Hexane-free mechanical extraction by screw pressing: a viable alternative to chemical extraction of oilseeds

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While chemical extraction is an effective way of obtaining raw vegetable oil, screw pressing of oilseeds is becoming increasingly popular for good reasons. The benefits of mechanical extraction (without chemical solvents) by screw pressing over chemical extraction include lower investment costs, lower space requirements, less stringent safety measures, and better food safety of the products. On the other hand, there are limitations in terms of yield and capacity. Different screw pressing technologies lead to different product qualities (the two main products are vegetable oil and expellers). This article presents the results of company studies comparing expellers (EX) and extracted meals (EM), the most common sources of protein in animal nutrition.

- **Screw pressing of oilseeds is becoming increasingly popular, but different screw pressing technologies lead to different protein qualities.**
- **The relative protein digestibility in soybean, rapeseed, and sunflower seed expellers and extracted meals from different technologies was recently compared.**
- **This article describes what was learned.**

There are currently several technological sources of EX and EM with varying nutritional value. In our project, we analyzed relative protein digestibility in soybean, rapeseed, and sunflower seed expellers and extracted meals from different technologies. These technologies differ mainly in the exposure of heat that EX or EM undergo. The temperature and the time for which the material is exposed to the heat are the main parameters that influence its digestibility. The heat causes the proteins to denature (unfold), which inactivates a part of the enzymes that decrease protein digestibility. On the other hand, overexposure to heat leads to the formation of Maillard reaction products as saccharides fuse with amino acids into indigestible complexes.

In chemical extraction, heat exposure of extracted meal is the highest in the desolventizer/toaster, where the meal is heated up for the remaining solvent to evaporate away. In the case of screw pressing, the highest heat exposure occurs inside the screw press as well as in the equipment for preliminary heat treatment (toaster/extruder). In screw pressing, we distinguish several modes of processing depending on the number of pressing steps and oilseed treatment. The most common division is into either single-stage or two-stage pressing, indicating the number of times the

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FIG. 1. CP2 technology for rapeseed—40,000 metric tons (MT) per year

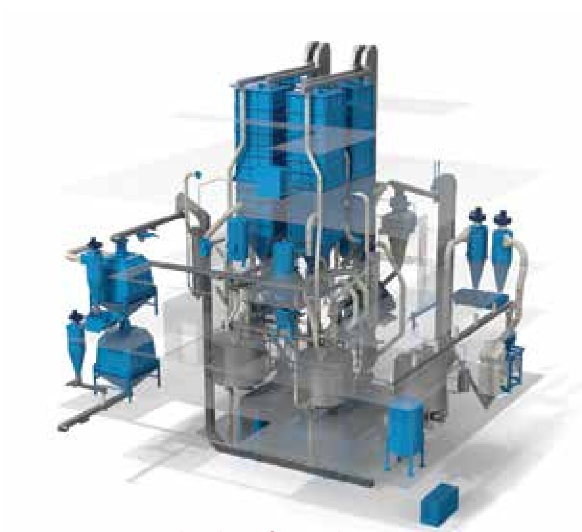

FIG. 2. EP1 technology for soybean produces—100,000 MT per year

FIG. 3. EP2 technology for rapeseed, sunflower—15,000 MT per year

oilseed undergoes expression. Furthermore, technologies differ in seed pre-treatment, being either cold (absence of heating), hot (with heating), or combined with extrusion. Generally speaking, the most common technologies are those of single-stage cold pressing (CP1), two-stage cold pressing (CP2, Fig. 1), single-stage pressing with extrusion (EP1, Fig. 2), two-stage pressing with extrusion (EP2, Fig. 3), single-stage hot pressing (WP1), and two-stage hot pressing (WP2). Seeds may be pre-heated to increase oil yield. The highest heat exposure (temperature over time period) occurs in hot pressing and extraction technologies. It is the extended time period at a high temperature and low humidity that causes the formation of unwanted Maillard reaction products. In pressing technologies combined with extrusion, the seeds are heated up to a very high temperature but only for a short time. That's why this process is very gentle to the nutritionally valuable substances while effectively eliminating the digestibility-decreasing agents.

DIGESTIBILITY OF RAPE, SUNFLOWER, AND SOYBEAN PROTEINS

One of our studies looked at the digestibility of proteins in the expellers and extracted meal from rapeseed, sunflower seed, and soybeans from different technological sources, which we tested via balance trials in chickens (Table 1). The experiment involved cockerels at the age of 35 days. The cockerels were held in balance cages in pairs and given feed *ad libitum* with an addition of chromium oxide as an external indicator of digestibility (it is not absorbed in the intestine). The chyme and feed were analyzed for their contents of proteins and chromium

TABLE 1. Relative protein digestibility

Oilseed	CP1 [%/protein content]	CP2 [%/protein content]	EP1 [%/protein content]	EP2 [%/protein content]	WP1 [%/protein content]	Extracted meal [%/protein content]
Rapeseed	84	81	-	85	80	74
Sunflower	85	82	-	86	-	78
Soybean	-	-	87	-	78	81

TABLE 2. Evaluation of layers

	Feed consumption/ egg [g]	Feed consumption/ day [g]	Average egg weight [g]	Intensity of lay [%]
Extracted soy meal (EM)	182.2	137.2	69.1	76.5
Soy expellers (EX)	178.2	137.4	68.0	78.1
Full-fat extruded soy	179.1	135.8	69.1	76.9

oxide. The results demonstrated significantly better digestibility levels in technologies of pressing with extrusion, compared to other technologies. This is because of the short retention time at high temperature and pressure, which causes a "thermal enhancement" of the press-cake. Upon extrusion, the expellers become more digestible, while the heating and disruption of cellular structures allow for a higher yield in the subsequent pressing step, achieving levels similar to those of hot pressing. On the opposite side of the spectrum, the lowest values were measured for the WP1 technology and chemical extraction. This is caused by the prolonged exposure of the seeds to high temperatures.

COMPARISON OF SOY PRODUCTS

In another study, we focused on comparing extracted soy meal (EM), soybean expellers (EX), and full-fat soy. The tests were performed in chicken layers ISA Brown and broilers ROSS 308.

Layers

The layers were split into 3 groups of 40 individuals. Experimental feeding started in their 20th week and ended in the 60th week. The layers were fed a granulated complete compound feed containing either EM, EX, or full-fat soy. The compound feed was divided into individual mixes according to the age of the animals. We evaluated the consumption of feed per egg, the consumption of feed per day, average egg weight, and the intensity of lay (Table 2).

In terms of nutrition and compound feed production, soybean expellers appear to be the most efficient source, considered an optimal protein component for layers, both with respect to their energy demands and their need for linoleic acid. EX-containing compound feed resulted in the greatest intensity of lay as well as the lowest feed consumption per egg.

Broilers

Chicken broilers were fed a complete compound feed designed according to nutritional norms for meat chickens, specifically for the hybrid combination ROSS 308.

TABLE 3. Nutrient conversion of different soy products

	Conversion [kg/kg]
Extracted soy meal	1.56
Soy expellers	1.43
Full-fat extruded soy	1.44

In terms of feed conversion, best results were achieved with full-fat soy, closely followed by expellers (Table 3). Overall, extruded full-fat soy can be considered the best of the three observed protein sources, because the mixture doesn't need any additional fat source, and the granules exhibit the right consistency.

EXTRUSION IS BENEFICIAL

In general, expellers have the same or better relative protein digestibility compared to extracted meals. Combining screw pressing with dry extrusion brings benefits to the process, such as increasing the nutritional value of expellers and increasing vegetable oil yield. Because of a higher oil content, expellers have a higher energy value and need to be seen as an independent product with an added market value. The technology of screw pressing has an outstanding potential, especially for local processing of oilseeds at capacities up to 500,000 metric tons (MT) of seeds/year. A significant advantage of local processing is possible quality control from seeds to the final products. This technology is also convenient for the processing of certified products, such as GMO free, Certified Organic, and Clean Label.

Michal Kaválek is the head of R&D projects at Farmet a.s, where he seeks to find innovative ways of processing local agricultural products for feed and food. The aim of company R&D is to design and manufacture highly efficient technologies for production of vegetable oils and fodder in small and medium capacities. The company's customers are looking for effective processing of local commodities and efficient use of local resources as a path to sustainable use of food and natural resources.