Promote Oil Stability & Extend Shelf-Life of Soy Meal Up To 12 Mo

Soybeans were first cultivated and consumed as early as 11th century B.C. in eastern China[11]. Soybeans are now a global crop utilized in both feed and food products for their balanced source of nutrients, specifically amino acids and fatty acids. Despite the nutrient dense profile of a soybean, they need to undergo processing before they can be consumed due to the natural presence of anti-nutrients inherit to the raw soybean.

Anti-nutrients of particular concern to proper digestion of the protein and energy in soy are trypsin inhibitors. However, soy ingredient quality can vary depending on the thermal process used. Thermal processing with high-shear dry extrusion thoroughly deactivates anti-nutrients and promotes greater protein and energy digestibility in soymeal and oil when the process is controlled under recommended parameters[7, 17].

Soybeans are classified as an "oilseed" due to the presence of 18-20% oil in the whole bean. The purpose of a soy crush plant is the separation of the soy oil from the protein-rich meal to provide two valuable ingredients. While soymeal is primarily intended to market for animal feed, the soy oil – often sold as crude soy oil – can be sold directly for animal feed, biodiesel production or can be fully refined and sold as a valuable vegetable oil in the food market[11]. Soy oil is composed primarily of polyunsaturated fatty acids (i.e. linoleic and linolenic acids), as shown in ***Table 1*** below[13]. Although, some new varieties of soybeans contain higher levels of monounsaturated fatty acids (i.e. oleic acid). The soy oil fatty acids play a critical role in body maintenance and are supplied mainly through the diet.

The stability of fats, oils, and their products play an important role in determining the ingredient's quality and longevity. The oxidative stability index (OSI) is a measurement of the oxidative potential of the product which can be used to determine shelf-life[1]. The OSI can be used to compare various fats/oils to determine if the use of anti-oxidants as a preservative is required or how much longer an oil can be used before it spoils and become rancid, also known as lipid peroxidation.

Additionally, there are economic concerns when using an unstable or peroxidized oil in animal diets. In regard to oil quality, the biggest concerns are oil instability, which can lead to rancidity and cause reduced growth and performance by broilers fed the rancid oil and even negatively impact breast meat quality in the carcass with a potential impact on profitability[8, 12, 16]. If production animals are fed an unstable or rancid oil, there can be loss of performance and even impacts on the quality of the meat, milk, or eggs. A research study evaluating broiler digestibility of extruded and mechanically pressed soymeal, processed under different conditions, showed the highest amino acid digestibilities and lowest urease activity – measured by pH change – were measured in meals processed at 150-160 degrees Celsius[6]. Similarly, a review study observed pigs fed a diet containing peroxidized lipids had an average decrease of 11.4% in growth rate and 8.8% decrease in feed intake compared to the diets with non-peroxidized lipids of the same source[10].

Also, the addition of fats and oils in the animal diet constitutes the largest economic factor in the diet cost. As an example, most poultry diets include at least 5% fat inclusion in the total

formulation which is significant to the overall diet cost. This makes energy the most expensive part of the animal's diet. It is also highly critical to the performance outcomes of the animal in the production of animal proteins. More importantly, fats and oils varying significantly in quality and therefore, price varies greatly. Therefore, it is important to note, that mechanically processed soymeal, such as high-shear dry extruded and mechanically pressed (i.e. ExPress®) soymeal, contains 6% – 8% residual oil which provides a nutritionally relevant source of energy as well as a source of protein in a single ingredient.

In a recent layer study, the animal performance of egg laying hens was evaluated and showed the improved feed intake of layers fed ExPress® soymeal resulting in 0.6 g/day more egg mass and an overall 2% improvement in feed conversion[2]. This finding demonstrates how using high-quality soy ingredients can lower the diet costs and have a positive impact on profitability of the producer. When ExPress® soymeal is used, there is no need for additional fats/oils to be added to the diet, often cheapening the overall formulation. Furthermore, the quality of that oil is consistent and high-quality leading to the many nutritional benefits.

On the contrary, commodity soybean meal processed by large-scale hexane-extraction contains almost no oil (<1%) as it is removed prior to the thermal processing of the soybean meal. The nutritional advantages of the residual oil in ExPress® soymeal have been evident through animal feeding trials. For example, dairy cows fed ExPress® soymeal increased milk production while exhibiting decreased dry matter intake as compared to cows fed commodity soybean meal. Furthermore, the oil from the ExPress® soymeal had a positive influence on the fatty acid composition in the milk, including an increase in unsaturated fatty acids (C:18) and a decrease in saturated fatty acids (C:17)[4]. As this data suggests, the use of high quality and highly stable oil-rich ingredients impact animal growth and performance and play an important role in the final quality of the animal products, like meat and milk. Furthermore, low-quality or rancid oils should be avoided in animal diets due to their instability and negative impacts on animal performance.

Different methods of soy oil extraction could affect the minor component profile of the oil. In regard to the oil's phospholipid content, specifically phosphatidylcholines, are different between solvent-extracted commodity soy oil and ExPress® soy oil[15]. As shown in ***Tables 1 and 2***, ExPress® oil is naturally trans-fat free and contains lower levels of free-fatty acids (FFA) than commodity soy oil promoting oil stability and a longer shelf-life[13, 14].

Common measures of lipid quality include moisture, insoluble and unsaponifiables matter, and FFA which are correlated to lipid peroxidation. Through the main effects of high-shear dry extrusion on lipids which inactivates hydrolytic enzymes such as lipases, lipoxygenase, and peroxidase; their inactivity promotes stability and prevents rancidity. Furthermore, due to the rupturing of plant cell walls via high-shear dry extrusion, the naturally-occurring tocopherols – vitamin E-like compounds – are preserved and present in the oil. These tocopherols act as natural anti-oxidant and assist in promoting a longer shelf-life. As shown in ***Table 2***, ExPress® soy oil has lower FFA and higher overall tocopherol levels than commodity soy oil[3, 14]. It is important to note, this is a comparison of refined soy oils. In the case of refined commodity soy oil, there are added chemicals to reduce FFA levels. Hexane, a chemical solvent in commodity soy oil

extraction, can destroy naturally-occurring tocopherols and requires the addition of synthetic stabilizers, commonly referred to as anti-oxidants, to stabilize the oil[13].

Shelf-life studies were conducted on high-shear dry extruded soy products to measure the longevity of the anti-oxidant properties. In ***Table 3***, ExPress® soymeal, flour, and TSP – all processed via high-shear dry extrusion, had a shelf-life exceeding 20 months for TSP and more than 40 months for soymeal and flour[5].

A follow-up study was conducted at Iowa State University in 2021 to test the shelf-life of ExPress® soymeal under moderate to extreme storage conditions, measured by temperature and relative humidity, for a period of 12 months[9]. Shown in the ***Figure 1***, there were no significant changes to OSI value for ExPress® soymeal stored over the 12-month period regardless of moderate or extreme storage conditions. The OSI reference value of 6.5 was measured in a previous study evaluating ExPress® soy oil quality[14]. Overall, this data suggests soybeans processed via high-shear dry extrusion preserves oil stability and promotes anti-oxidate potential leading to many benefits, including a long shelf-life for extruded soy products.

Based on the processing method used to separate protein-rich meal and oil from a soybean, there are quality implications that should be considered. From a mechanical processing standpoint, high-shear dry extrusion should be used to promote oil stability and anti-oxidant activity which can lead to a long-lasting product shelf-life. In comparison when solvent-extraction methods are used to produce commodity soybean meal and oil, additional processing steps need to be taken to ensure oil stability, such as the addition of synthetic anti-oxidants.

Furthermore, there are economic considerations when choosing an energy source for an animal's diet. Precision formulation using high-quality ingredients should be employed to ensure proper animal performance and cost-effectiveness. High-shear dry extrusion and mechanical oil pressing of soy will produce ExPress® soy meal with residual oil. Therefore, by utilizing ExPress® soymeal over the solvent-extracted, commodity soybean meal with all of the oil removed, the diet is supplied with high-quality protein and oil – at a least cost compared to if soybean meal and additional oil from another source is added. All in all, there are many benefits to feeding ExPress® soymeal. The high-shear dry extrusion process by which ExPress® soymeal is made promotes product stability through the preservation of naturally-occurring tocopherols and promotes a prolonged shelf-life of at least 12 months for extruded soy ingredients.

TABLE 1

Fatty Acid Compositions (%) of Soy Oil

	16:0 Palmitic	18:0 Stearic	18:1 Oleic	18:2 Linoleic	18:3 Linolenic
ExPress® oil	10.1	4.2	24.3	51.5	8.3
Commodity oil[a]	10.8	4.9	25.2	51.6	7.5
		ExPress®	0.0	0.0	
	Trans fat[b]	Commodity	5.4	1.4	

[a]Wang T. 2001
[b]Warner K. 2004

TABLE 2

Quality Analysis of Soy Oils

	ExPress® oil, refined	Commodity oil, refined
Free Fatty Acid[a] (%)	0.09	0.17
Peroxide Value (meq/kg)	2.70	2.13
Total Polar Compounds (%)	13.22	10.44
Moisture & Volatile Matter (%)	0.10 – 0.29	0.30 max.
Unsaponifiable Matter (%)	0.40 – 0.50	1.50
Total Tocopherols[b] (ppm)	922	874
Alpha-tocopherols	59	96
Gamma-tocopherols	592	584
Delta-tocopherols	253	174

[a]Ganjyal G. 2019
[b]Warner K. 2006

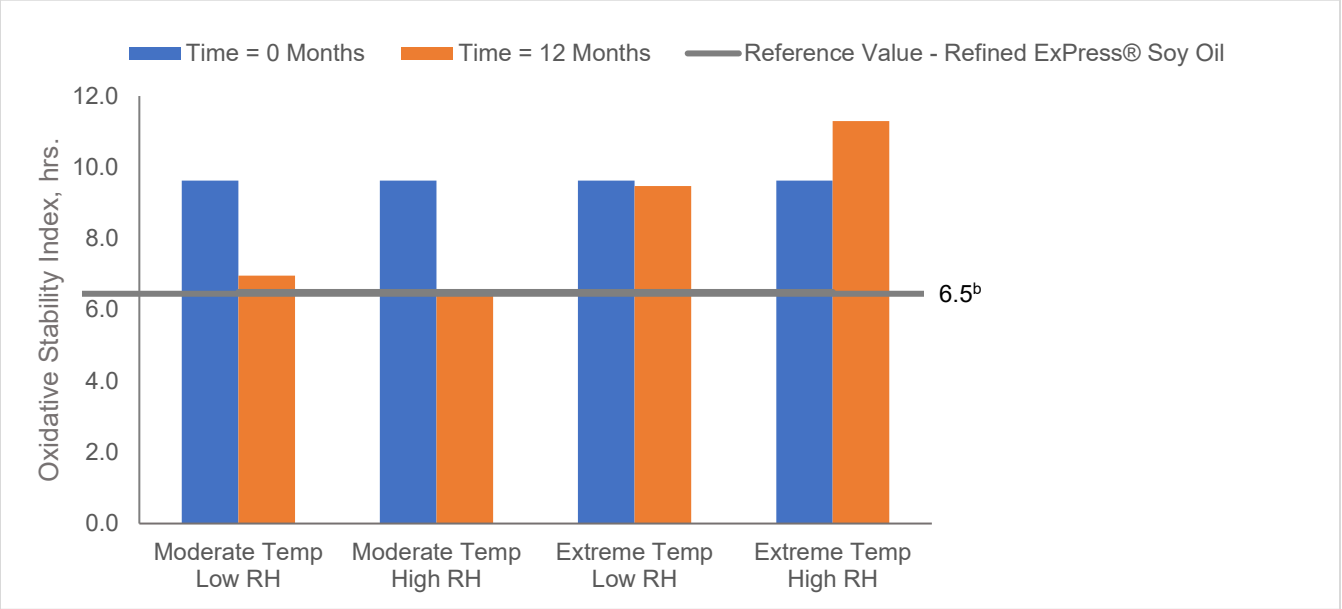
TABLE 3

Shelf-Life of Various Extruded Soy Products
*Stored Under Ambient Temp (68° F) Conditions

	ExPress® Soymeal	ExPress® Soy Flour	Texturized Soy Protein
Shelf-Life[a] (Months)	40.8	120.0	20.4

[a]Johnson L. 2000

FIGURE 1 OXIDATIVE STABILITY INDEX (OSI) OF EXPRESS® SOY OIL AT 0 MONTHS AND 12 MONTHS UNDER VARIOUS STORAGE CONDITIONS[a]



[a]Rosentrater, K. Iowa State University. 2021.

[b]Warner, K. USDA. 2006.

Abbreviations: RH – relative humidity (%); NS – no statistically significant differences between OSI at T_0 and T_{12}

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