Table 5. List of feed ingredients that are used or have the potential to be used as protein and/or energy supplements in milkfish feed (nutrient content as % dry matter)

Feed ingredients		Primary use			Moisture DM (%)	Crude protein (%)	Gross energy (kJ/g)	Inclusion (% max)	Main nutritional interest	Main nutritional deficiencies	Processing restrictions
		Protein supplement	Energy supplement	Both							
Animal orgin	Fishmeal (local)	☑	☑	☐	10	64	19	25	Protein, essential amino acids, minerals	Fat soluble vitamins	Air drying reduces protein and fat content
	Fishmeal (Peruvian)	☑	☐	☐	8	68	20	25	Protein, essential amino acids, minerals	Fat soluble vitamins	Air drying reduces protein and fat content
	Fishmeal (tuna)	☑	☐	☐	9	65	20	25	Protein, essential amino acids, minerals	Fat soluble vitamins	Air drying reduces protein and fat content
	Shrimp meal (*Acetes*)	☑	☐	☐	8	69	19	10	Chemoattractants, lysine, methionine, HUFA	Poor mineral digestibility	Oven drying may damage fatty acids
	Meat meal (snail meat)	☑	☐	☐	4	52	16	5–10	Protein, essential amino acids and fatty acids, xanthophyll	Anti-nutritional factor in slime	Cooking is required
	Meat & bone meal	☑	☐	☐	6	47	16	10–15	Protein, minerals	Isoleucine, methionine+cystine	Hygienic standard needed
	Mussel meal (green)	☑	☐	☐	6	65	21	5	Protein, unsaturated fatty acids, chemoattractant	Contains enzyme inhibitor thiaminase	Heating destroys thiaminase
	Poultry by-product meal	☑	☐	☐	8	61	22	35	Essential amino acids, iron, zinc, choline	Low digestibility due to keratin and raw feathers	

Feed ingredients		Primary use			Moisture DM (%)	Crude protein (%)	Gross energy (kJ/g)	Inclusion (% max)	Main nutritional interest	Main nutritional deficiencies	Processing restrictions
		Protein supplement	Energy supplement	Both							
Plant origin	Poultry feather meal	☑	☐	☐	5	71	25	5–10	Protein, glycine, cystine, phenylalanine	Histidine, lysine, methionine, tryptophan	Too high autoclaving temperature, undercooked meal
	Blood meal	☑	☐	☐	6	88	23	5–10	Protein, iron	Fat and carbohydrate	High temperature damages protein and decreases digestibility
	Oilseed meal and cakes										
	copra meal	☑	☐	☐	8	22	16	5–15	Protein	High fiber; lysine, methionone	
	palm kernel	☐	☑	☐	10	16	13	5–10	Manganese, protein quality	High fiber; protein, lysine, methionine	
	Cereal grains										
	corn grain	☐	☑	☐	30	11	18	35	Energy		Boiling is required
	corn meal	☐	☑	☐	8	8	18		Energy, vitamin A in yellow corn	Lysine, methionine, tryptophane	
	wheat grain	☐	☑	☐	11	16	18	10–15	Energy, B vitamins, phosphorus	Lysine, threonine, valine, vitamin A and D, calcium	Grinding and heat processing improve energy values
	Cereal by-products										

Feed ingredients		Primary use			Moisture DM (%)	Crude protein (%)	Gross energy (kJ/g)	Inclusion (% max)	Main nutritional interest	Main nutritional deficiencies	Processing restrictions
		Protein supplement	Energy supplement	Both							
	rice bran	☐	☑	☐	9	13	18	35	Energy, B-vitamins	High fiber and phytate phosphorus	
	rice hull	☐	☑	☐	7	3	9	5	Fine rice hull as carrier of vitamin and mineral premixes	Protein, fat; high fiber	
	corn germ meal	☐	☑	☐	5	47	21		Protein, vitamin E	Lysine, methionine, tryptophan	
	corn gluten meal	☑	☐	☐	8	61	22	20	Protein, β-carotene, xanthophyll	Lysine, methionine, tryptophan	
	corn starch	☐	☑	☐	12	0	17	35	Energy, as binder	Protein, fat, fiber, ash	
	wheat gluten	☑	☐	☐	9	81	23	2–5	Protein, B vitamins, phosphorus	Lysine, threonine, valine, vitamin A and D, calcium	
	wheat pollard	☐	☑	☐	10	15	16	10–20	Energy, B vitamins, phosphorus	Lysine, threonine, valine, vitamin A and D, calcium	Grinding and heat processing improve energy values
	wheat flour	☐	☑	☐	13	11	18	10–15	Energy, B vitamins, phosphorus, as binder	Lysine, threonine, valine, vitamin A and D, calcium	Grinding and heat processing improve energy values
	Pulses										

Feed ingredients		Primary use			Moisture DM (%)	Crude protein (%)	Gross energy (kJ/g)	Inclusion (% max)	Main nutritional interest	Main nutritional deficiencies	Processing restrictions
		Protein supplement	Energy supplement	Both							
	cow pea (Vigna sp.)	☐	☐	☑	8	25	18	15	Protein, energy, iron, nicotinic acid	Sulfur containing amino acids, presence of trypsin inhibitor	Heat treatment necessary
	feed pea (Pisum sativum)	☐	☐	☑	12	25	18	26	Protein, lysine		
	soybean meal, as is	☐	☐	☑	6	36	22	30	Protein, amino acid profile	Lysine, methionine; presence of trypsin inhibitor	
	soybean meal, defatted	☐	☐	☑	8	44	18	20	Protein, amino acid profile	Fat, lysine, methionine; presence of trypsin inhibitor	
	Root crop										
	cassava tuber	☐	☑	☐	56	2	16		Energy	Methionine	
	Leaf meals										
	ipil-ipil leaf meal, native	☑	☐	☐	10	29	18	5–10	Protein, pigments (β-carotene, xanthophylls)	High mimosine	
	ipil-ipil leaf meal, giant	☑	☐	☐	8	25	16	5–10	Protein, pigments (β-carotene, xanthophylls)	High mimosine	
	swamp cabbage	☑	☐	☐	-	28	15		Protein		
	sweet potato	☑	☐	☐	-	23	16		Protein		
	cassava leaves	☑	☐	☐	6	22	17		Protein, lysine, carotene	Methionine	

Feed ingredients		Primary use			Moisture DM (%)	Crude protein (%)	Gross energy (kJ/g)	Inclusion (% max)	Main nutritional interest	Main nutritional deficiencies	Processing restrictions
		Protein supplement	Energy supplement	Both							
	Azolla	☑	☐	☐	8	27	14		Protein		
	molasses, black strap	☐	☑	☐	19	25	16		Energy	Minerals	
	Single cell protein	☐	☐	☐							
	Natural food										
	Acartia (copepods)	☑	☐	☐	8	71	22		Lipids, n-3 fatty acids,amino acids, vitamin C, carotenoids		
	Artemia	☑	☐	☐	8	56	18		Protein, lipids, essential fatty acids		Lipid composition of diet affects fat composition of body
	Brachionus	☑	☐	☐	8	52	19		Protein, lipids, essential fatty acids		Lipid composition of diet affects fat composition of body
	Moina	☑	☐	☐	9	58	20		Protein, n-3 fatty acids		

Data source: Centralized Analytical Laboraotory (SEAFDEC); Hertrampf and Pascual (2000); Støttrup and McEvoy (2003), Lumasag (1985) (for *Moina*)