

The value of processing cereals

There is a growing interest in the use of processed cereals in animal feeds. Technological treatments reduce microbial contamination, increase nutrient digestibility and improve productive performance. Some processing techniques might reduce feed cost and allow the use of higher amounts of liquids or alternative raw materials. This article evaluates the effects of processing cereals on piglet performance.

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The increase in productivity observed worldwide for pigs in the last years are mostly due to management and genetic improvements. However, nutrition also plays an important role. Three key issues that will influence animal-feeding techniques drastically are:

1. The ban of most growth promoters and drugs used for the control of coccidiosis;
2. The ban on the use of some animal proteins (meat products) and the constraints to the use of others (fish products) and
3. The trend towards extensification of the animal production systems (due to the lack of control of the microbial disbiosis in the gastrointestinal tract which increases the incidence of diarrhoea and mortality in weaned piglets).

Post-weaning problems

At weaning the young pig is subjected to many stressors, which cause post-weaning growth problems and losses in many commercial operations. Associated with weaning are marked changes in the histology of the small intestine, which result in a reduction in the capacity of the gut to digest feeds, a major contributor to post-weaning diarrhoea.

It is known that fine grinding of cereals improves nutrient digestibility, probably at expenses of mucus health and intestinal comfort, and that pelleting consistently reduces feed wastage and improves pig performance. However, few data exist on the benefits of using heat-processed cereals in diets for monogastrics. The available data do not always favour the use of processed



Gelatinisation of starch through expanding improves the digestibility at the small intestine level. The degree of gelatinisation is not fully clarified yet. (Photo: ARS/Keith Weller)

cereals in diets for piglets. It is generally accepted that heat processing modifies the structure of the fibre fraction, improves nutrient availability, increases palatability and increases animal performance. In addition, the heat applied to feed, as in the case of the expansion procedure, improves feed mill productivity and pellet quality and reduces microbial contamination of the final products.

Gelatinisation effect

Heat processing of cereals disrupts cellular structure, gelatinises the starch and alters the protein fraction. The degree of effectiveness depends on type of cereal, na-

al grains for piglets

Table 1 - Main effects of heat processing of corn and barley on performance of piglets

	0 – 14 d		14 – 25 d	
	ADG ¹	FC ²	ADG ¹	FC ²
Barley				
Raw	272	1.30	564	1.26
Extruded	314	1.10	592	1.23
Micronised	305	1.17	596	1.13
P	0.11	*	*	0.10
Corn				
Raw	285	1.16	526	1.28
Extruded	289	1.20	584	1.14
Micronised	256	1.19	588	1.24
P	NS	NS	*	NS

¹Average daily gains (g). ²Feed conversion (g/g). P < 0.05. (Medel *et al.*, 1999)

ture of the treatment, and conditions of time, pressure, and temperature applied. For example, expansion and extrusion ruptures native cells rendering the nutrients more available for digestion and absorption. Also, the conditions applied will modify the structure of starch in different ways according to the nature of the cereal.

It has been reported that gelatinisation of the starch improves the digestibility at the small intestine level, an effect that might be of particular interest in young piglets because amylase production is low at early ages. However, the influence of the degree of gelatinisation of the starch on piglet performance is not fully clarified at present.

Vestergaard and co-workers observed that extruded barley gave the highest degree of gelatinisation, but not the greater improvement in performance. In fact, a high amount of gelatinisation, obtained through excessive heat, can be detrimental because of the increase of unavailable starch and the reduction of amino acid availability due to Maillard reactions.

The role of fibre

An area of growing interest in animal nutrition is the role of the different fibres in the feed on the incidence of enteric processes in piglets. Fibre value in piglets' diets has been little explored partly because it is believed that the microflora of the gut is of minor interest in young pigs.

Fibre is chemically and physically a heterogeneous mixture of substances and therefore it is unwise to

generalise about its properties and effects in the gut. It is known that some portions of the fibre fraction modify digestive transit time and stimulate the physiology of the digestive tract, which might be implicated in colonic health. The improvements may be due to the mechanical effects on the intestinal walls of the dietetic fibre itself or to the production of volatile fatty acids.

Intestinal microbes ferment fibres and the end products obtained, such as short-chain fatty acids, influence proliferation and differentiation of the epithelial tissue in the colon.

It is well known that processes such as extrusion and cooking that involve heating, affects dietary fibre in terms of physiological and physical properties. Extrusion of wheat flour modifies the solubility of the fibre fraction that consequently was more extensively degraded than the fibre of raw wheat.

The short chain fatty acids produced are physiologically important, specially in the large intestine, in which they are required to maintain the health of the epithelial cells lining the gut. Butyric acid might be used with preference to other fatty acids as a direct source of energy by the colonocytes and other cells of the digestive tract and might have regulatory effects on gene expression and cell growth. Also, the production of volatile fatty acids might change pH and protect the intestine media from pathogen microbial growth.

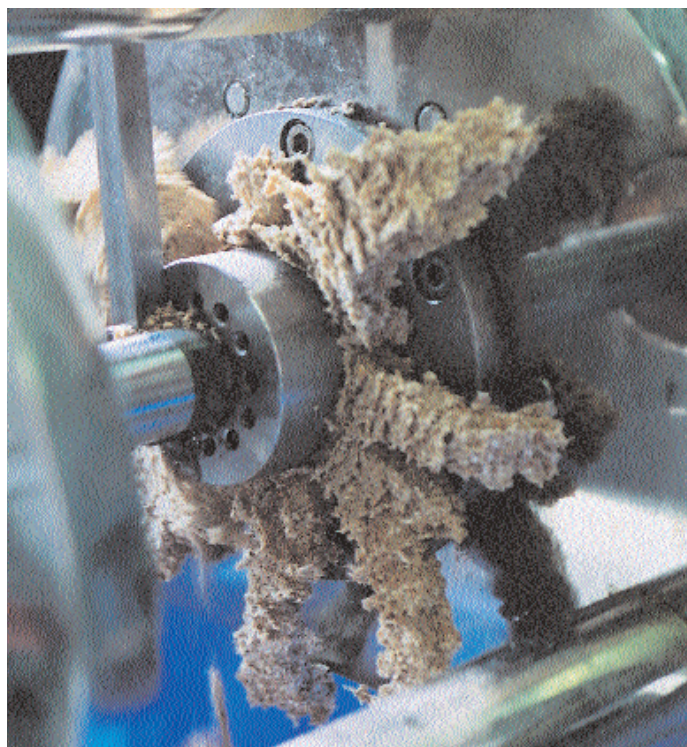
These changes modify the physiology of the gastrointestinal tract and may improve productive performance traits. Several authors have indicated that the inclusion of some fibres in the diet (beet pulp, soy hulls, oat hulls, etc) is beneficial for intestinal mucosa health and piglet performance.

Heating improves performance

Heat processing of cereals consistently improves piglet performance, especially at early stages of growth. Medel and co-workers have shown that the inclusion of expanded or micronised barley in diets for piglets improved average daily gains and tended to improve the digestibility of organic matter in piglets from 21 to 35 d of age.

The authors compared diets containing 50% of raw, expanded (Amandus Kahl) or micronised (UK Micronising Company) barley in diets for weaned piglets. Feed intake increased by 8.5% and average daily gain by 13.7% when barley was processed. Processing of barley also improved the digestibility of organic matter by 4.5% and feed conversion by 4.9%, but no differences were observed between the types of processing (and therefore between degree of starch gelatinisation). Oth-

Processing



The use of cooked rice in the diet benefits feed intake and piglet growth, especially the first ten days after weaning.

(Photo: Dick Ziggers)

Table 2 - Influence of cooked rice and corn feeding on piglet performance

	Rice	Corn	P
Daily gains, g	205	161	0.001
Feed intake, g/d	262	203	0.001
Feed conversion, g/g	1.28	1.30	NS
Dry matter dig., %	84.1	77.3	0.001
Crude protein dig., %	66.9	62.4	0.01

(Mateos et al., 2002)

ers have also observed that expansion of the feed improved apparent faecal digestibility of the fibre portion of the piglet diet and reduced daily production of faeces and moisture content.

Medel and co-workers also compared diets based on corn or barley, raw, extruded (Wenger) or micronised (UK Micronising Company) on performance of piglets from 21 to 46 d of age. The main effects of the cereal are shown in *Table 1*. In general heat processing improved piglet performance but the beneficial effects were more pronounced for barley than for corn diets. No differences were obtained between wet extrusion and micronisation of the cereal on productive parameters.

The incidence of enteric disorders requiring treatment during this period was greater for corn than for barley fed piglets (13 vs 7%) although the difference did not reach significance.

In a recent trial Medel compared diets based on raw

or cooked and expanded barley on apparent ileal digestibility of starch and other nutrients and performance of young pigs. From 21 to 35 d of age piglets fed heat-processed barley grew faster (213 vs 184 g/d) and tended to have better feed conversion (1.09 vs 1.20 g/g) than piglets fed raw barley diets.

Others, however, did not find any benefits when micronised barley instead of raw barley was used in diets for piglets from 10 to 27 kg of body weight. Recently, we studied the influence of heat processing of cereals on productive performance of piglets. There were eight treatments with four cereals (corn, barley, oats, and decorticated oats) and two types of processing of the cereal (raw; cooked and flaked).

From 28 to 50d of age, in which each replicate received their experimental diet, heat processing improved growth and feed efficiency by 10.6% and 7.8%, respectively. Also, heat processing was more efficient for barley than for corn, although piglets fed corn grew faster and more efficiently than piglets fed barley.

Rice performs well

In another trial we investigated the influence of type of cooked cereal (corn, oats, decorticated oats and rice) and the inclusion of 2.6% of expanded oat hulls on performance of piglets. Piglets fed cooked rice showed the best growth and feed conversion but the improvements over the remaining cereals were only significant ($P < 0.05$) for daily gains. The addition of oat hulls did not affect adversely performance from 21 to 31 d of age, and in fact feed conversion was improved when hulls were added ($P > 0.05$).

In another recent trial we investigated the influence of substituting 30% of cooked corn for cooked rice with or without the inclusion of cooked and expanded oat hulls, on nutrient digestibility and performance of piglet weaned at 20 d.

In summary

Cereal grains are the major sources of energy for pigs and their nutritive value can be improved by heat processing. Processing affects all fractions of the cereal including starch, protein, vitamins, and fibre. Type of processing (toasting, extrusion, cooking, expansion, etc) affects differently animal performance, and the influence of pressure and heat of the feed on gut morphology, microbiology, health, and performance at early ages has not been elucidated.

Therefore, current available information does not allow recommending the use of a particular cereal or heat process in the diet. Data from our lab indicate that most heat processing techniques of cereals improves piglet performance (21

Diets based on full-fat soybean, fishmeal, and milk products were fed from 20 to 40 d of age and nutrient digestibility was determined at 33 d of age. At the end of the trial piglets fed rice tended to grow faster (345 vs 315 g/d) but had the same feed conversion than piglets fed corn. Adding oat hulls to the diet tended to improve daily gains (458 vs 426 g/d) and improved feed conversion (1.57 vs 1.70 g/g) from 30 to 40 d of age but not from 20 to 30 d. Digestibility of organic matter (76.0 vs 73.8%), crude protein (67.1 vs 62.8%), and gross energy (72.0 vs 69.0%) improved when oat hulls were included in the diet.

In a second trial we compared diets with 52% of heat-processed rice or corn and 0, 2, or 4% of cooked and expanded oat hulls. Each of the six treatments was replicated eight times and the trial lasted 20 d. At the end of the trial, daily gains were greater for piglets fed rice than for piglets fed corn (315 vs 286 g/d) but feed conversion was not affected.

Increasing the level of oat hulls did not affect performance from 20 to 29 d of age but improved feed conversion from 29 to 40 d of age ($P < 0.01$). We therefore concluded that the use of cooked rice in the diet benefits feed intake and piglet growth, especially for the first 10 days after weaning. Also, the inclusion of a moderate amount of heat-processed oat hulls improved feed conversion from 30 to 40 d of age without affecting body weights at any age (Table 2).

The reasons for the beneficial effects of cooked rice feeding as compared to other cereals on piglet performance are not known but might be related to its influence on the fermentation pattern in the large intestine. ●

This article is an edited version of a paper presented at the 5th International Kahl Symposium in Reinbek, Germany

to 40 d) and might be beneficial for gut health of the animals. Heat processing of cereals showed most of the beneficial effects early in life and the data indicate greater improvement with rice and barley than with other cereals. The reason is not known but heating modifies the structure and chemical properties of the fibre fraction and hygienises the feed, increasing nutrient digestibility and palatability. The influence of the degree of starch gelatinisation on piglet performance is controversial at the present time. In spite of the benefits, cost of processing is deterrent in some situations but its use in diets for early-weaned piglets is recommended.