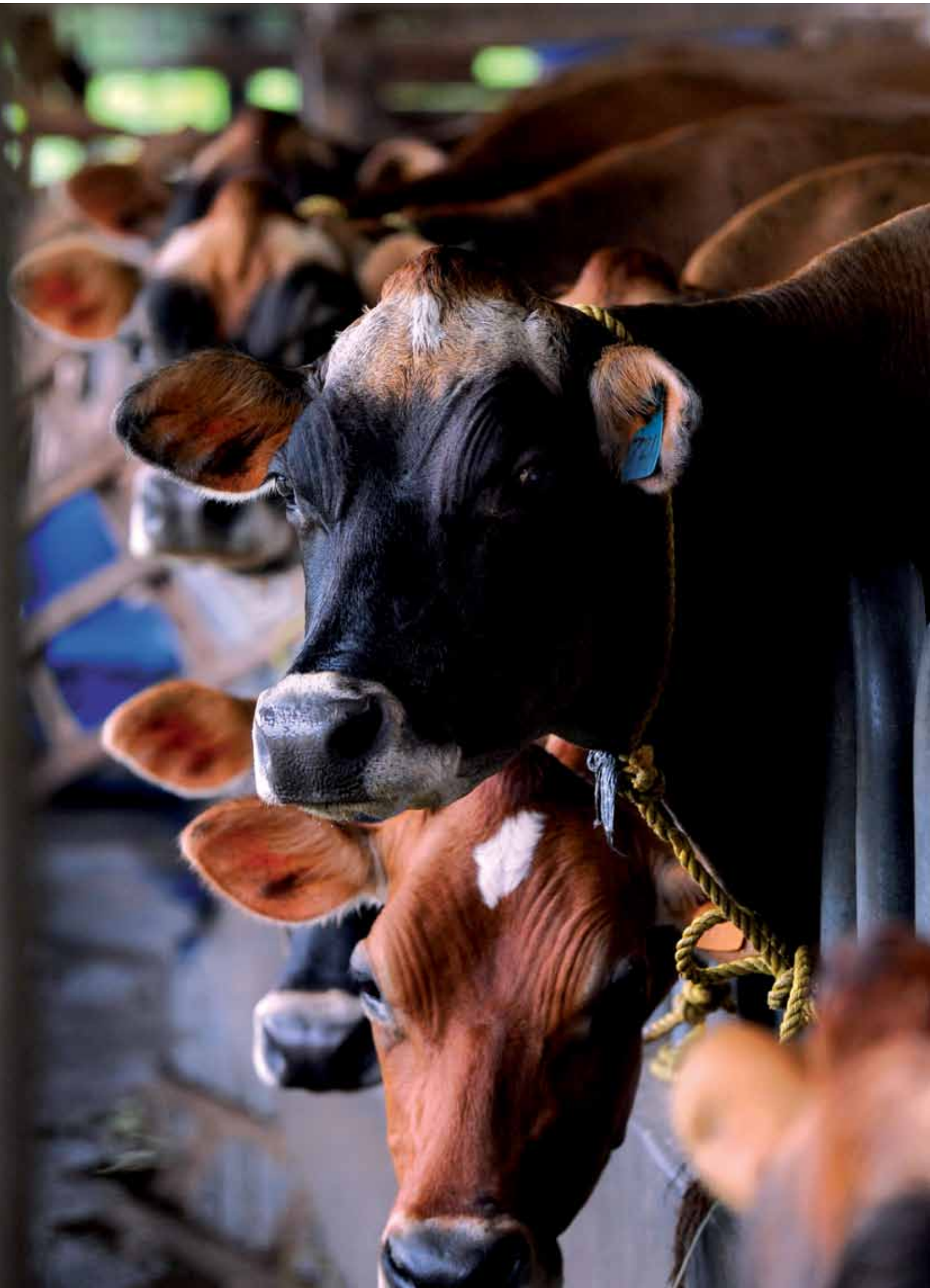
» Milk : feed price ratio is a determining factor for farming systems, feeding systems and feed intensity: Milk prices and feed prices are not correlated and both are volatile and fluctuating. This may represent a risk factor and the fluctuating milk : feed price ratio may require an adjustment of the feeding system.

6.4. FUTURE WORK

This report builds a knowledge foundation for animal feeding systems that will serve as a valuable resource for the dairy industry in the future by the wealth of information on the diversity of animal feeding systems for dairy cows, water buffaloes, sheep and goats contained herein. This information, used as a technical resource, will enhance feeding systems already in use by examining the success of similar systems from around the world. Additionally, the animal feeding systems in the report will be used for the development of new feeding systems as dairy production systems change and advance in both developed and developing countries.

The diversity of animal feeding systems contained in this report will serve as valuable tool for advancing the global sustainability of dairy production. Accurate information on feeding systems is necessary for comprehensive life-cycle analysis of dairy production on a variety of spatial distinctions, which this report provides. Resource efficiency and carbon footprint analyses will be enhanced through the use of more accurate animal feeding systems, as described in this report. The animal feeding systems can be used as a source of data to assist in modelling changes in a variety of production aspects (such as breeding technology, intensification and milk composition targets) prior to implementing actual changes.

This report should not be viewed as the end of examination of the diversity of animal feeding systems in dairy production. Rather it is intended to be the beginning of understanding and sharing information on this diversity. Future work will improve data collection and expand the universe of animal feeding systems reported.



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WORLD MAPPING OF ANIMAL FEEDING SYSTEMS IN THE DAIRY SECTOR

Animal feeding is the first step in the production of milk and affects the rest of the production chain. Information on feeding systems is necessary for estimating the environmental impact of the livestock sector; for developing diets and feeding strategies to reduce the carbon footprint and to optimize milk composition; for enhancing animal productivity, health and welfare; for increasing the quality and safety of animal products; and for improving economic sustainability of milk production.

Three partner organizations (IDF, FAO and IFCN) undertook separate but complementary approaches to map dairy feeding systems in the world. This report builds a knowledge foundation for animal feeding systems to serve as a valuable resource for the dairy sector and connected chain partners. It can be used both to compare and improve feeding systems already in use by examining the success of similar systems from around the world and for the development of new feeding systems.

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