POSSIBILITY OF USE OF RESIDUE FROM THE PURIFICATION OF SOYBEAN OIL (SOYBEAN GUM) IN COMMERCIAL POULTRY FEEDING: A REVIEW

Caio Cesar Ouros[1]
Antonio Carlos Laurentiz[2]
Rosemeire da Silva Filardi[2]
Rosangela da Silva Laurentiz[2]
Bruno Lala. [3]
Lucas Felipe Ouros[2]

ABSTRACT

Brazil stands out among the largest producers of broilers and soybeans in the world. The amount of soy produced and processed in the country means that any residue from the process is considered to have a great environmental impact. Therefore, an alternative to using soy gum, which is a by-product from oil purification, is necessary. Soy gum is a complex of phosphatides that can function as an emulsifier in animal diets, with poultry farming being a production chain capable of absorbing the amount of soy gum production in the country. Due to the high concentration of lecithin present in soy gum, added to preliminary studies that used it as an alternative emulsifying product in the diet, we can infer that soy gum is indeed a product with emulsifying potential and can be used to facilitate the digestion of lipids by broiler chickens and may even be a viable alternative for the initial phases in which the birds have digestion and absorption interference due to the digestive system not being completely developed.

Keywords: lecithin, lipids, phosphatides, soy by-product

POSSIBILIDADE DE UTILIZAÇÃO DO RESÍDUO DA PURIFICAÇÃO DO ÓLEO DE SOJA (GOMA DE SOJA) NA ALIMENTAÇÃO COMERCIAL DE AVES: UMA REVISÃO

RESUMO

O Brasil se destaca entre os maiores produtores de frango de corte e soja do mundo. A quantidade de soja produzida e processada no país faz com que qualquer resíduo do processo seja considerado de grande impacto ambiental, portanto, uma alternativa ao uso de goma de soja, que é um subproduto da purificação do óleo, é necessária. A goma de soja é um complexo de fosfatídeos que pode funcionar como emulsificante em dietas animais, sendo a avicultura uma cadeia produtiva capaz de absorver toda a produção de goma de soja no país. Devido à alta concentração de lecitina presente na goma de soja, somada a estudos preliminares que a utilizaram como um emulsificante alternativo na dieta, podemos inferir que a goma de soja é de fato um produto com potencial emulsificante e pode ser utilizada para facilitar a digestão de lipídios por frangos de corte, podendo até ser uma alternativa viável para as fases iniciais em que as aves apresentam interferência na digestão e absorção devido ao sistema digestivo não estar totalmente desenvolvido.

Palavras-chave: lecitina, lipídios, fosfatídeos, subproduto da soja

[1] Universidade Federal da Grande Dourados – UFGD. *Correspondência: caio_ouros@hotmail.com
[2] Universidade Estadual Paulista – UNESP. antonio.laurentiz@unesp.br
[3] Universidade Federal Rural da Amazonia – UFRA. bruno.lala@ufra.edu.br

POSIBILIDAD DE UTILIZACIÓN DEL RESIDUO DE LA PURIFICACIÓN DEL ACEITE DE SOJA (GOMA DE SOJA) EN LA ALIMENTACIÓN COMERCIAL DE AVES: UNA REVISIÓN

RESUMEN

Brasil se destaca entre los mayores productores de carne de pollo y soja del mundo. La cantidad de soja producida y procesada en el país hace que cualquier residuo del proceso tenga un gran impacto ambiental, por lo tanto, es necesaria una alternativa al uso de goma de soja, que es un subproducto de la purificación del aceite. La goma de soja es un complejo de fosfatídidos que puede funcionar como emulsionante en dietas animales, siendo la avicultura una cadena productiva capaz de absorber toda la producción de goma de soja en el país. Debido a la alta concentración de lecitina presente en la goma de soja, sumada a estudios preliminares que la utilizaron como un emulsionante alternativo en la dieta, podemos inferir que la goma de soja es de hecho un producto con potencial emulsionante y puede ser utilizada para facilitar la digestión de lípidos en pollos de engorde, pudiendo incluso ser una alternativa viable para las fases iniciales en las que las aves presentan interferencia en la digestión y absorción debido a que el sistema digestivo no está completamente desarrollado.

Palabras clave: lecitina, lípidos, fosfatídidos, subproducto de soja

INTRODUCTION

As a result of the great advances in nutrition, genetics and management, over the years Brazil has stood out as one of the largest producers of chicken meat in the world, currently the largest exporter and the third largest producer in the world, in addition to presenting a large consumption in the domestic market, reaching 45.56 kg/habitant/year. In 2021, 14.329 thousand tons of chicken carcass were produced in the country, and 4.610 thousand tons were exported, corresponding to 32.17% of the total (1).

Brazil also appears as the world's largest producer of soy. Brazilian production in the 2021/2022 harvest was forecast for approximately 153.54 million tons, in an area of 43.2 million hectares (2).

The processing of soybeans results in a wide variety of products, among them we have the oil that is destined for animal or human consumption, or the production of biofuels, and soybean meal, which is the solid part of the process and is used as the main protein source for poultry and swine feed formulations. The refining of oil for human consumption results in other by-products that require an ecologically viable destination. One of these compounds obtained during the refining of crude oil into degummed oil is soy gum, obtained by centrifuging the crude oil after it has been hydrated.

Taking into account the large amount of soy produced in the country, any by-product generated in processing has a great environmental impact, which makes it necessary to correctly dispose of this residue. The crude soybean oil degumming process has a yield of 97%, that is, for each ton of crude oil we have 970 kg of degummed oil and 30 kg of gum. Considering that the yield of crude oil is 22% for each ton of soy processed, in the 2022/2023 harvest it is estimated a production of 33.78 million tons of crude soy oil, resulting in the production of 1.01 million of tons of soy gum, only in Brazil (3).

Soy lecithin, present in the composition of soy gum, is a complex mixture of phosphatides, its main components being phosphatidylcholine (16 to 26%), phosphatidylethanolamine (14 to 20%), phosphatidylinositol (10 to 14%), phytoglycolipids (13%) and phosphatidylserine (4%) (4, 5). It is believed that phospholipids are essential for the utilization of fats by the animal body. Lecithin and consequently soy gum are natural complexes of phospholipids, mainly composed of phosphatidylcholine (6).

With that in mind, aiming to stimulate further research with the residue and the attempt to find an ecologically viable destination for it, this literature review follows as a base of information describing possible uses of the residue from the degumming of soybean oil (soybean gum) as an additive in poultry nutrition.

DEVELOPMENT OF THE THEME

Emulsifiers

Emulsifiers are functional additives widely used in the food industry, which promote various changes in products, such as improved texture, softness, stability, homogeneity and aeration (7). It is characterized by promoting interactions at the interface of two immiscible substances, by reducing the surface tension, and consequently, the energy required to form the emulsion (6). Its structure is composed of a hydrophilic part, which interacts with the aqueous phase, and a lipophilic part, which interacts with the oil phase, thus allowing the emulsion (8).

Some examples of emulsifiers are oligosaccharides, cellulose, gums, pectins, casein, gelatin, fatty acid esters, monoglycerides, diglycerides and lecithin (9). In digestion, the emulsification of fats to allow the action of lipases and the subsequent formation of micelles with fatty acids are essential for the process of absorption of liposoluble nutrients (10, 11). It is noteworthy that the performance improvements resulting from the greater use of nutrients also serve to reduce production costs, as well as other additives (12, 13, 14, 15).

Soy Gum

Information on the use of soy gum as an additive for animal production is very limited. Because it is a residue that usually undergoes purification processes to extract lecithin, little is known about soy gum in its raw form. The use of soy gum as a food additive in the diets of broilers and laying hens had positive results for economic and performance characteristics (3, 16, 17, 18).

With the decrease in the use of lecithin, due to changes in the market caused by the advent of transgenic soy, the need arose to use soy gum in a new commercial niche, mainly to avoid any kind of environmental impact. Because its composition relies on the complex mixture of phosphatides, we can speculate its use as a viable emulsifier, even without a significant amount of results available in the literature (3, 17, 18).

Obtaining Soy Gum

Akechi (16) details how to obtain soy gum from its arrival at the factory until obtaining the product. Upon arrival at the factory, soybeans undergo a pre-cleaning process, which consists of removing impurities such as straw, green matter, soil, among others. This procedure is particularly important to remove materials subject to fermentation (green materials and straw) that can affect batch quality. For this operation, a so-called pre-cleaning machine is used, basically consisting of two vibrating sieves and an air stream to remove impurities. In the production flow, after pre-cleaning, the soybeans are directed to dryers, with the purpose of reducing the humidity of the grain, which will then be sent to storage or directly to the crushing sector.

The soybeans, after being crushed, are directed to roller breakers where the grains are reduced, approximately 12% of the original size. In this step, part of the soybean hull is removed by means of an air flow, an important process due to the fact that soybean hulls have a high fiber content. The non-removal of the husk will determine the very high fiber content in the soybean meal, a drop in the crude protein content and a lower efficiency in the removal of soybean oil. During the breakdown, the cellular enzymes lipase and peroxidase are released, which impairs the quality of the oil and bran. To avoid these problems, the later stages of the process must be carried out as quickly as possible (19).

After breaking, the material is sent to the conditioner, which is equipment for cooking the soybeans while providing moisture, in order to adjust the humidity and change physical characteristics, providing ideal plasticity and reducing the formation of fines and dust, resulting in the product quality for the next step in the process. This partial cooking coagulates and denatures the proteins, in addition to partially inactivating the lipolytic enzymes (19). The inactivation of the enzymes prevents the breakdown of triglycerides into free fatty acids, thus reducing the acidity of the oil, providing better quality of the degummed oil at the end of the process.

Upon leaving the conditioner, the mass is transferred to the rolling mill where it is pressed until obtaining small flakes with previously determined thickness to increase the contact surface with the solvent. In the extraction, two processes are carried out, the first through pressing to partially remove the oil and in the second where the flakes are introduced into the extractor and the oil is removed with an organic solvent (hexane). After bathing the material with the solvent, the oil dissolved in the solvent is directed to distillation, while the solid at this point is called white bran and is directed to equipment called a desolventizer and toaster (DT).

In the DT, the white bran is heated to remove the solvent residue and to inactivate the soybean anti-nutritional factors (trypsin, hemagglutinins and phytohemagglutinins inhibitors). The control of this process is essential to guarantee the final quality of the soybean meal at the factory, especially the temperature and time of exposure of the material, factors that directly influence the quality of the product. After toasting, the bran is directed to the pellet machine and soon after it is cooled, ready for shipment.

The mixture of oil and solvent, called micelle, is directed to three evaporators in order to recover the solvent. After the heating process, the crude oil is directed to the hydration tank where it receives water, which reacts with the phospholipids present in the crude oil so that they can be removed in the centrifuge. The products removed by centrifugation are degummed soy oil and soy gum (17).

Lecithin

Soy lecithin can be defined as a complex mixture of phosphatides. Its structure is composed of phosphoric acids linked to nitrogenous bases and cyclic alcohol, thus forming structures such as phosphatidylcholine, phosphatidylethanolamine and phosphatidylinositol (9). According to Araújo (6) the composition of lecithin is approximately 20% phosphatidylcholine, 15% phosphatidylethanolamine, 20% phosphatidylinositol, 5% other phosphatides, 5% carbohydrates and sterols and 35% triglycerides.

The main function of lecithin is the coating of particles, especially those with fat in the composition, in such a way that when in aqueous solution there is a reduction in the surface tension between the solid and liquid phases (20, 21). Thus, lecithin appears as an important natural emulsifier composed of a mixture of phospholipids. Among its components, phosphatidylcholine stabilizes oil/water emulsion and phosphatidylethanolamine and phosphatidylinositol stabilize water/oil emulsion. Commercial lecithin is obtained after obtaining soy gum through a process of extracting the oil present with acetone, which may or may not undergo an alcoholic fractionation to promote the concentration of phosphatidylcholine in order to improve the oil/water emulsion (6).

Of all the phospholipids present in lecithin, phosphatidylcholine is singularly the most important, since phospholipids are essential for the formation of biological membranes and participate in several processes in the animal organism. Phosphatidylcholine is present in metabolism processes influencing the digestion and absorption of fats (22).

Among the properties of phospholipids we can mention: increase the emulsion of lipids in the small intestine, thus increasing the contact surface for the activity of pancreatic lipase; incorporate nonpolar fatty acids in the micellar phase; improve fat digestibility and control cholesterol absorption (23, 24).

There are many studies of lecithin in animal nutrition, but studies with soy gum are practically non-existent. The use of lecithin in broiler chicken diets promotes a nutritional increase in the diet due to the emulsification of fats, thus improving their digestion and absorption, according to Raber (25). Lecithin has the ability to increase the active surface for the lipase enzyme to act and also incorporate mono and diglycerides into the micelles, which now have their digestion facilitated. This effect is extremely noticeable in young birds that have difficulty performing synthesis and enterohepatic reincorporation of bile salts (23, 24).

However, the results using this substance are not unanimous. Azman & Ciftici (26) did not obtain an increase in digestibility with the gradual increase in the inclusion of lecithin in the diets. Peña (27), testing the use of lecithin in conjunction with degummed soybean oil, also did not find better performance results in diets for broilers compared to the control treatment.

According to the Ministry of Agriculture, Livestock and Food Supply (MAPA), soy lecithin is a technological additive, classified as an antioxidant, stabilizer and emulsifier, with no restrictions on its use, through Normative Instruction No. 2010, which provides a list of ingredients and additives used in human food with use in animal feed.

Lipids

Lipids are compounds that have one of the main characteristics the insolubility in water, and also have solubility in organic solvents (28). Thus, they act as a vehicle for fat-soluble vitamins and, due to their high energy content, are important in the diet of animals (29). Lipids are considered mixtures of glycerides that feature structures formed by the chemical association between glycerol and one, two or three molecules of fatty acids (30).

Among the lipids there are triglycerides, which have the function of storing energy; phospholipids being constituents of biological membranes; cholesterol, an important compound in biological functions in the body, as a precursor of hormones and bile acids; arachidonic acid, which is a precursor of compounds that regulate metabolic pathways and inflammatory processes, and finally, fat-soluble vitamins, which are important for various metabolic functions in the body (31).

Triglycerides represent about 90% of lipids and undergo hydrolysis in the intestinal lumen through the action of enzymes, thus resulting in fatty acids, glycerol and monoglycerides (32).

Lipids can be solid or liquid, and those considered fats have animal origin and are solid, while liquid lipids are known as oils, and have vegetable origin (33). They have some functions in the body, for example, they are responsible for providing precursor molecules of steroid hormones and prostaglandins and maintain body heat by supporting and protecting the viscera (31).

The lipids present in poultry diets play an important role in poultry production, highlighting the improvement in the palatability of feeds, increase in energy levels and help in the absorption of fat-soluble vitamins, thus improving animal performance. Among the vegetable oils commonly used in poultry formulations are oils from the processing of oilseeds such as soybean and sunflower. It is noteworthy that the inclusion of these oils depends on availability and cost. In addition to increasing the energy concentration of the diet, lipid sources (oils and fats) are also added as a source of essential fatty acids (10, 29).

Fats can be considered a digestive problem for animals, due to their insolubility in water, which makes the processes of digestion and transport of these compounds complicated (31, 34).

An emulsifying action in the intestine is required to dissolve these compounds before they are absorbed so that they can undergo the actions of water-soluble hydrolytic enzymes in the gastrointestinal tract. Thus, phospholipids and bile acids, functional components of bile, are important for the digestion and absorption of fats (34).

Lipid Digestion

Digestion of lipids takes place mostly in the duodenum, jejunum, and ileum. Upon reaching the small intestine, fats encounter an alkaline environment that stimulates the release of bile and pancreatic juice (35). In general, in the lipid digestion process there are four phases involved: emulsification, hydrolysis, micelle formation and absorption. Paying attention to the emulsification process, this begins in the stomach, where the lipids are heated, under the internal temperature conditions of the body, and subjected to mixing, agitation and separation actions performed by the stomach (32).

The liver, an important secretory gland of the digestive system, among many important functions for the organism, secretes bile, which plays an important role in the digestion of fats (34, 36). Bile, composed of bile acids (cholic acid), phospholipids, cholesterol, proteins and bile pigments (32), has the function of emulsifying lipids, stimulating gastrointestinal peristalsis and aiding in the absorption of dietary lipids. The emulsion caused by bile aims to increase the appropriate surface for the action of pancreatic lipase in the oil/water interface. According to Freeman (35), lipolysis is directly related to the exposed surface area of the substrate to the action of the enzyme.

In the intestinal chyme, micelles are formed, which are made up of lipids, bile salts and products of lipid digestion. Micelles are soluble and therefore able to move in the aqueous intestinal environment. They present the polar part of the conjugated bile salts on the surface and the non-polar part occupies the central part of the micelle (32).

In the intestinal microvilli, with the aid of the fatty acid transporter protein, the micelles release monoglycerides, fatty acids, cholesterol and fat-soluble vitamins into the enterocytes, where short-chain fatty acids and free glycerol are absorbed directly into the intestinal mucosa and transported to portal circulation (37). Long-chain fatty acids are re-esterified to triglycerides and grouped to cholesterol, phospholipids and specific proteins (apolipoproteins), making them water-soluble.

Bile salts remain mixed with the digesta until the terminal part of the small intestine (ileum), being reabsorbed by enterocytes and transported via blood to the liver to be reused in the synthesis of bile, this process is called enterohepatic circulation (37).

Importance of Lipids in Poultry

The inclusion of lipids in diets determines benefits that are not limited to providing calories. Lipids improve the palatability of diets, reduce dust and nutrient loss, help with equipment maintenance, facilitate pelleting and improve diet conversion (38, 39).

In general, lipids, carbohydrates and proteins are the energy suppliers present in diets, and lipids, including fats and oils, are considered the best energy suppliers for animals, as they have a high energy value, low metabolic increment and are sources of essential fatty acids. Through the industrial processing of products from animal and plant production, fats and oils are obtained. There are several lipid sources used as energy in poultry diets, such as: soybean oil, acid soybean oil, poultry slaughterhouse oil, degummed soybean oil, tallow, among others (40).

The main factors that lead to the choice of the type of oil to be used in the diets are the cost, the quality of the energy source, the nutritional composition and their effects on the zootechnical performance of the animals. Several researches are carried out in order to verify the effect of different sources of lipids added to the diets on the performance of broilers (41).

Much of the fat present in the diet is in the form of triglycerides, compounds insoluble in water, whose emulsification begins in the stomach and is subsequently digested and absorbed in the intestine (22). Some researches are developed encompassing different sources of fat and their combinations, use of stabilizers, emulsifiers and other products that favor the digestion and absorption of fats (17, 18, 42, 43).

Among vegetable oils, soybean oil is widely used in the formulation of poultry feed as a readily available energy source and as a source of essential fatty acid for these animals (12). In this scenario, some by-products from the processing industry of these oils, such as gums (lecithins), are also used in animal nutrition (9).

Interferences in Lipid Absorption

The metabolizable energy value of lipids is proportional to their digestibility and absorption by the birds, and there are several factors that interfere with the digestion and absorption of lipids in the body of the animals, such as, for example, the degree of saturation of the lipids, age of the birds and the size of the carbonic chain of fatty acids (44).

Other factors such as diets composition, lipid inclusion level, intestinal health and the type of source used also influence lipid digestibility (30, 45).

According to Macari, Furlan & Gonzales (32) there is a certain relationship between the age of the bird and the efficiency of digestion and absorption of lipids, related to the maturity of the organs involved in the digestion process. The effectiveness of young birds in digesting and absorbing fats is related to the mechanisms of the intestinal mucosa, the secretion of enzymes and the emulsification of fats through the bile. The main difference between ages occurs between the first and third week and stabilizes between the fifth and seventh week of life (44).

Therefore, when birds are younger, there is a difference in relation to the digestibility of fats when compared to adult birds. In the initial phase this condition is reduced due to the production of pancreatic lipase being lower and consequently the digestibility of lipids becomes less efficient. This circumstance compromises the initial development of the birds, so the inclusion of emulsifying substances is indicated in order to improve the productive efficiency in the initial phase of the birds (12).

Digestion and absorption of nutrients from the diet must occur efficiently so that the ingested energy can be used by the animal, considering that there are several changes that occur in the digestive system of birds until their functional development is reached (46, 47).

According to Sakomura et al. (48), in a study carried out to verify the effect of the age of birds on the digestibility of nutrients in the production of digestive enzymes in the pancreas, it was observed that the digestibility of lipids varies in relation to age, being associated with the activity of lipase. A quadratic behavior between the age of the birds and the digestibility of lipids found increasing values until the third week of age, which remained constant until the sixth week of life.

This digestibility behavior is related to the rate of growth of the pancreas and the activity of the enzyme lipase. Fat uptake by young birds is also limited by incomplete enterocyte development. After the second or third week, fat digestion reaches its normal state (32). In addition, young birds have difficulty reabsorbing bile salts due to their immature enterohepatic circulation (49).

Sources of vegetable origin have a better composition to be used in poultry farming due to their fatty acid profile being rich in their unsaturated forms (oleic, linoleic and linolenic) which have better assimilation from the metabolic point of view. In general, the main vegetable oils used are soy, corn, sunflower, canola and cotton and also by-products from refineries such as gums and acid lees (50, 51).

Animal sources in general have an economic advantage, since their prices are more accessible, but they also show greater variation in terms of their composition and higher proportion of saturated fatty acids. The main sources of animal origin used in animal nutrition are poultry viscera oil, beef tallow, pork fat and fish oil (51).

FINAL CONSIDERATIONS

Brazil has the capacity to produce soy gum on a commercial scale to meet demands for the use of this product in animal nutrition. Considering the composition of the product and its ability to act as an emulsifier in the diet of commercial birds, it is possible to highlight that its use as an emulsifying additive is feasible and should be better studied, since it can result in gains from an economic point of view, with the economy in the use of high-value energy ingredients (oils and fats), as well as environmental gains by allocating the by-product of the commodity production chain.

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