

The Value of Wheat Offals for Milk Production

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Even before the war, when concentrated feeding stuffs could be imported into this country in apparently unlimited quantities and at very low prices, the feeding of a good dairy cow in full lactation was a matter of some little difficulty. By a good dairy cow is meant an animal giving at least 750 gallons a year, not the poor scrub which is so frequent in so many of our alleged dairy herds. The difficulty was due in part to the fact that cows of this type have become so highly specialized for milk secretion that the functional activities of the udder tissue put a tremendous strain on the digestive capabilities of the animal. Thus, for an animal giving the by no means unusual figure of 4 gallons of milk a day, $2\frac{1}{2}$ times as many calories and 4 times as much protein a day are required as are needed by the same cow when she is dry. If such an animal is to maintain her milk yield within reasonable distance of her potentialities, she must be fed both before parturition and during lactation with care and discrimination, and it must be taken into account that her capacity for consuming *bulk* of foodstuff, which for present purposes can be conveniently measured as weight of dry matter, is limited. Though the lactating cow has a large appetite, even the most accommodating animal of average size will not consume more than about 34 lb. of dry matter daily. Into this weight of feeding stuff must therefore be compressed both the food needed for maintenance, required whether she is lactating or not, and that required for milk production and for the developing foetus.

I hope those here today who are familiar with the rationing of dairy cows will allow me to give a few further details of the requirements of the lactating cow in order that I may provide a background, for those who are not so well acquainted with milk production, against which they may assess the place occupied by wheat offals in that ration. As ruminants, dairy cows can of course, make use, for energy purposes, of carbohydrate sources such as cellulose which cannot effectively be utilized by non-ruminants. They are able also, because of their enormous population of rumen micro-organisms, to make extensive use of sources of nitrogen even as simple as urea or ammonium bicarbonate, and to synthesize for themselves most if not all of the vitamins of the B group.

It is convenient to consider the lactating cow's food as consisting of two parts, one for maintenance and the other for production. The feeding standards for the dairy cow are usually computed on the basis that 6 lb. of starch equivalent containing 0.6 lb. of protein equivalent are required per 1000 lb. live weight every day for maintenance, and 2.5 lb. of starch equivalent containing 0.5 lb. of protein equivalent are required for each gallon of milk of average composition, containing, say, 3.7 per cent. of fat, that she produces.

For present purposes "starch equivalent" may be regarded as a measure of energy. If a foodstuff has a starch equivalent of 70, it may be taken to mean that 100 lb. of it will produce as much energy, in the particular type of animal concerned, as 70 lb. of starch. Protein equivalent may be taken for present purposes as a measure of the value of a nitrogenous

vol. 4, 1946]

foodstuff as a source of digestible nitrogen for the ruminant. The same foodstuff may have different starch and protein equivalents for the ruminant and the non-ruminant.

Essentially a herbivore, the cow can provide almost all her nutritional needs from grass, which if young is highly digestible and contains much protein. The wild cow can both maintain herself, and produce enough milk for her calf until it is able to fend for itself, on grass. Her more civilized relative can, on really good pasture, maintain herself and produce up to some 3 or 4 gallons of milk a day, but such pasture in most parts of this country is only available for, at most, some 4 or 5 months of the year. Even during these months, if the pasture is only a little short of first class, or the milk yield of the cow is high, she will either lose condition, producing milk at the expense of her own tissues, which is more likely to happen when she is in the early stages of lactation, or she will fall off more or less rapidly in milk yield. Supplements to pasture are, therefore, needed during the summer months in many parts of the country and for many cows.

Since human demands for liquid milk are almost constant throughout the year, dairy farmers have for many years endeavoured to arrange calving dates so that a substantial proportion of their cows produce milk throughout the winter, when grass is available, if at all, in small quantities only. Bulky, stored farm foods then form the basic part of the diet. It is during the winter months, therefore, that high quality supplements are required almost everywhere in this country by the average, or better than average, cow. In the winter months, the basic maintenance ration will consist on most farms of average to poor hay, not infrequently straw, preferably oat straw, but often the less nutritious wheat straw, some kale or cabbage in the earlier part of the winter, and roots, with sometimes silage of varying quality; these are foods containing much indigestible dry matter in proportion to their energy or protein content. Supplements in winter for the cow in milk must, therefore, contain much protein and energy in a small bulk, in order that she may get sufficient calories and protein within her total food capacity of some 34 lb. dry matter to enable her to maintain both her milk output and her health. More precisely, the good cow requires a winter concentrate with a starch equivalent of not less than 60 and a content of crude protein of not less than 18 to 20 per cent. Mixtures containing crushed cereals, pulses, and oil seed residues, fed at the rate of $3\frac{1}{2}$ lb. of mixture per gallon, form suitable concentrated rations for winter milk production. Examples of such feeding stuffs are set out in Table 1.

In summer, on pasture, the average cow will derive most or all of her protein from grass, in fact, on a good pasture, she will normally get more protein than she requires. Supplements are needed, therefore, which are lower in protein than in winter; 8 to 12 per cent. protein would be ample but, again, they should be high in starch equivalent, 63 to 70 or more. Crushed cereals, or crushed grains mixed with limited quantities of bran or middlings, and containing if possible a feeding stuff such as flaked maize to offset the mild scouring effect of the fresh grass, form suitable concentrates for summer feeding. As the feed derived from pasture goes down so the protein equivalent and total quantity of the late summer and autumn supplement should go up. The nice assessment

of the changes required, complicated as it is by the vagaries of rainfall, is one of the most difficult tasks of the dairy husbandman. Finally a complete winter milk production ration is reached.

In war time, with shortage of imported concentrates of high starch equivalent and protein equivalent, the dairy farmer is driven to make the utmost use of bulky farm feeding stuffs of low starch equivalent and

TABLE 1

PROTEIN (N \times 6.25) AND STARCH EQUIVALENT OF TYPICAL FEEDING STUFFS FOR DAIRY COWS*

Feeding stuff	Protein per cent.	Starch equivalent
High protein		
Bean meal	25	66
Decort. groundnut cake	47	73
Linseed cake	30	74
Soya bean cake	43	69
Palm kernel cake	17	81
Low protein		
Wheat	12	72
Maize	10	77
Oats	10	59
Middlings	15 to 16	57
Bran	14 to 15	43
“Bulky farm foods”		
Hay, average	9	33
Straw, oat	3	20
wheat	3	13
†Soda straw, from wheat	?1	40 to 45
†Roots	10	40 to 50

* Figures calculated for material as used on farms, *i.e.*, not specially dried.

† Calculated on a basis of moisture content comparable with that of dry straw.

protein equivalent, together with what supplementary concentrates he can grow on his own farm or obtain under the rationing scheme from the much reduced pool of by-products from oilseed crushing and flour milling. War time feeding for milk production is a fight against bulk. Both the farmer and the compound feeding stuffs manufacturer find it very difficult to put together sufficient quantities of mixtures which will give a starch equivalent above 60, and contain enough protein to complement the deficiency in the bulky winter maintenance ration. Even the official National Dairy Ration usually has a starch equivalent of only 57 to 58. Both farm foods and available concentrates contain far too much indigestible material. The poorer cow, giving a milk yield of not more than 450 gallons may not be seriously incommoded, but the better cow in many cases is hard put to it to get the necessary quantity of nutrients into the bulk which she can digest. How do wheat offals fit into the present picture and into the possible future of feeding for milk production?

Composition of Wheat Offals

To give detailed figures for the exact composition of the various commercial forms of wheat offals is not easy. There has been a good deal of shuffling with names of the various grades in the past twenty or thirty

years (Woodman and Evans, 1944). Before the last war, in descending order of coarseness, were bran, pollards, coarse middlings (sharps, thirds and toppings), and fine middlings. During the last war the bulk of the offals were sold as bran or coarse middlings. Between the wars coarse middlings were rechristened fine wheatfeed, and fine middlings, superfine wheatfeed. Later there was some attempt to relate quality to nomenclature, and home produced coarse middlings became weatings with a maximum crude fibre content of 5.75 per cent., and fine middlings became superfine weatings with a maximum crude fibre content of 4.5 per cent. As regards quantities, Kent-Jones (1939) gives a typical example of a mixed wheat which after milling gave 72.6 per cent. flour, and 27.4 per cent. offals containing 18.0 per cent. middlings and 9.4 per cent. bran.

On October 1st 1944 the extraction of National flour in Great Britain was reduced from 85 to 82½ per cent. Analyses published by the Ministry of Food (1944) showed a consequent reduction in the percentage bran content of National flour from 4 to about 2.4. The rate of extraction has crept a little further down to 80 per cent. quite recently. It may be assumed that the amount of bran now separated in milling is from 9 to 10 per cent. and the amount of middlings 11 to 10 per cent. As compared with 85 per cent. extraction, there is a small change in the composition of the middlings, namely, a slight rise in their content of riboflavin, vitamin B₁, nicotinic acid and iron at the cost of the flour but, as compared with those from a 73 per cent. extraction, the middlings from an 80 per cent. extraction will be inferior in energy content as a food for any kind of farm stock.

TABLE 2

STARCH EQUIVALENT AND CONTENT OF DIGESTIBLE PROTEIN AND FIBRE IN WHEAT OFFALS FOR FEEDING SHEEP AND CATTLE (WOODMAN AND EVANS, 1944)

Cereal product	Fibre per cent.	Digestible protein per cent.	Starch equivalent
Extraction about 70 per cent. (pre-war)			
Bran	9.50	10.90	42.6
Middlings	6.07	11.74	57.2
Extraction 75 per cent.			
Bran	9.60	11.00	42.0
Middlings	7.47	12.24	49.0
Extraction 85 per cent.			
Coarse bran	10.31	11.02	40.4
Fine bran	9.41	10.81	44.0

In digestibility trials with sheep, Woodman and Evans (1944) found that the bran or "coarse bran" was approximately equal to the pre-war bran in its digestible protein content (11 per cent.) and only slightly inferior in starch equivalent (40.4 against 42.6). War middlings (or "fine bran") were, however, much inferior to the middlings from 73 per cent. extraction, the starch equivalent being depressed from 57.2 to 44. The "fine bran" in fact was little different in respect of fibre, digestible protein or starch equivalent from the pre-war grade of bran (Table 2). From 80 per cent. extraction the fine bran will be a little better than that from 85 per cent. extraction.

For present purposes it will probably be sufficient to regard war time wheat middlings as rather better in energy and protein content than pre-war bran and consider for milk production the value of the pre-war bran and the pre-war middlings. To provide *protein*, neither of them is a really good material for the winter milk production ration if a cow is short of protein in her maintenance ration, as she is at present and will probably be for some time after the war. What is much to be preferred for the production ration under such circumstances is a feeding stuff of not less than 18 to 20 per cent. protein content. As regards *starch equivalent*, bran is undoubtedly low, and middlings approach the minimum of requirement for incorporation in a winter milk production ration. They are not high enough for a summer milk production supplement.

Both bran and middlings are not far from "balanced" as regards protein and starch equivalent for winter milk production. By this is meant that the ratio of protein to starch equivalent is about that needed for a production ration which, it will be recalled, should contain for each gallon of milk 0.5 lb. of protein to 2.5 lb. of starch equivalent, a ratio of 1:5. A food already "balanced" has the virtue that a farmer can add it to a milk production ration without troubling to consider with what other foods it should be mixed to achieve "balance". The main drawback of bran is, of course, that since both protein and starch equivalent are low, the cow has to eat far more in total weight to obtain the needed quantities of protein and starch equivalent per gallon. This may be a serious matter for a high yielding cow, limited as she is in her digestive capacity to not more than 34 lb. of dry matter a day. With bran she has to eat a good deal that she cannot digest. Woodman and Evans (1944) calculate that with recent coarse millers' offals as much as 7 lb. is required for each gallon of milk produced. A three gallon cow could hardly keep within her total dry matter consumption if much of her production ration consisted of bran. What is needed in such cases for the production ration is not bran, and not middlings, but a mixture of high protein value such as soya bean cake or decorticated groundnut cake with flaked maize or crushed cereals which can be given in much smaller total bulk.

To provide minerals it is good practice on dairy farms to give mineral mixtures of common salt and ground limestone either where the cows can help themselves, or added to the concentrates at the rate of 2 to 3 per cent. Very heavy yielding cows are frequently given in addition a small quantity of sterilized bone flour. Therefore, though bran is a good source of P, containing about 1.3 per cent., the content of Ca and P in wheat offals hardly comes into the picture at all for milk production in this country.

The ruminant seems to be able to produce all the essential *B vitamins*, doubtless with the aid of the high population of micro-organisms in the digestive tract. Thus, the B vitamins in wheat offals are in fact wasted on the cow.

In addition to possession of the nutritive values just described, there are one or two other aspects to be taken into account in assessing the value of wheat offals for milk production. A bushel of bran weighs only some 16 lb. compared with a weight of about 47 to 50 lb. for a bushel of maize meal or bean meal. As a consequence, when mixed with the heavier concentrates even in small proportions, bran makes the whole

mixture lighter and rather more attractive to the bovine palate, and may even assist in the rate of digestion by facilitating a more intimate mixture of the digestive enzymes and of the organisms in the rumen and intestine with the concentrate ration. This argument does not apply, or not to the same extent, to middlings.

Another consideration, particularly important in peace time, is that of price. A few months before the war, bran at £5 or thereabouts per ton was attractive to the farmer when compared with oats at £7 per ton, despite the higher starch equivalent of the oats. At present a farmer cannot buy exactly what he wishes, but has to take what is available and is limited also for quantity by the number of ration coupons he receives each month, which are proportional mainly to the number of gallons of milk he sells off the farm.

A further consideration is in the quasi-medicinal properties of bran. Bran is frequently used not only for cattle but also for various other farm animals as a mild laxative in certain emergencies, which may be parturition, constipation, or a great variety of other disorders. It is, of course, not infrequently used for the same purpose by human beings. With certain non-ruminant farm animals its laxative effect may well be due to the indigestible fibre and pentosans, but with cattle it seems probable that it must be due to some other constituent. Little work on this question seems to have been done since 1906 (Jordan, Hart and Patten, 1906). Bran has a fairly high Mg content of about 0.55 per cent., but the quantity in the 3 lb. bran used for a bran mash would appear to be of relatively little significance compared with the quantity in the rest of the daily ration, oats containing 0.12 per cent. Mg, and clover hay 0.28 per cent. While bran is frequently used as a stockman's remedy, more information is needed as to *how* it works.

The total production of wheatfeed before the war averaged 1,700,000 tons a year. When an average yearly import of some 650,000 tons is added, we had some 2,350,000 tons for disposal. If we assume that rather less than one-third was bran, we see that about 700,000 tons of bran and say 1,600,000 tons of middlings were available for farm stock.

It is difficult to say, in precise terms, how this was distributed between different types of farm animals before the war, but there can be no doubt that whilst bran was used almost entirely for horses and cattle with a little for poultry, the middlings both coarse and fine were used mainly for pigs and poultry and only to a small degree for milk production. At present most dairy farmers are glad to get any type of wheat offals owing to the general dearth of anything approaching a concentrated food. The peace time dairy cow, however, would not be seriously disturbed provided the extraction of flour did not go above, say, 90 per cent. This would give her ample supplies of bran, a proportion of which she is very glad to have in her diet for the reasons I have touched upon. She would, in fact, be unhappy to take up residence on a farm where a few bags of bran were not available in the food store.

That the dairy cow is largely dependent in either peace or war on wheat middlings is incorrect. To regard them as an ideal concentrate for milk production is a flight of fancy. There are much more valuable materials for this purpose that could be imported in the shipping space needed for the extra wheat to provide the middlings. Given good farming

to provide quantity and quality of grass and home produced feeding stuffs, including home grown grain and legumes, milk production would be most benefitted not by the availability of middlings but by the importation of a reasonable quantity of maize together with some really high quality protein cake, or oil seeds to provide such cake. Given these and her present quantity of bran, the peace time cow could get on quite comfortably without any wheat middlings at all.

The cow is, fortunately, not a serious competitor with the human being for food. The peace time dairy farmer, if he had bran and the imported concentrates just mentioned, would be quite happy to leave on the one hand the human consumer who wishes for a more nutritious loaf than that provided by 73 per cent. extraction flour, and on the other the votaries of the pig and hen, to thrash out between them what the rate of flour extraction should be. I am sure Mr. Halnan will explain that the pig and the hen are concerned in a way that the cow is not in having a substantial supply of middlings fairly rich in B vitamins.

I am much indebted to my colleague, Mr. A. S. Foot, for his help with certain aspects of this short paper.

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Value of Wheat Offals for Pigs and Poultry

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Introduction

Wheat offals consist of a variety of products of varying composition arising from the milling of wheat for flour. Wood and Adie (1917) showed that the finer grades of wheat offals sold in this country could be classified into three pure grades, pollards, coarse middlings and fine middlings, and three mixed grades consisting of admixtures of two or more of the three pure grades. Subsequently the Millers' Mutual Association (1933) standardized the grades of wheat offal manufactured in England and Wales into three grades, superfine weatings with a maximum fibre content of 4.5 per cent., weatings with a maximum fibre content of 5.75 per cent., and bran, whose fibre content normally exceeds 7.5 per cent. The amount of home milled wheat offals forms a material contribution to the supply of animal feeding stuffs, the estimated 5,000,000 tons of wheat milled in this country yielding, on the basis of a 70 per cent. extraction of flour, 650,000 tons of bran and 800,000 tons of middlings or weatings.

The main body of the wheat grain consists of an endosperm composed of starch cells with an outer layer of protein cells known as the aleurone layer. The germ or embryo is on the dorsal side of the grain, and extends

vol. 4, 1946]