Expanded crumbs for feeding productive livestock. An alternative to mealy and-or pelleted feed

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Expanded crumbs for feeding productive livestock. An alternative to mealy and/or pelleted feed

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SUMMARY - The production, product qualities, and the possibility of using an expanded structurized feed for different productive animals are described. This type of feed is produced by expander without a pelleting press. The granulate which is produced can considerably increase the value of meal feed and it can, in many cases, replace pelleted feed. Thermal treatment by expander improves the physical product qualities such as flow behaviour, structure, and absence of dust. At the same time such important ingredients as starch, crude protein, fat, and crude fibre are improved with regard to their utilization by the animal. Heat-treated granulate is free from pathogenic germs and mould fungi. The structure of the expanded feed can be changed during production and can be adapted to the respective animal and to the growth of the animals. This satisfies the demands for a feed structure which corresponds to the needs of the animal, is friendly to the environment and ensures the best possible utilization of the genetic performance.

Key words: Feed structure, hygienics, performance.

RESUME - *"Miettes expansées pour l'alimentation des animaux en production. Une alternative à l'alimentation avec farine et/ou granulés". La production, les propriétés du produit et les possibilités d'application pour différentes espèces d'animaux utiles sont décrites. L'aliment est produit par un expandeur sans presse à granuler. Le produit émietté obtenu peut considérablement augmenter la valeur d'un aliment farine et dans beaucoup de cas peut remplacer l'aliment sous forme de granulés. Le traitement thermique avec l'expandeur permet une amélioration des propriétés physiques du produit comme l'écoulement, la structure, l'absence de poussière. En même temps, des composants importants comme l'amidon, la protéine brute, la graisse ou les fibres brutes sont améliorés quant à leur utilisation par l'animal. Le produit émietté qui a subi un traitement thermique est exempt de germes pathogènes et de moisissures. La structure du produit expansé peut être modifiée pendant la production et peut ainsi être adaptée à l'espèce animale respective et à la croissance des animaux. Cela répond aux exigences d'une structure d'aliment qui prend en considération les besoins des animaux, est favorable à l'environnement et qui permet la meilleure utilisation possible des performances génétiques.*

Mots-clés : *Structure de l'aliment, hygiène, performances.*

Why expanded structurized feed?

An "expanded structurized feed" is a compound feed which has been exposed to hydrothermal treatment by expander and which has been produced without pelleting as granulate for direct feeding (Fig. 1).

The granular product is free from pathogenic germs, easily dissolves in water and has very good flow properties which allow to discharge it without problem from silo cells or automatic feeders.

The processing parameters such as moisture, temperature, pressure and electromechanical energy input in the expander influence the nutritive and physical feed characteristics. The requested grain structure is achieved by crushing equipment, such as structurizing machines and crumblers, which follow the expander.

The term expanded structurized feed includes a complete feed, an energy concentrate, protein concentrate, or a ready to use compound feed.

Expanded structurized feed replaces the following 3 traditional feed structures: (i) mealy feed, for avoiding bad flow properties, dust formation, and low feed utilization; (ii) pellets, if dimensional stable

pellets are not required for feeding and if mealy feed is not wanted; and (iii) crumbles from pellets, produced by crumbling the pellets by crumbler.

The expander is also suitable for structurizing individual feed mixtures for giving them mixing stability resp. for turning them into a carrier substance for micro components, for example for medicated feed, organic acids, or dietary feed. Individual feed components which are rich in fibre, such as bran or coarse extraction meals, can be conditioned according to requirement before being included in compound feeds. The reasons are: modification of fibres, compacting of volume, reduction of germs, ANF-decontamination.

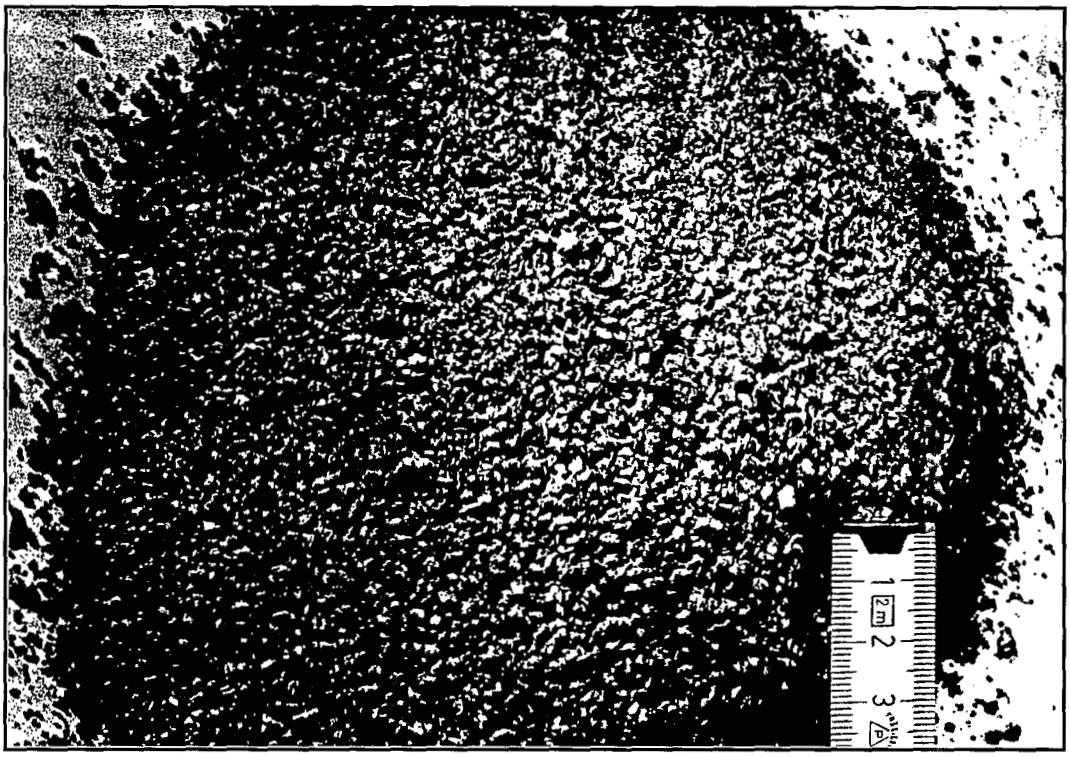

Fig. 1. Expanded structurized feed.

Expanded structurized feed can be used for feeding: (i) piglets and pigs (dry or wet feeding); (ii) layers (breeding and egg production); (iii) broilers, especially during the first weeks of their life; and (iv) dairy cattle and fatstock, preferably when mixing a ration (TMR) including roughage in the mixing trough or when producing a starch modified individual component such as sorghum, maize, barley, or wheat.

Expanded structurized feed corresponds to the needs of the animals, as granulate:

(i) It is not as hard as pellets, so that it does not damage the gullet or the stomach; this applies to pigs for example (Nielsen, 1995).

(ii) It is coarse grained and dust free so that it will not block the chewing and respiratory organs.

(iii) It, in contrast to meal or pellets, easily dissolves in water, it is firm and can be pumped without difficulty, which is of special importance for pigs -wet feeding.

(iv) It has a large particle surface and porous structure which allow digestive juices and enzymes to penetrate it more easily.

Production process

The production of expanded structurized feed is shown in Fig. 2:

(i) A mixing conditioner is used for preconditioning the product by adding steam, water, and other liquids. Depending on the grain size of the product fed, conditioning temperature and moisture, the conditioning time is between 0.5 to 2 minutes.

(ii) A standard expander as already described in literature (Frank and Pipa, 1989; Elstner, 1997) and as shown in Fig. 3 is used for hydrothermal pressure treatment and for agglomerating the feed to larger product lumps.

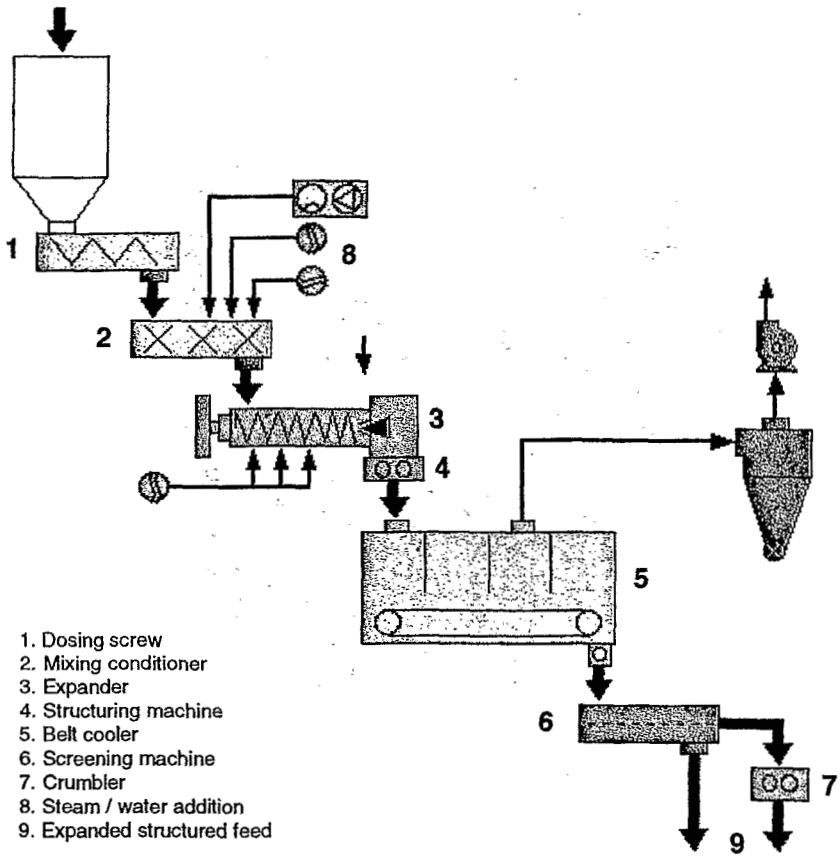

Fig. 2. Production of expanded structurized feed.

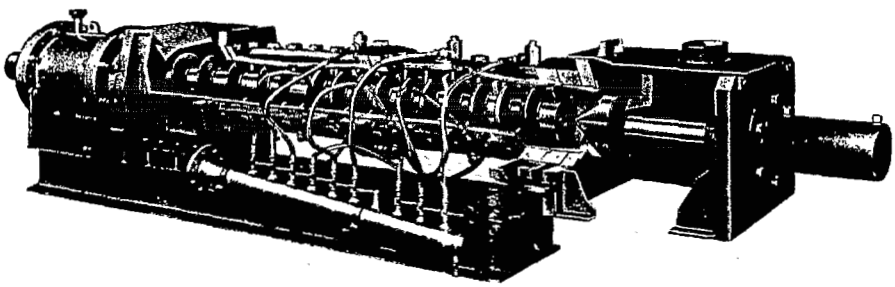

Fig. 3. Standard expander.

(iii) The expander is followed by a structurizing machine = crusher with screen inserts. The screens can be exchanged from outside. Screen perforation and speed of the structurizing machine are variable and determine the grain size of the intermediate product. This intermediate product can easily be cooled, transported, and crushed.

(iv) A belt cooler which has been adapted to this kind of product is used for cooling. The belt cooler had to be modified, as the specific surface of the expanded product is much larger than that of pellets; different cooling parameters are therefore required.

- Pellet surface (ø 5 mm): abt. 450 m^2/m^3 pellets.
- Expanded product surface up to 3 mm: abt. 3250 m^2/m^3 exp. product.

(v) Heat and water absorption are very high in the first third of the cooler, so that the formation of condensate inside the cooler and the evacuation system must be avoided by measures basing on heat technology and by insulation. For assuring uniform cooling and for avoiding that ducts are formed in the product layer, the thickness of the product layer is reduced in contrast to pellet cooling and the cooling time is shortened.

(vi) The final structure is determined by a screening machine which is followed by a crumbler. By choosing a corresponding screen perforation all particles which are smaller than the chosen maximum grain size are separated. Fines do not have to be screened nor returned, as particles having a smaller grain size are also a granulate and no dust producing meal. The oversized particles are led to a crumbler and reduced to the desired grain size. The same crumbler as for pellet crumbling is used, its rollers, however, have a different corrugation and their speed can be adjusted. Due to preliminary screening the crumbler is only charged with 40 to 60% of the expander output.

Physical product quality

Intensity of thermal treatment and granulate size have an influence on: (i) bulk density; (ii) grain structure; (iii) flow properties; and (iv) dissolution in water.

Bulk density

Expansion reduces the bulk density as compared to meal or pellets. Fig. 4 gives a comparison with pig feed which has been produced with different processing temperatures.

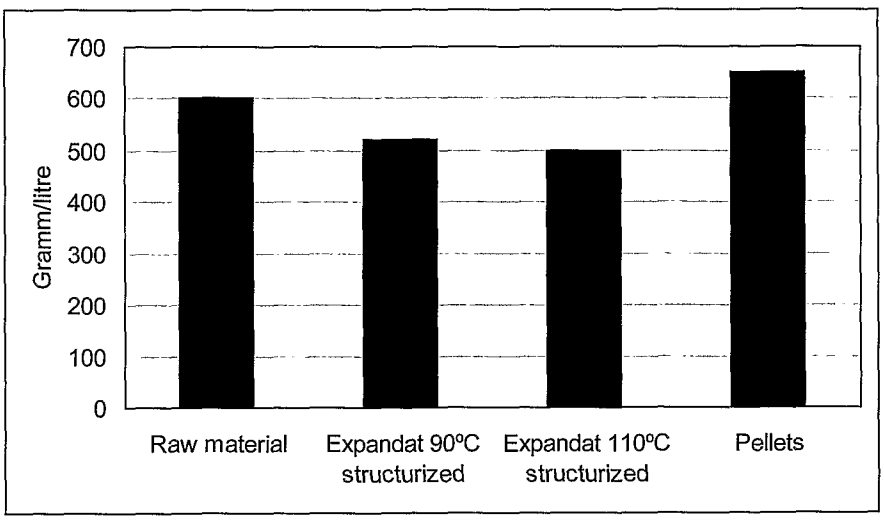

Fig. 4. Bulk density of different structures of feed.

In practice is must be taken into consideration that cells, farm silos, tank trucks, and automatic feeders have a different volumetric content in kg. This may be regarded as a negative aspect at first sight, it, however, is an advantage with regard to animal feeding, as will be explained under the topic "Expanded structurized feed for layers".

Grain structure

Our aim is to produce a product which will not demix and which has a narrow particle size range, i.e., as many particles as possible should be within the same particle size range. Fig. 5 shows the differences in grain structure by comparing meal with expanded crumbles.

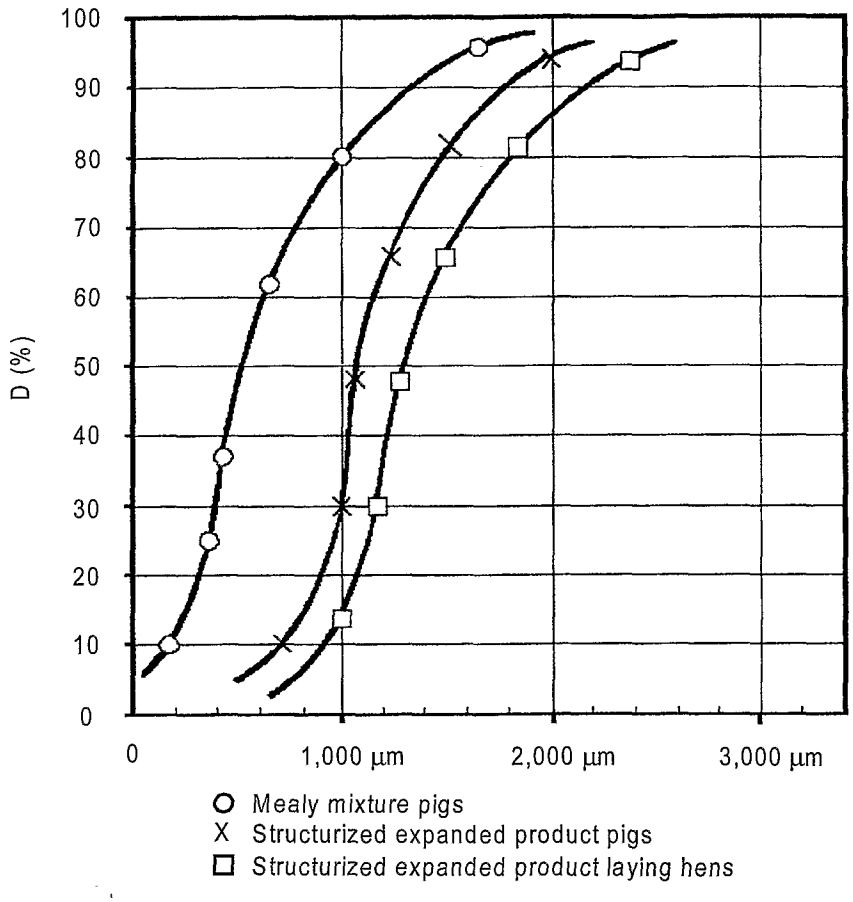

Fig. 5. Grain size structure.

Dissolution in water

This item is of special interest for the wet feeding of pigs and will be explained in detail under the topic "Expanded structurized feed for pigs". Expanded structurized feed has a higher water binding capacity. The suspension from water and expanded feed is stable and solid materials are not deposited or selected as in case of a meal/water mixture.

Nutritional changes of the product

The intensity of thermal treatment changes important ingredients. The aim of the treatment should be defined as these changes require a certain amount of energy and excessive treatment may have a negative effect.

Hygienics

For assuring animal health and the production of healthy animal products, an hygienic feed production should always be ensured. The aim is to extinct all pathogenic germs such as *salmonellae*, coliform and *E. coli* bacteria, campylobacter as well as mould fungus. Depending on the degree of contamination, expanded structurized feed requires a temperature of 105 to 110°C inside the expander (König, 1994).

Peak temperature thus exceeds the temperature of the standard expander-pelleting press combination (Israelsen *et al.*, 1996) by 5 to 10°C. The slightly shorter retention time in the active temperature area is compensated by the higher temperature.

Table 1 gives an example of the influence of the processing parameters on the total aerobic count and on the different pathogenic germs in compound feed. The effect on the mortality of pathogenic micro-organisms in the final product which is independent from the initial aerobic count should be pointed out. This means that the intensity of the treatment is the same for a highly contaminated product as for a less contaminated product.

Table 1. Hygienic treatment of animal feed mixtures with the KAHL-Annular Gap Expander®

	Broiler feed		Pig feed	
	Raw material meal 20°C	Expander 100°C	Raw material meal 27°C	Expander 110°C
Aerobic mesophilic germ	12,100,000	30,000	16,500	9,000
Coliform bacteria/g	110,000	0	400	0
E. coli bacteria/g	400	0	90	0
Moulds/g	7,000	0	450	0
Salmonellae/25 g	ND	ND	ND	ND

ND: Not detected

Stability of vitamins and amino acids

Studies regarding stability are of utmost importance for the user and they have therefore been made by different laboratories.

The results in Table 2 and 3 show that these valuable ingredients will not be damaged up to a processing temperature of 110-120°C. The influence of expander treatment on vitamin stability is lower than that of traditional pelleting.

Starch gelatinization

The degree of starch gelatinization which can be achieved depends on the intensity of the treatment, see Fig. 6. Starch gelatinization is required for piglets as these young animals do not yet produce enough enzymes of their own.

In general, however, starch gelatinization should only be as high as required by the respective animal, as a more intensive treatment will also increase the solubility of the NSP-fraction (non-starch-polysaccharide). This will cause an unwelcome increase of viscosity in the small intestine of poultry, if it is not compensated by enzyme addition.

Table 2. Vitamin retention in processed mixed feeds†

Vitamin	Vitamin retention (%)					
	Expander		Expander + pelletmill		Pelletmill	
	101°-105°C	111°-115°C	86°-90°C	91°-95°C	86°-90°C	91°-95°C
A protected	97	95	93	90	94	91
D_3 protected	98	96	93	91	93	92
E acetat 50%	97	95	92	90	93	92
K_3 MSBC/MPB/MNB	82	78	63	58	75	72
B_1 Thiamine Mono-Nitrate	96	92	87	82	89	87
B_2 Riboflavin	92	88	84	78	89	87
B_6 Pyridoxine	94	91	85	79	87	85
Cyanocobalamine	97	96	94	92	96	96
Ca-Pantothenate	95	92	86	82	89	87
Folic acid	94	91	85	81	89	87
Biotin	94	91	85	81	89	87
Nicotinic acid	93	89	85	80	90	89
C Ascorbyl phosphate	98	96	92	89	93	92
Cholin chloride	99	98	97	95	97	97

†Source: Coelho, M. *Feedstuffs*, July 29/1996 (Extract)

Table 3. Influence of expansion on protein-bound and supplemented aminoacids†

	Before expander	After expander	After expander and pelletmill
Methionine	0.46 ±0.017	0.45 ±0.015	0.44 ±0.004
Cystine	0.29 ±0.006	0.28 ±0.005	0.28 ±0.008
Methionine + cystine	0.75 ±0.012	0.73 ±0.019	0.72 ±0.012
Lysine	1.12 ±0.009	1.10 ±0.013	1.10 ±0.005
Threonine	0.71 ±0.025	0.72 ±0.009	0.70 ±0.005
Suppl. methionine	0.20 ±0.013	0.21 ±0.011	0.19 ±0.002
Suppl. lysine	0.13 ±0.005	0.14 ±0.003	0.13 ±0.003
Suppl. threonine	0.06 ±0.005	0.06 ±0.003	0.05 ±0.002

†KAHL-Annular Gap Expander® 110°-115°C; Broilerfeed: 18% crude protein, 11% crude fat

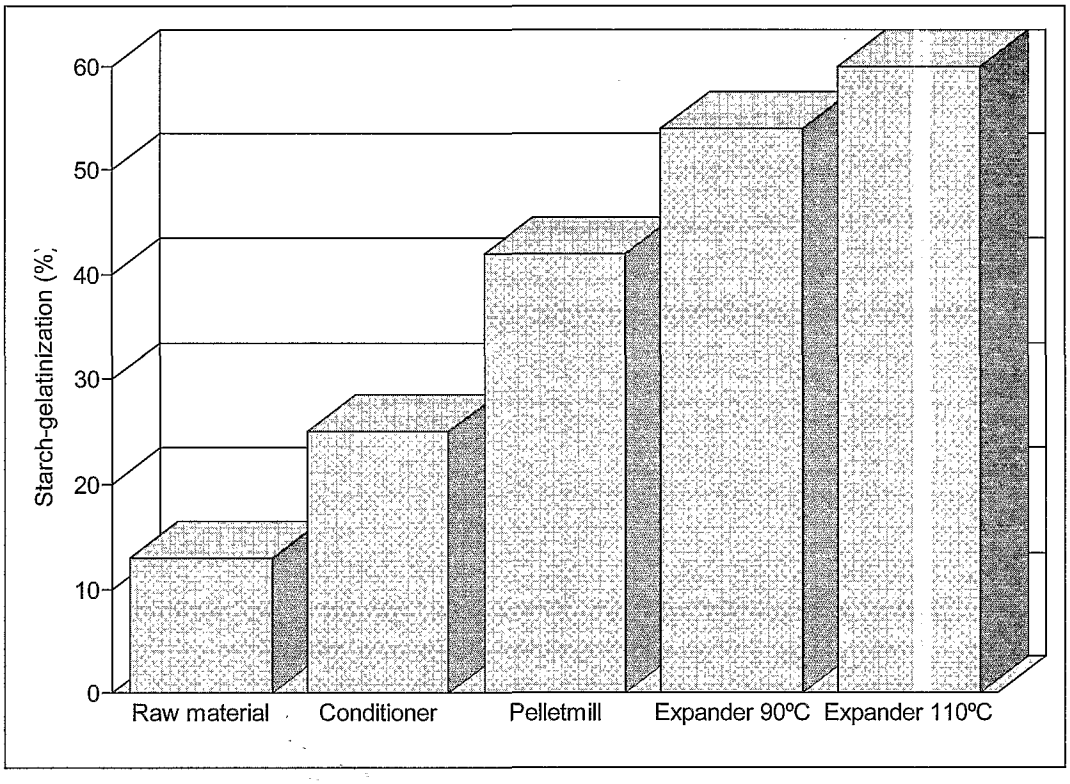

Fig. 6. Starch-gelatinization in piglet-feed.

Use of expanded structurized feed

Expanded structurized feed for pigs

Expanded structurized feed is mainly used for fattening pigs. This is done for the following reasons:

(i) Expanded structurized feed considerably reduces affections in the gullet and ulcers in the stomach and at the stomach entrance. This was found out in the years after 1990 in Denmark (Nielsen, 1995). As can be seen from Fig. 7 these affections have a negative effect on feed consumption and utilization.

(ii) Concentrate in the form of expanded structurized feed can well be used for mixing with farm produced coarsely ground cereals, wet grain or corn cobs (CCM).

(iii) Due to its good flow properties structurized feed is especially suited for liquid feeding, as it is, apart from water, easily dispersible in other liquids such as whey or "soups" from food waste.

(iv) The well balanced proportion of water to feed is of great importance in liquid feeding. Expanded feed needs a smaller quantity than feed meal for dissolving and achieving a consistency which can be pumped. Energy concentration in the wet mix feed is therefore higher and no additional energy is required for increasing feed temperature to body heat. The time required for dissolving in water is shorter than in case of pellets or meal. The wet mix feed is also stable, i.e., mealy components do not deposit on the bottom of the mixing tank.

(v) Similar to liquid feeding expanded structurized feed is also well suited for "automatic wet mix feeders". Pigs mix their feed from water and expanded feed themselves. Due to quick dissolution no feed rests or water remain in the trough. As this system applies *ad libitum* feeding, feed consumption increases and the animals grow faster.

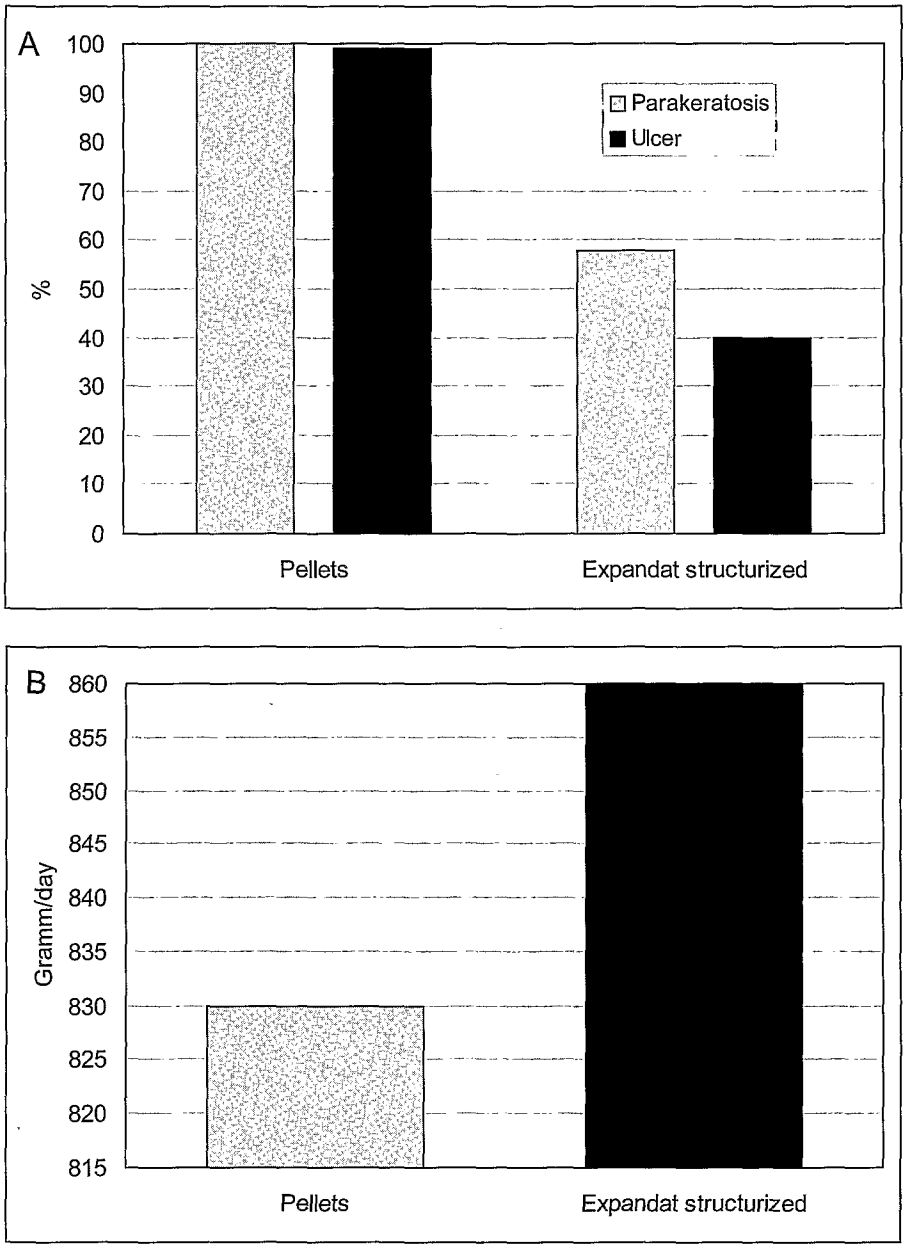

Fig. 7. A: Effect of pellets or expandat in development of ulcer; B: Daily gain.

Expanded structurized feed for layers

Pellets or granulated pellets are not fed to layers, as energy consumption would be too high which leads to an unwelcome fatness. For this reason a coarse meal is fed in general, its grain ratio is partly ground by crumblers. This type of feed has an unwelcome ratio of fine particles which partly consists of pre-mixture components. In most cases the meal is not thermally treated so that the feed does not meet hygienic standards.

These shortcomings can be excluded by using expanded structurized feed.

The following advantages result:

(i) The feed is free from pathogenic germs, such as salmonellae and mould fungi.

(ii) The feed has a coarse structure which corresponds to the needs of the animal.

(iii) Fines are integrated in this structure so that the hen cannot select.

(iv) Feed flows easily and dust-free and thus is well suited for automatic feeding.

(v) Expanded structurized feed does not demix during transport, in farm silo or in the feed chain.

(vi) Due to its low piled weight as compared to meal or pellets the animals will consume the same volume but less weight, so that luxury consumption is avoided.

(vii) Lucerne or lucerne meal can be processed as energy diluent.

(viii) Expanded structurized feed can easily be mixed with farm-produced whole grain cereals such as wheat.

Expanded structurized feed for feeding cattle

Depending on the intensity of expander treatment, starch gelatinization of the same or a higher level than that achieved by flaking with pre-connected steaming can be achieved. This process is therefore well suited for decomposing for example maize or milo (sorghum) or other cereals as individual components for cattle fattening feed.

Advantages in comparison to flakes: (i) better flow properties; (ii) higher piled weight; (iii) dust free; (iv) no fines which reduce the feed value; and (v) due to its grain structure it can easier be mixed with silage or roughage than flakes (TMR).

After expanding, concentrates which are rich in protein show results after treatment which can normally only be achieved by chemical processes. The ratio of protein (UDP) which is not digested in the rumen is significantly increased and can be taken into consideration corresponding to the ratio formula for ruminants. Table 4 gives the relative ratio of protein which is not digested in the rumen, determined by *in vivo* tests with cows during lactation, as measured after having treated the individual compound feeds. Intestinal digestibility of protein is not restricted by the treatment.

For this reason concentrate mixtures in the form of non-pelleted expanded structurized feed are well suited for producing a complete feed together with silage or roughage in a mixing truck (TMR) and allow to meet the needs of a high-performance dairy cow for protein which is digested in the intestines without using separately treated protein components.

Table 4. Influence of expanding on UDP content

	UDP content (%)		
	Untreated	Expander	Hydrothermal reactor + expander
Cereals	10-15	25-35	45-55
Soya beans	<10	25-30	40-45
Soya extr. meal	40-45	45-50	55-60
Rape extr. meal	25-35	35-45	55-60
Rape expeller	25-30	40-45	50-60
Corn gluten feed	25-30	30-40	35-50

References

Elstner (1997). Technologie die mangimi espansi. *Tecnica Molitoria,* March 1997.

Frank and Pipa (1989). High-pressure conditioning with Annular Gap Expander. *Advances in Feed Technology,* 2/1989.

Israelsen, M., Busk, J., Virsoe, M. and Hansen, I.D. (1996). Reduzierung des Salmonellenbefalls durch Expandieren und Pelletieren. *Kraftfutter,* 12/96.

König (1994). *Mikrobiologische Dekontamination von Futtermitteln mit Hilfe der Expandertechnik (Druckkonditionierung) unter besonderer Berücksichtigung der Salmonellenproblematik.* Dissertation 1994, FU Berlin.

Nielsen, L.C. (1995). Danish experiences with structurized pig feed. *VICTAM International,* May 1995.