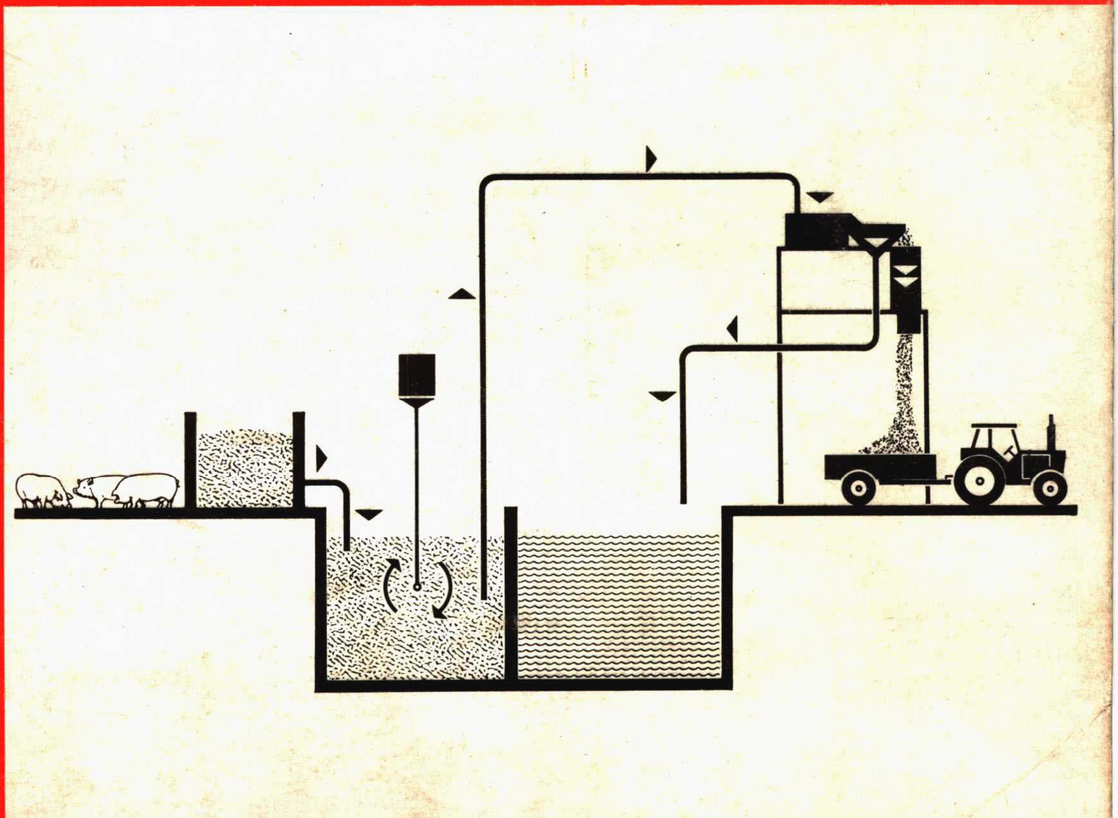
FAO ANIMAL PRODUCTION AND HEALTH PAPER 28

feed from animal wastes: feeding manual



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by

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ABSTRACT

This manual is a continuation of an earlier book, *Feed from Animal Wastes: State of Knowledge* (FAO Animal Production and Health Paper 18 published by FAO in 1980. Its primary objective is to provide practical guidance in animal waste feeding to livestock by setting out a variety of formulas. It is intended primarily for animal growers, particularly in developing countries, who seek advice in the practical application of unconventional feed resources, in which animal wastes play an important role.

The first chapter presents established standards of nutritional requirements for various species and classes of animal: lactating animals (dairy cows and milking buffaloes), dry pregnant cows, beef cattle, replacement cattle (heifers and other young growing cattle), lactating and gestating ewes and fattening lambs, pigs and poultry. Based on these standards, rations containing different levels of various animal wastes are formulated throughout the manual. Standards established for large and small ruminants are designed for a medium plane of nutrition, but some rations allow for a high plane.

In formulating rations, only a limited number of feed ingredients other than animal wastes are used; the result is a series of typical simple formulas which can be adjusted to other conditions. Non-legume hay or green forage is used as a source of forage and/or roughage. Molasses is incorporated in most rations, except that in fruit-waste-based rations, the necessity for taste improvement and a supply of soluble carbohydrate does not arise. Cereal grain, protein feed, and wheat bran are the other main sources of conventional nutrients. In addition, limestone, dicalcium, tricalcium or monosodium phosphate and salt are used to cover mineral requirements in formulated rations. In case any of the "typical" ingredients comprising formulated rations is not available, a number of nutritionally similar ingredients is listed, with approximate conversion factors, to enable farmers to select appropriate substitutes available on their farms.

The chapter on processing animal wastes at the farm level introduces only simple systems which can be applied to a wide farming community: ensiling, stacking, chemical treatment with formalin, and non-mechanical dehydration. Special attention is focused on the ensiling of animal wastes: description of the ensiling process, nutritional and feeding value of animal-waste-based silages, examples of ensiling of poultry litter with green forages, ensiling of layer and cattle manure with crop residues,silages comprising root crops and their by-products, fruit wastes, dry animal-waste-based silage and complex silages.

A separate chapter sets out typical rations for dairy cows (or milking buffaloes) with broiler and replacement-bird litter and with broiler and layer manure. These poultry-waste-based rations, designed for dairy animals, are presented only with selected principal counterpart ingredients, such as non-legume hay and green forage, root crops and their by-products, almond hulls, apple pomace, banana fruit waste, banana peelings, banana plant (leaves + pseudostem), citrus and date fruit wastes, date kernel meal and pineapple cannery wastes. Similar examples of poultry-waste-based rations are formulated for beef cattle. Less comprehensive coverage is provided for poultry-waste-based formulas for dry pregnant cows, replacement heifers, lactating and gestating ewes and fat lambs.

Examples of typical livestock rations containing dry and wet cattle manure are given for dairy and dry cows, beef, replacement cattle, and various classes of sheep, pigs and poultry. Fewer details are given for formulas for pig-faecal-waste-based rations for large and small ruminants, and use of pig waste for monogastric animals is discouraged.

The manual contains 17 tables, 134 formulas with poultry wastes, 26 formulas with cattle waste and 11 formulas with pig waste. These formulas are adjusted to 990 sub-rations, to take account of differences in livestock weights and dry matter intakes.

EXPRESSIONS, SYMBOLS AND ABBREVIATIONS

AA	Acetic acid
ADF	Acid detergent fibre
ADG	Average daily gain
Broiler	Chicken broiler
BW	Body weight
BWG	Body weight gain
Ca	Calcium
Cd	Cadmium
CF	Crude fibre
Cl	Chlorine
Co	Cobalt
CO_2	Carbon dioxide
CP	Crude protein
Cu	Copper
CW	Cell wall
DE	Digestible energy
Dig	Digestible, digestibility
DM	Dry matter
DMD	Dry matter digestibility
DMI	Dry matter intake
EE	Ether extract
F	Fluorine
Fe	Iron
g	Gramme(s)
grnd	Ground
I	Iodine
IU	International units
K	Potassium
Kcal	Kilocalories
kg	Kilogramme(s)
LA	Lactic acid
Layer	Chicken layer
LC	Lactating cow
LW	Live weight
Mcal	Megacalories
ME	Metabolizable energy
Mg	Magnesium
mg	Milligramme(s)
mn	Minimum
Mn	Manganese
N	Nitrogen
Na	Sodium
NE	Net energy
NE_g	Net energy for gain
NE_1	Net energy for lactation
NE_m	Net energy for maintenance
NFE	Nitrogen-free extract
NPN	Non-protein nitrogen
OMD	Organic matter digestibility
P	Phosphorus
Pb	Lead
Poultry	Chicken poultry
ppm	Parts per million
S	Sulphur
Si	Silicon
TDN	Total digestible nutrients
t	Metric tonne
US$	United States dollar
USA	United States of America
VFA	Volatile fatty acids
Zn	Zinc

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Chapter 1

FEEDING ANIMAL WASTES

The fact that the availability of the world's raw materials is diminishing as population grows exponentially, together with the real threat of global food shortages, contributes to a new awareness of the need for conservation and the re-use of things which once would have been thrown away without a second thought. Originally, recycling mainly concerned the urban environmentalists, but when livestock scientists discovered that poultry and other animal wastes could in fact constitute a precious resource, inputs into this research and technology began to expand rapidly. The technical feasibility and, even more, the economic viability of feeding animal wastes back to animals was stimulated by the commodity crisis.

The primary purpose of this aspect of recycling is to prevent animal husbandry from competing with humans for the same food resources, cereals and pulses in particular. The unique digestive capacity of ruminants makes it possible without serious technical or technological problems, and the simplest methods of feeding animal wastes are now being widely applied in both developed and developing countries.

The philosophy behind systems involving the feeding of animal waste is to find a substitute for the common soil/plant/animal cycle. Since feed costs usually represent 60-90% of total production costs, replacing feed by wastes of little or no commercial value inevitably leads to a significant reduction in the cost of meat, milk and other animal products. This is the target, and the key to economical livestock production.

Properly processed animal wastes are wholesome in appearance, taste and smell, and they do not have their original characteristics. Animal wastes are almost 50% higher in crude protein than the feeding ration from which they derive. In addition, they contain other basic nutrients: crude fibre, calcium, phosphorus, other minerals and trace elements, vitamins and some unidentified nutritional factors. Most of the vitamins, in fact, are contained in animal wastes in much greater quantities than in the original animal feed. The protein of animal waste, part of which is of microbial origin from intestinal biosynthesis, is of high biological value for rumen microflora. These facts are brought out by numerous scientific and practical studies indicating that some animal wastes -- poultry wastes in particular -- can, in terms of protein quality, replace most valuable protein feeds such as soybean meal, groundnut meal, cottonseed cake, etc. Though animal wastes are normally rich in protein and mineral matter, they are usually low in digestible energy. Whereas the protein content of some poultry wastes would grade them as protein feeds, the level of energy in animal wastes reduces their nutritional classification to that of legume hay.

Properly processed animal waste has no undesirable effects on animals because their digestive tracts (including microflora), liver, kidneys and other organs have a considerable capacity to remove, break down, transfer or convert most or all metabolic wastes. Most recent studies have also shown that organisms of the rumen break down virtually all the metabolites derived from faecal wastes.

Animal wastes may not be equal in all ways to the feeds they replace, but they are cheap and they contain valuable nutrients which can be utilized effectively by ruminants and converted into body or milk protein, wool and other livestock products.

In the preparation of this manual, intended for developing countries, standards for medium production are used; only in specific cases, where the availability of feed ingredients may permit, a higher plane of nutrition is introduced. Some rations of high nutritient density are also presented, with the intention of ensuring feed intake during hot seasons, when voluntary intake may fall by 15 to 20% or even more. On the other hand, a higher feed intake can be expected during the winter season, during which rations of medium nutrient density are appropriate.

Estimated costs refer to prevailing rates in Southeast Asia in late 1980. Although in absolute terms, these figures may vary considerably from time to time and from region to region (and from country to country within a region), such variations are likely to be proportionate to variations in costs of conventional feed resources.

Chapter 2

FORMULATION OF LIVESTOCK RATIONS CONTAINING ANIMAL WASTES

Breed, management and environment all influence specific dietary requirements of livestock. Formulated rations may provide the best estimates in terms of nutritional values and cost, but there are many other factors that can strongly influence livestock performance. This is particularly true of rations containing animal wastes: the ration must be consumed, it must further be high enough in energy to encourage its intake, and it must have an appropriate roughage/concentrate ratio. This, however, varies from one species and category to another. Animal nutrition is basically a science, but feeding management is an art, fully in the hands of the farmer who transforms the achievements of science into reality.

The major constraints on optimum performance, though often disregarded in the field, are -

i) availability of clean water at all times;

ii) sound feeding management;

iii) minimal waste of feed ingredients;

iv) appropriate housing conditions (shelter, drainage, animal density, trough space, minimum solar exposure, optimum air movement, etc.); and

v) genetic quality and good health conditions of the herd.

In addition to these important factors, other considerations have to be borne in mind when feeding animal waste:

i) Palatability of the ration determines its intake and thus the supply of necessary nutrients. Voluntary intake is an important factor which will help to decide how much of the ration containing animal waste can be used. Feeding forages or roughages with low digestibility should be avoided initially, while molasses and other sugar-containing feeds (including fruit wastes) are of great importance because they increase the palatability of the new feed and supply the soluble carbohydrate necessary to enhance the utilization of NPN contained in animal wastes at and above the 50% level.

ii) Adaptation of animals to a new ration is a matter of management skill. European breeds and high-yielding animals generally adjust faster to new rations than *Bos indicus* or low-producing animals. Similarly, stall-fed ruminants accept the new feed more quickly than grazing animals, which require a longer adaptation period. In general, however, the primary factor is the exercise of the art of feeding, since even the most nutritionally complete rations may be a failure without proper feeding management. In practical terms, when animal wastes are fed below the 30% DM level, ruminants start to eat without difficulty within 3 to 5 days and only hardy animals (particularly those from pastures and loose type of housing) take some 7 to 10 days to adapt.

iii) Feed ingredients for balancing animal wastes should be high in digestible energy but low in mineral matter. Usually calcium is not necessary and limestone or other Ca donors should be excluded from the ration. Similarly, milling by-products (wheat bran, rice bran, etc.) should be used with great care, because their high mineral matter contents, their relatively high crude fibre contents and the presence of other indigestibles (lignin, cutin) may suppress the voluntary intake of the feed. Some quantity of milling by-products is, however, necessary because they are high in phosphorus, which is lacking in most animal wastes and energy-rich feedstuffs. Much, however, depends upon the class of ruminants and their plane of nutrition.

iv) Cereal grains and other starchy feeds (root crops, etc.) are important for increasing energy and reducing mineral and crude fibre contents, usually excessive in animal wastes.

2.1 Standards for lactating animals

Nutrient requirements for dairy animals are related to weight categories and are calculated on the basis of a fixed DMI and expected milk yields for medium production:

Body weight (kg/head)	270	320	400	450	500	550	600	650
Milk (kg/head/day)	←——6 to 14——→				←——14 to 18——→			
DMI (kg/head/day)	8	9	10	11	12	13	14	15

These production parameters are subject to a variation of ± 15%, and they may vary even further according to local conditions. Feed costs have only an indicative value, because the price of ingredients depends upon many variable factors (season, locality, etc.).

Minimum nutrient requirements (calculated in percentage of DM in the ration) are shown below:

Milk yield	CP %	CF %	Ca %	P %	TDN %	NE_1 Mcal/kg
Medium	14	17	0.50	0.34	67-68	1.52-1.55
High	14-16	(14)17	0.54	0.40	68-71	1.56-1.62

Under established norms, 12.4% of CP is considered sufficient for a medium milk yield, but a safety margin is necessary; this has partly been covered by using conservative values of CP in ingredients used in formulating rations.

The minimum level of CF is set at 17% to maintain proper metabolic functions and thus the good health of the cow. Only in warm climates is it reduced to 14%. The importance of a 17% minimum level (or its equivalent, 21% ADF) for lactating cows in maintaining an optimum level of butter-fat content in milk is fully recognized. The marginal or critical CF level is, however, a constant problem with farmers (usually urban farmers) using high levels of concentrates to induce high milk yield. Although some protein concentrates (oil cakes and milling by-products) are fairly high in CF, the particle size of this type of fibre is too small to enable it to fulfil the role of fibre derived from roughage (it often escapes ruminal digestion). It is therefore necessary to ensure that some "long fibre" in the form of hay or green forage is always available in the ration.

A considerable variation in the DMI of individual lactating cows is related not only to their live weight and milk yield but also to the nature of the forage being fed. Thus, for a large lactating cow, the expected DMI is between 2.4 and 3.0% of body weight. For example, the DMI of a 500-kg live weight lactating cow should be between 12 and 15 kg, the maximum applying in winter and the minimum in summer or, generally, in hot climates. High-yielding cows always consume more DM than low-yielding cows.

Small lactating cows consume relatively more feed, between 2.7 and 3.2% (DM) of body weight. A lactating cow of 300 kg live weight will consume 8 to 10 kg DM. In addition to size, production level,ambient temperature, humidity and quality of forage are important factors in deciding feed intake levels, but DE content and the volume of the ration are of the greatest importance. The higher the DE in the ration, the higher its intake; the smaller the volume of the ration, the more the cow eats. The capacity of the digestive track also plays an important role in the utilization of low-quality forages with a high level of indigestible material.

Minimum Ca requirements are established, but rations containing poultry and pig wastes are usually excessive in calcium and create difficulties in maintaining a proper Ca:P balance. Although the Ca:P ratio is often beyond the established limit (2:1), the origin (organic or inorganic) of the element is taken as a criterion. It is assumed that the biological availability of calcium of organic origin, particularly when in excess, is about 50%, and that of P between 75 and 85%; the biological availability of inorganic calcium and phosphorus is taken at between 90 and 100%.

Total minimum P requirements for medium- and high-yielding lactating cows are established at 0.34% and 0.40% of DM respectively. The ash content of all nutrient rations is limited to a maximum of 12% to safeguard against the negative effect of excessive mineral matter on the digestibility of the ration or on the metabolic functions of the rumen (buffering effect, pH, mineral imbalances, etc.). Only in a few cases was it necessary to waive this limitation.

Energy requirements are expressed in TDN because of the simplicity and general understanding and acceptance of this approach in developing countries, although its limitations (under-estimation of the energy value of concentrates in comparison to forages) are fully recognized.

2.2 Standard for dry cows

Dairy animals in developing countries usually have longer dry periods than the established range of 45-60 days for the developed countries. This is particularly true of the buffalo, whose dry period often averages 120 days. In establishing a standard for dry cows it is not feasible to relate the body weight to DMI because many other factors (e.g. the condition of the animal) must be taken into account.

The nutrient density of the ration is based on the following standards (%DM):

CP min.	11.0
CF min.	17.0
Ca min.	0.37
P min.	0.26
Ash max.	12
TDN min.	60

2.3 Standard for beef cattle

Beef rations containing animal wastes are also presented in this manual at a medium plane of nutrition (though some formulas allow for a high plane). The following minimum and maximum nutrient requirements for beef cattle are established:

CP	min.	12.6	% DM
CF	min.	11.0	% DM
Ca	min.	0.46	% DM
P	min.	0.36	% DM
Ash	max.	12	% DM
TDN	min.	70	% DM
NE_g	min.	1.00	Mcal/kg

This standard is adjusted to rations on an "as fed" basis in relation to BW, estimated BWG, and approximate DMI, as follows:

BW (kg/head)	100	150	200	250	300	350	400
BWG (kg/head/day)	---	< 0.9	-----	-----	------ >	0.9	-----
DMI (kg/head/day)	2.7	3.9	5.7	6.2	7.6	8.0	8.5

An indicative feed cost of rations designed for individual BW categories is computed in relation to the estimated DMI.

2.4 Standard for replacement cattle (heifers/young growing cattle)

The following nutritional requirements are established for this class of cattle (%DM):

CP	min.	12.0
CF	min.	15.0
Ca	min.	0.4
P	min.	0.26
Ash	max.	12
TDN	min.	60

Within these requirements, the primary established constraints are first computed on the least cost ration principle and then adjusted to the "as fed" ration.

2.5 Standards for lactating and gestating ewes

The nutritional requirements for lactating and gestating ewes at a medium plane of nutrition are as follows:

			Lactating	Gestating
CP	min.	% DM	12.0	12.0
CF	min.	% DM	-	-
Ca	min.	% DM	0.5	0.5
P	min.	% DM	0.4	0.4
Ash	max.	% DM	14	14
TDN	min.	% DM	65	58

It should be noted that neither minimum nor maximum restrictions are imposed on crude fibre, and a greater allowance is made for mineral matter content to allow for incorporation of larger quantities of animal wastes or other cheap ingredients into their ration. The rations computed within the established constraints are further adjusted to the"as fed" basis to facilitate their practical interpretation.

2.6 Standard for fat-lambs

This class of sheep has relatively higher nutrient requirements. Accordingly, no restrictions are imposed on crude fibre, and a lower ash content level is prescribed.

The standard given below is used (%DM):

CP	min.	11.0
CF	max.	14.0
Ca	min.	0.37
P	min.	0.23
Ash	max.	13.0
TDN	min.	70

2.7 Standards for poultry and pigs

The US National Research Council requirements are adopted in general, with some restrictions and/or limitations on CF and ash contents. The established requirements are listed below:

Species	Class	Level	CP	CF	Ca	P	Ash	ME Mcal/kg DM	LYS 1/	M+C 2/
			%DM						%DM	
Chickens	Grower	min. max.	17.0 18.2	– 5.7	1.07 1.25	0.68 –	– 10.0	3.00 –	0.97 –	0.57 –
	Developer	min. max.	13.6 15.9	– 8.0	1.07 1.20	0.80 1.00	– 10.0	3.00 –	0.83 –	0.45 –
	Layer	min. max.	18.2 19.3	– 6.0	4.00 4.26	0.70 –	– 17.0	3.00 –	1.00 –	0.57 –
Ducks	Grower	min. max.	20.5 –	– 4.0	1.02 1.25	0.70 0.91	– 7.0	3.30 –	1.02 –	0.91 –
	Breeder	min. max.	21.0 –	– 5.0	3.30 3.64	0.70 1.00	– 15.0	3.30 –	1.02 –	0.91 –
								DE Mcal/kg DM		
Pigs	Grower	min. max.	18.2 –	– 4.5	0.68 0.91	0.60 0.74	– 8.0	1.90 –	0.84 –	0.57 –
	Finisher	min. max.	15.3 –	– 8.0	0.51 0.63	0.47 0.60	– 10.5	1.90 –	0.68 –	0.34 –
	Gestating	min. max.	19.3 –	– 7.0	0.85 1.02	0.85 1.02	– 10.5	1.88 –	0.48 –	0.32 –

1/ lysine; 2/ methionine + cystine.

2.8 Feed ingredients used in rations

In formulating rations for various species and categories of livestock it is impossible to envisage all the many feed ingredients and their combinations. For this reason, only typical formulas are established, and these can then be adjusted or modified according to the circumstances. Special attention is however paid to some economically attractive combinations of waste resources in which the waste and by-products can form a complete ration with minimal inputs of conventional feeds or forages.