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Feed Processing and its Effects on Equine Nutrition – A Review

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Review Article

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Abstract

It's expected that the Brazilian production of industrialized feed for horses reach 2 million tons by the year 2020. Feed processing consists of physical, chemical or biological modifications that are made in the feed. These modifications can increase the availability of nutrients for horses and/or preserve the quality of these nutrients in the raw material. The objective of this review was to describe the main types of feed processing used in the manufacture of feeds for horses, showing the benefits and losses that they may cause in nutrition and production of these animals. There are several types of feed processing and they can be classified according to the use of thermal processing treatments: cold or hot processing. Processing of grains can cause several changes in feed, such as change and adjustment of particle size, improving nutrient digestibility, promoting the inactivation of enzyme inhibitors, and preserving feed. The effects that cause different kinds of processing depend on many factors, including the type of cereal, starch, temperature, time, humidity and pressure during processing. The process, when performed correctly, can increase the digestibility of starch and digestible energy content of the grains used to feed horses. However, you should be careful with the amount of concentrate used in horse feed.

Keywords: Horse; Extrusion; Flaking; Grains; Pelleting

Introduction

According to Samora in [1], the Brazilian production of feed for different species was about 67.4 milliontons. For equines, Lima et al. [2] Estimated that the potential for feed production can reach 2 million tons until the year 2020.

Feed processing have fundamental importance for the production of animal feed and consists in physical, chemical, or biological modifications that are made in feed before providing them to animals. These modifications are made in order to increase the availability of nutrients for horses and/or preserve the quality of these nutrients in raw materials [3]. Then, the efficiency of food utilization is maximized, and the animal can express better their potential [4,5].

Some forms of processing facilitate the storage and offering of feed, since they may reduce their volume, minimize wastage in feeding and increase shelf life.

Depending on the type and intensity, the processing can have a positive impact, destroying undesirable substances and increasing digestibility, or, in some cases, can cause a negative impact, reducing the content or availability of some nutrients. As examples of positive changes, can be cited the destruction of anti-proteases on toasting of soybean and increase in pre-caecal digestibility of starch by gelatinization phenomenon that occurs within the cooking of corn. However, it should be considered that the processed feed, depending on the amount offered, may predispose horses to metabolic disorders such as laminitis or overweight with consequent insulin resistance [6]. Some possible negative impacts include: increased feeding costsand the loss of vitamins in treatments that submit the feed at high temperatures.

The objective of this review was to describe the main types of food processing used in the manufacture of feeds for horses, showing the benefits and losses that they may cause in nutrition and production of these animals.

Literature Review

Main types of processing

According to Lewis [7], the processing of grains may be classified as to the use or non-use of heat treatment, and may be, with cold or warm. Hot processing are flaking, expansion, extrusion,micronizationor pelleting. These treatments cause structural changes in the molecules of the feed, improving access of enzymes and, consequently, increasing the digestibility of nutrients such as starch. The most common cold-processing are grinding and milling and are also called mechanics. The mechanical processes facilitate chewing of animals and increase the contact surface between the digestive enzymes and feed, optimizing your digestion.

As Juliand et al. [8], in the manufacture of feed for horses, the grains may be subjected to mechanical (milling and grinding), thermal (toasting and micronization) or thermo-mechanical (flaking, popping, expansion, extrusion and pelletizing) in wet or dry atmosphere. Among all the processing, the most used are grinding, micronization, flocculation, extruding and pelletizing.

Processing of the grains can cause various changes in feed, such as changing and adequacy of the size of the particles, improving the digestibility of nutrients, mainly starch, inactivation of enzyme inhibitors, improved palatability and increased storage time, preserving the quality of the feed [3,9]. The processing also facilitates access and amylolitic enzymes action and speeds up the time of retention of feed in the gastrointestinal tract of horses, which can range from 1.6 to 9.9 h for rations depending on the type of processing [10].

Effect of Processing on Starch Digestibility

The digestibility of starch from cereals ranges from 20 to 90% depending on the type of structure formed by the granules of starch and from the processing [8]. According to Denardin and Silva [11], the structure of starch granules are composed of polymers of amylose and amylopectin. The amylose consists in linear chains of glucose, showing a crystalline appearance to the starch. Amylopectin is the branched component, being more susceptible to enzymatic degradation.

Mechanical processes can increase the pre-caecal digestibility of corn starch up to 15% but has moderate impact on other cereals [12]. So overall, the pre-caecal digestibility of starch increases with the thermal and hydrothermal processes. In the presence of water, the heating causes rupture of the crystallinity of the starch granules in a phenomenon known as gelatinization, making it more susceptible to the action of enzymes and increasing the pre-caecaldigestibility.

As Gobesso et al. [4], the total digestibility of starch does not change with the processing of grains due to the microbial fermentation in the cecum, but, according to literature consulted, is shown that pre-caecaldigestibility of starch in horses has increased with the micronization [13], extrusion [14] and flocculation [15]. These researches showed that feed processing is interesting to avoid overloads of starch in the large intestine of horses, where can be fermented, reducingthe pH by excess lactic acid produced, which will cause an imbalance of the microbial profile on that site [16].

McLean et al. [17] showed the influence of processing on caecal fermentation of ponies. Diets composed of 50% of hay cubes and 50% micronized, extruded barley or milled in a diet with 100% of hay cubes without grain were compared. The caecal fermentation did not change when micronized or extruded barley has been included, as these processes have allowed itsdigestion before they reach the cecum. Grounded barley already negatively altered fermentation due to the reduction in the caecalpH.

Depending on where the starch is hydrolyzed, energy efficiency can change. So, greater energy efficiency is achieved when the starch is transformed into glucose in pre-caecalcompartments than when it is degraded by caecal microorganisms [8]. Thus, the processing is a strategy to increase the energy efficiency of the equine diet. Argo et al. [18] showed that the digestible energy consumption on a diet without processing was only 73% of which occurred when the same diet has been pelletized.

A negative effect that can cause thermal processing on starch digestibility is the retrogradation, which occurs during accelerated cooling of grain due to the reorganization of the starch molecules into hydrogen bonds stronger, especially of amylose, which makes it indigestible by enzymes [19]. Other factors such as repeated heating and cooling cycles, botanical origin of starch, amylose: amylopectin and the amount of water used during the gelatinization can increase the content of resistant starch.

Effects on Protein Digestibility, Fiber, Lipids and Vitamins

The effects of processing on pre-caecaldigestibility, or ileal, of protein for equines are not yet well defined. Potter et al. [13] found no difference in the total digestibility of crude protein in horses receiving oats or sorghum processed by compression (*rolling*) or micronization. Yet Hymøller et al. [20] reported an increase in pre-caecaldigestibilityofcrude protein when the barley and corn were flocculated, compared with the grinded grains. Whitehouse et al. [21] also observed that the resulting corn gave greater total digestibility of crude protein when compared with broken corn. Rosenfeld and Austbø [14] compared to total digestibility of protein of corn, oats and barley are subjected to different types of processing: grinding, pelletizing, and extrusion and micronization. The authorsshowed that total digestibility of crude protein increased with extrusion ormicronization of grains. However, there was no effect of thermal processing on pre-caecal digestibilityof crude protein.

Conditions of temperature, pressure, humidity and duration of the processing may interfere with the quality of the final product. The primary processing may not be sufficient to eliminate anti-proteases present in soybeans. On the other hand, overheating can reduce the bioavailability of amino acids, due to Maillard reactions, which are complex formations unavailable formed between amino acids and sugars. Särkijärvi and Saastamoinen [9], evaluating the digestibility of nutrients in diets containing oatmeal without treatment or autoclaved, they found lower digestibility of crude protein and ether extract when the oatmeal was autoclaved. The authors attributed the results to the occurrence of Maillard reactions.

As for the digestibility of the protein, grain processing effects on fiber digestibility are controversial. Casalecchi et al. [22] compared digestibility of diets containing corn resulting, laminated or milled and found greater digestibility of organic matter and acid detergent insoluble fiber when the corn was conditioned. Gobesso et al. [4] noted that diets containing extruded corn or extruded sorghum hadlarger coefficients of digestibility of: dry matter, organic matter, crude protein, neutral detergent fiber (NDF) and acid detergent fiber (ADF) than those obtained with diets containing these ingredients only ground. However Pimentel et al. [23] assessed the hay intake and digestibility of whole *coast cross*, chopped at 5 cm, milled to 5 mm and 3 mm and found that the grind has not affected the dry matter intake and digestibility of the NDF, ADF, cellulose and hemicelluloses, but reduced the amount of time spent with consumption.

One disadvantage of thermal processing of the beans is the loss of vitamins and carotenoids, which can range from 5 to 40% [24], and vitamins A, B and E are the most affected during the extrusion [25].

Effect of Processing on The Dry Matter Consumption

The process can change size, density and texture of feeds which can influence the acceptability of the animal. According to the NRC [3], the pelleting of alfalfa hay can increase the consumption of dry matter for equines adults, especially when the material has low leaf: stem ratio.

According to Argo et al. [18], the total diet pelleting (concentrate and hay) reduced the rate of chewing and the time spent with feeding. Meyer et al. [26], cited by Hill [27], observed that the feed pelleting textured (mixture of ground and whole grains) decreased the time spent in feeding of 18.6 min/kg to 8.3 kg/min. This potentially increases the risk of development of stereotypes and, therefore, the pelletized hay should not be provided as only hay. On the other hand, the NRC [3] recommended the use of pelleted forage for horses with orthodontic problems.

Effect of Processing on Equine Health

Andrew et al. [28] evaluated the interference of processing in the growth of weaned foals. The authors tested the use of a diet with 50% alfalfa cubes and 50% concentrate in two forms: a total diet pelletized; and another diet composed of hay and commercial concentrate, supplied separately. They noted that the diet pelleting provided a tendency (p = 0.057) for greater weight gain of foals (0.87 x 0.58 kg) without affecting the insulinemic behaviors or stereotyped response.

Low-Glycemic diets are being recommended for the prevention and improvement of numerous diseases in humans which involves insulin resistance, such as diabetes *mellitus* type 2 and heart diseases. For horses, help prevent some forms of laminitis, rhabdomyolysis by effort and orthopedic diseases development [29]. According to Kabe et al. [30], by-products are rich in pectin, like soybean hulls, can be used as a substitute of starch-rich feeds to reduce the glycemic index of the equine diet without changing the energy content Vervuet et al. [14] analyzed the effect of the processing of barley on glycemic response and equine insulinemic. The types of productions were: barley, finely ground, steamed, *popped* and flocculated. Glucose and insulinemic responses occurred with the highest consumption of barley flocculated. The authors comment that, unlike with humans, these responses are not associated with the degree of gelatinization of the starch that was 28.7% for barley flocculated against 95.6% for barley clicked. Other factors such as rate of consumption, gastric emptying and starch interaction with other nutrients may have interfered in the results found.

Flores et al. [31] evaluated the effect of pelleting of total diet (50% alfalfa hay cubes and 50% commercial concentrate textured) about the weight gain and the appearance of gastric ulcers in weanling horses, which were previously only fed with alfalfa hay. When the colts began to receive total diet, there has been greater appearance of ulcers compared to coltswhich received the total pelleted ration. The authors attributed the results to a possible lower rate of chewing when the animals received total pelleted ration, which may have triggered a smaller production of saliva and, consequently, reduced the buffer ability in the stomach. In addition, according to Juliand et al. [8], with the increased digestibility of starch in processed feed, there is starch fermentation in the stomach and formation of lactate, which may have reduced the stomach pH. However, the daily weight gain was higher in the group that received the total pelleted ration due to a possible greater pre-caecaldigestibility of nutrients.

Hessel et al. [32] found that the use of flocculatedbarley or commercial concentrates compared to ground barley or ground oats will reduce the risk of respiratory problems due to lower inhalation of fine particles during feeding.

Final Considerations

The effects that different types of processing cause on nutrient utilization and intake depend on many factors, including type of grain, starch content, temperature, time, humidity and pressure during processing.

The processing, when performed correctly, can increase the starch digestibility and digestible energy content of the grains used in equine nutrition. However, you must be careful about the amount of concentrate processed provided the animals to avoid the appearance of gastric ulcers, hyperinsulinemia and overloads of starch in the large intestine, and may be used by products rich in pectins to reduce the starch content of the concentrate and keep the contents of digestible energy.

Other studies are needed to define the effects of thermal processing on the digestibility of other nutrients such as protein, fiber and lipids and also to describe his influence on health and digestive physiology of equines.

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