From Raw Soybeans to Animal Products: Energy and Protein Conversions

A White Paper

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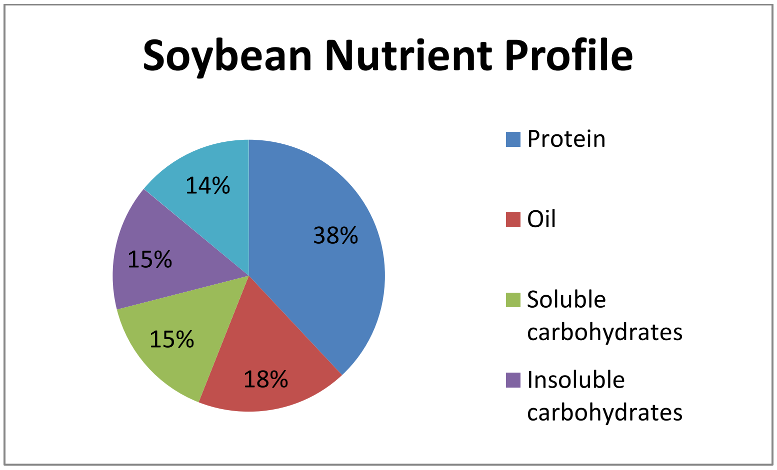
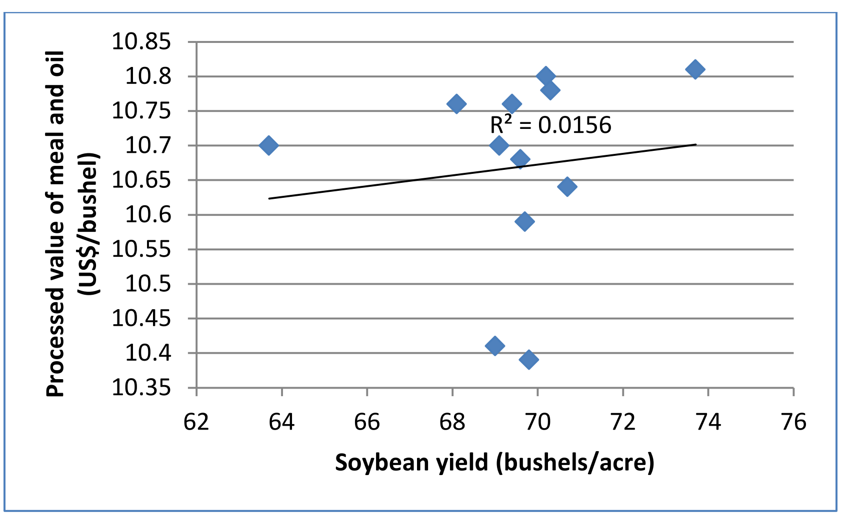
Why Soybeans? Soybeans have a vast nutrient profile, and with nearly one-quarter billion metric tons harvested annually[1] in a variety of countries around the world[2], it is an important global oilseed crop.



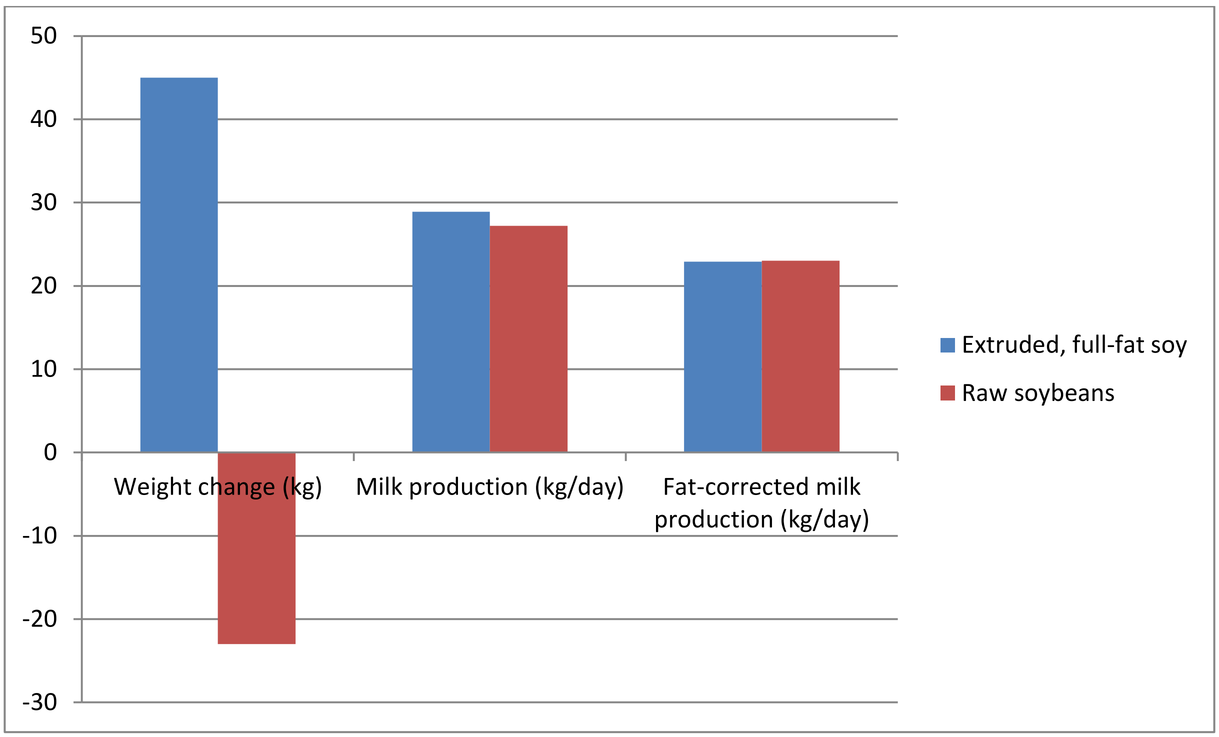
As seen by this graph, soybeans contain a wide array of nutrients, and in particular, it is the protein and oil that are highly valued in animal and human nutrition. Soybean products are used around the world to convert plant proteins and energy from oil, into animal products for human consumption. These products include meat, milk and eggs. As human populations continue to grow and advance, demand for these products will certainly increase – most notably, the majority of growth will be in developing countries[3].

The purpose of this white paper is to examine relevant data and concepts regarding the conversion of soybeans into animal products for human consumption. A major challenge with this conversion process is that soybean yields in the field and the processed value of the soybeans (the protein-containing meal and oil portions) do not necessarily correlate (see below)[4].

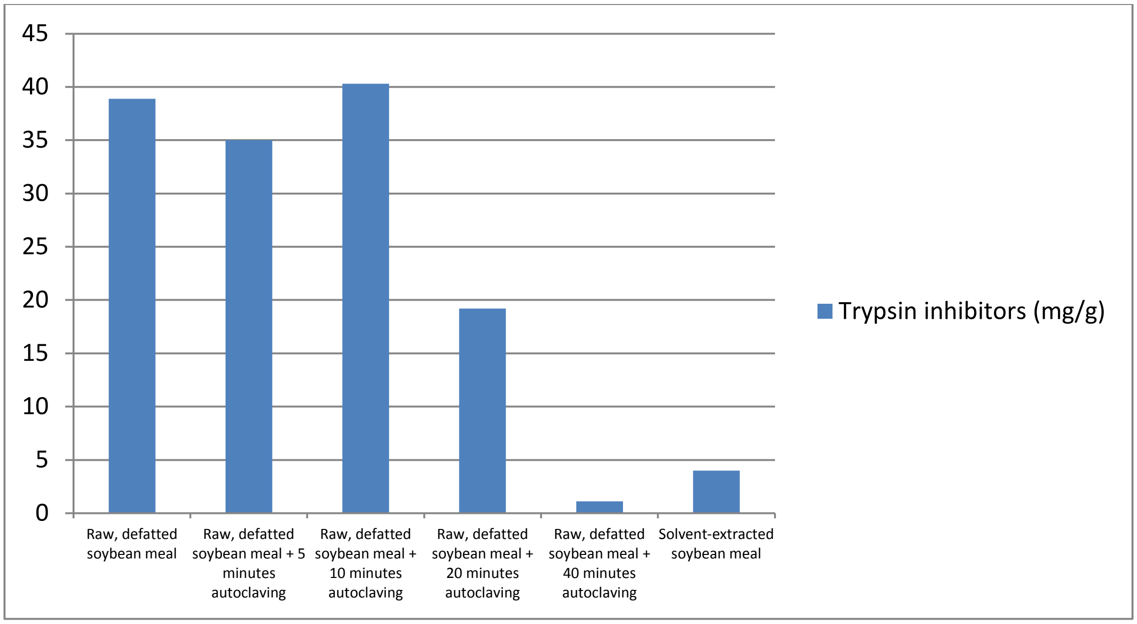


Soybean farmers pick varieties based on two main factors; yield in the field and premiums offered by processors (end users) to grow varieties with specific output traits. End users typically demand protein and oil; therefore, it is important for the industry to source soybeans adequately, and monitor the quality of the raw materials.

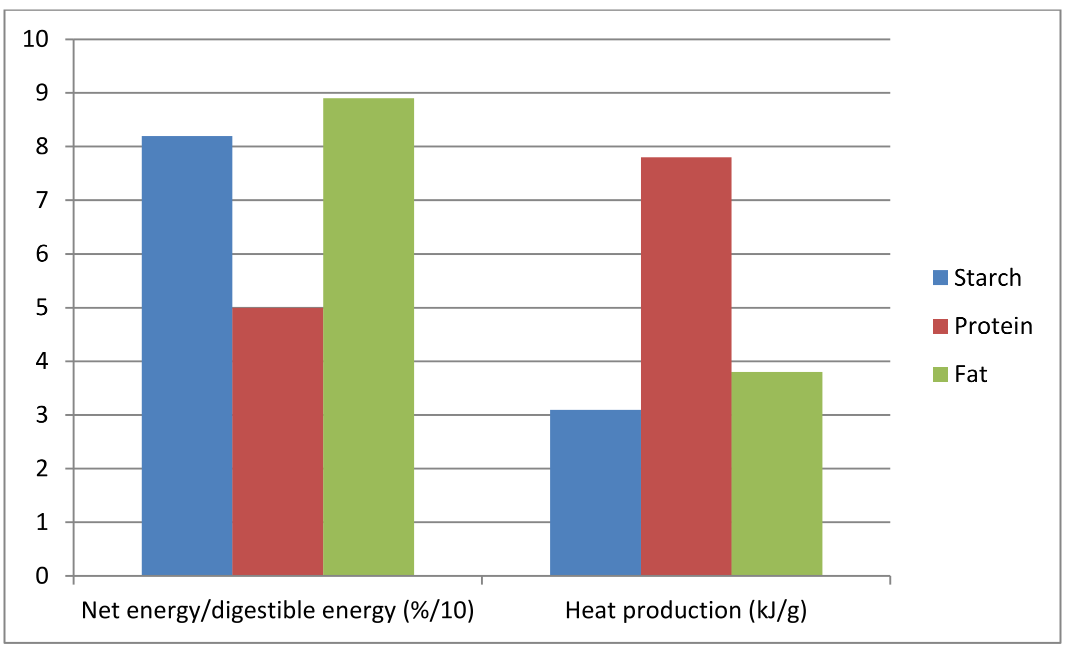
The preferred method of feeding soybeans to livestock is after thermal processing (heating); however, in select cases, raw soybeans could support animal performance in the short term, but perhaps not in the long term. Multiparous dairy cows in early lactation, characterized by high energy requirements, fed raw soybeans had similar energy-corrected milk production compared to soybeans subjected to high temperature and pressure cooking for a short time (extrusion; see below)[5]. However, cows fed raw soybeans could not maintain body weight, which could lead to production challenges later, including conception difficulties, pregnancy maintenance issues and diminished lactation performance.



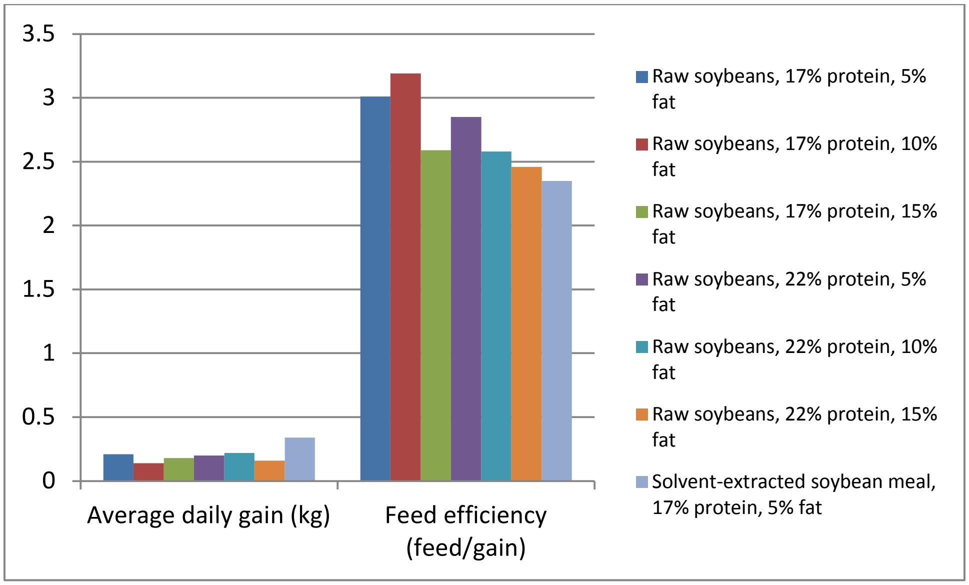
This is partly because soybeans contain anti-nutrients, which hinder digestion, and eventually, performance. Thermal processing (heating) deactivates anti-nutrients (see below)[6]. Note that the thermal treatment must be performed properly – in this case, for enough time – to deactivate trypsin inhibitors, a class of anti-nutrients in raw soybeans.



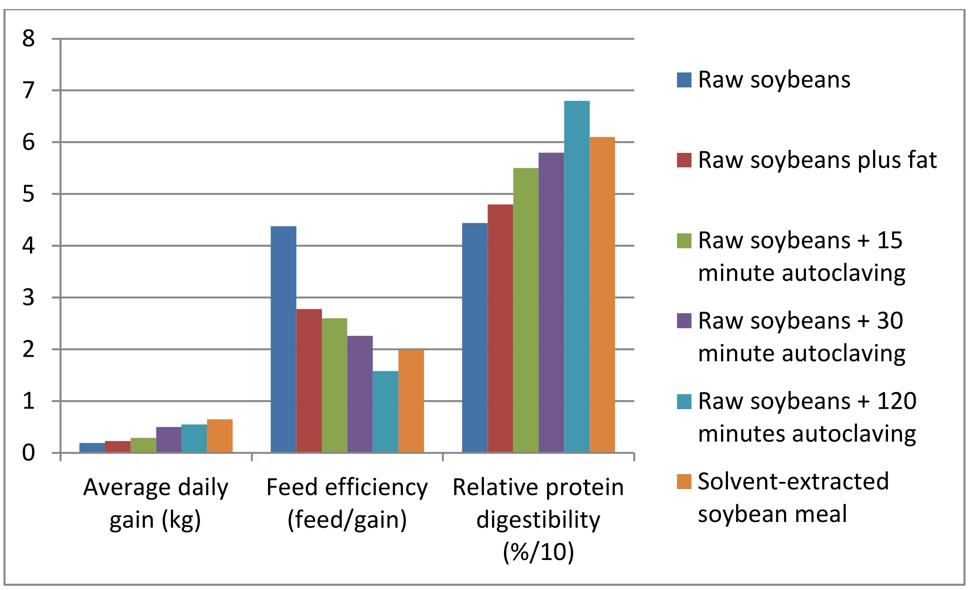
In addition, it is much more difficult to digest protein than starch (carbohydrate), fats and oils (see below)[7]. Digesting and assimilating protein is associated with more energy loss and heat production versus other macronutrients. This represents inefficiency, and therefore, anything that promotes protein digestibility should enhance the conversion of soy protein to animal products.



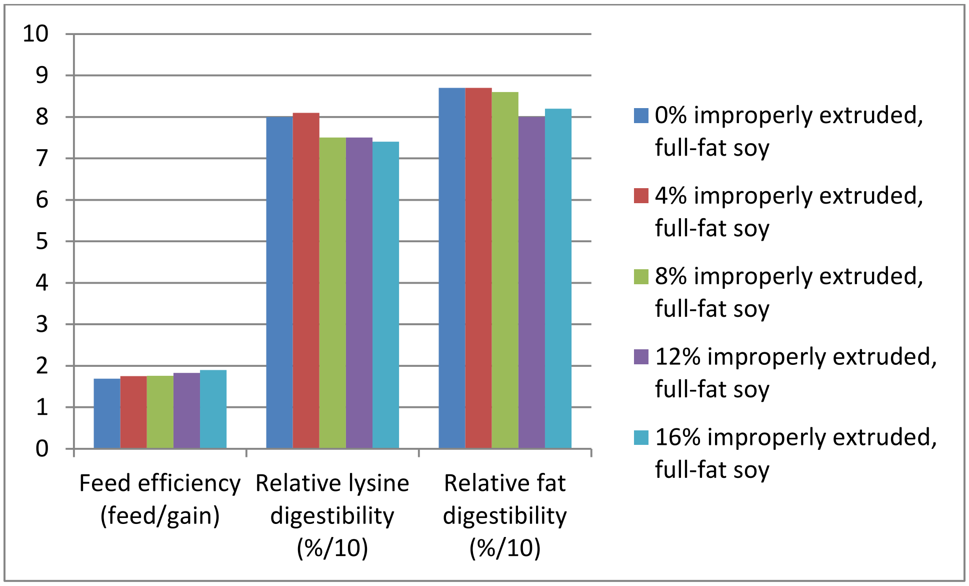
Some species, such as swine (domesticated pigs), perform poorly when fed raw soybeans. As determined by animal performance experiments, increasing the protein and fat contents of the diet could not overcome the effects of anti-nutrients in raw soybeans, along with the increased inefficiencies of digesting more protein. In this study, swine performance on diets containing raw soybeans was always inferior to heated and de-oiled, soybean meal (solvent-extracted; see below)[8].



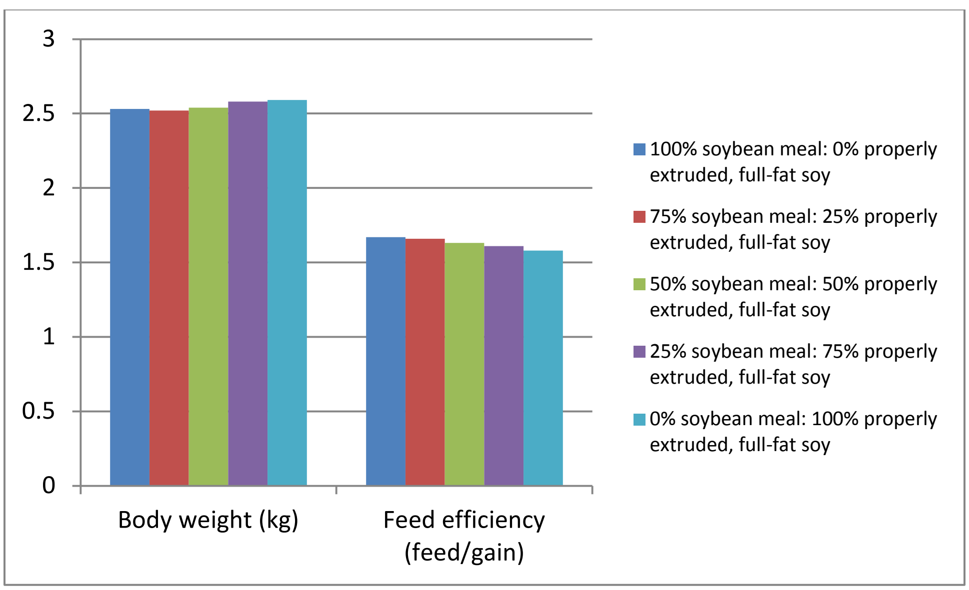
However, adequate heating of raw soybeans did result in improved swine growth and digestibility performance versus heated and de-oiled, soybean meal (see below)[8].



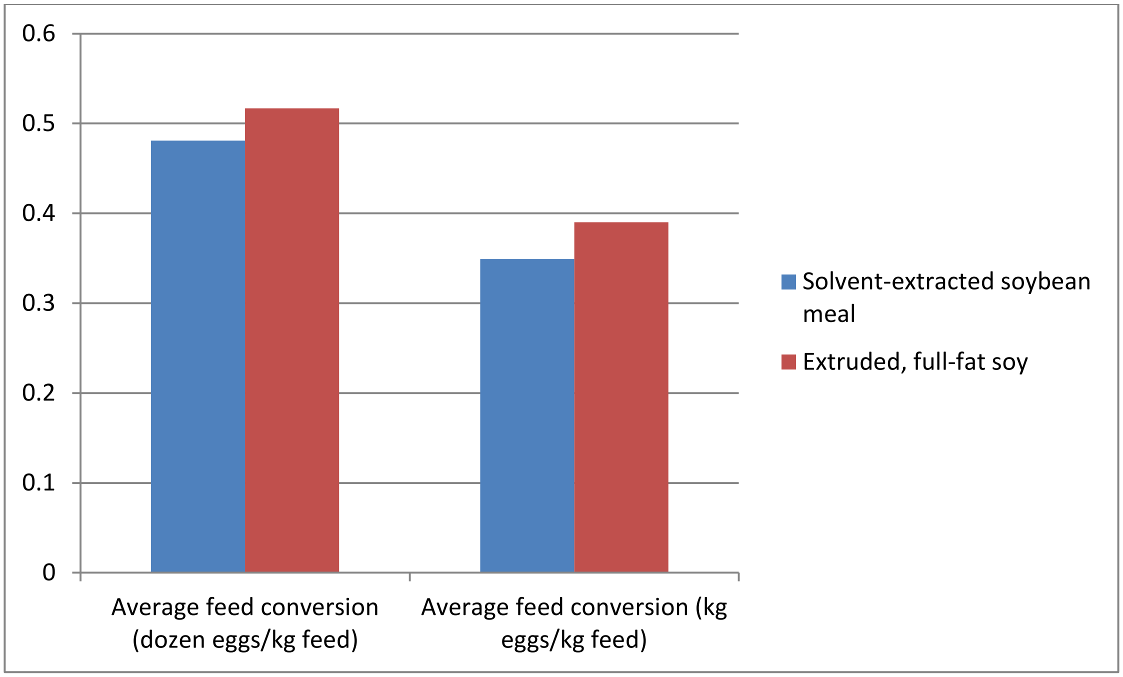
Poultry are also highly sensitive to anti-nutrients in raw soybeans. The inclusion of increasing levels of improperly extruded, full-fat soy, which still contained excessive anti-nutrient levels, reduced broiler chicken growth and digestibility performance (see below)[9]



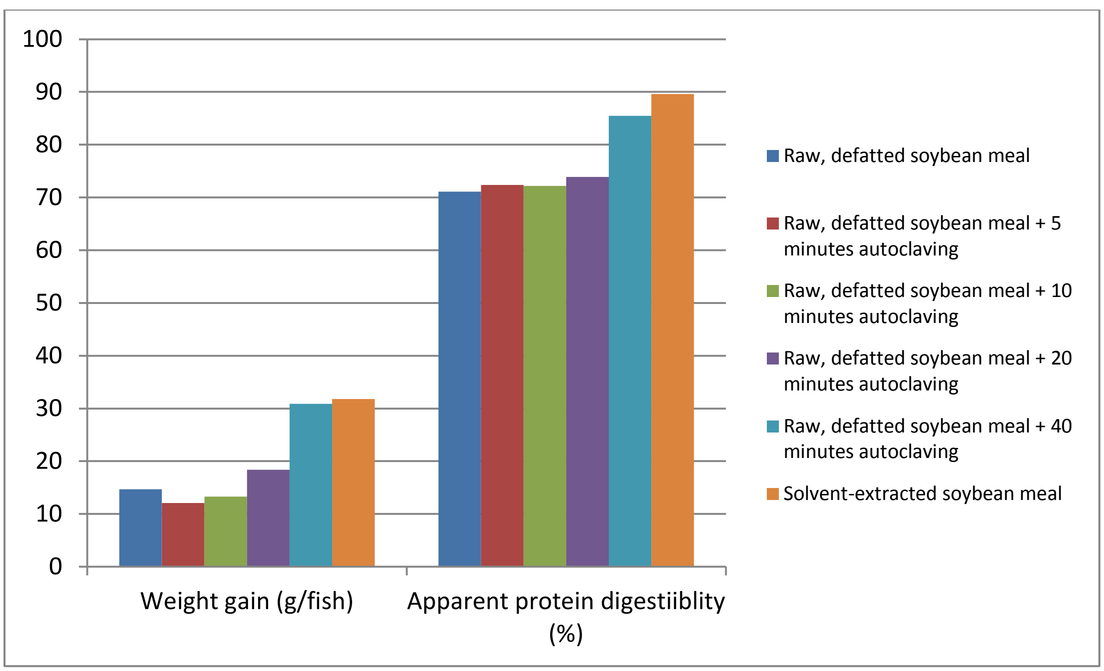
However, when properly extruded to deactivate anti-nutrients to acceptable levels, broiler chicken performance was improved when extruded, full-fat soy completely replaced solvent-extracted soybean meal (see below)[10].



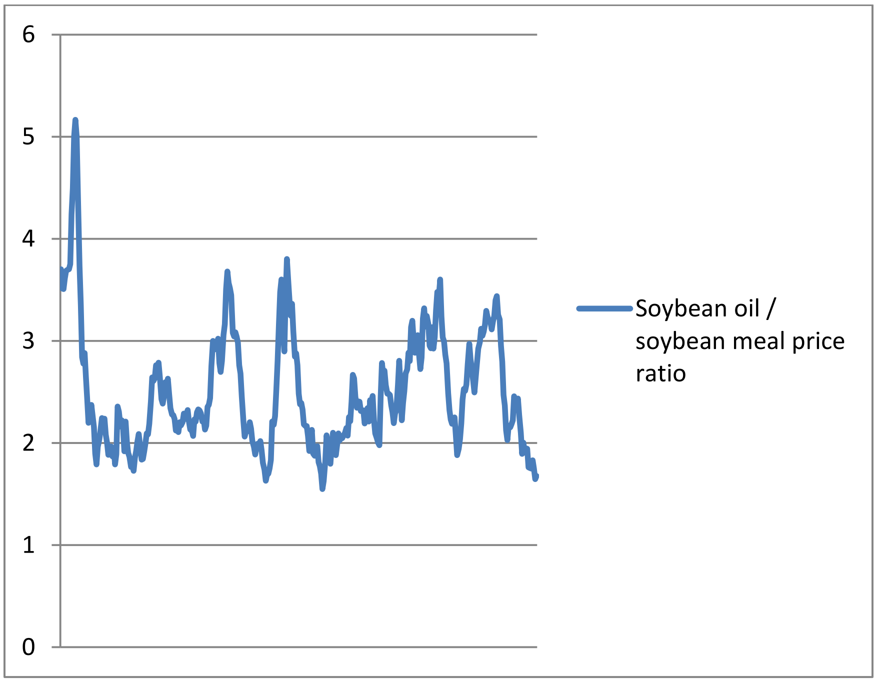
In addition, the same is true for laying hens used for egg production. Properly-extruded, full-fat soy, when replacing solvent-extracted soybean meal, enhanced the efficiency of egg production (see below)[11].



Farmed fish also do not perform well with improperly-processed soy. As an example, catfish fed de-oiled soybean meal, even when autoclaved for 40 minutes, did not exhibit growth and protein digestibility equal to catfish fed solvent-extracted soybean meal (see below)[6].

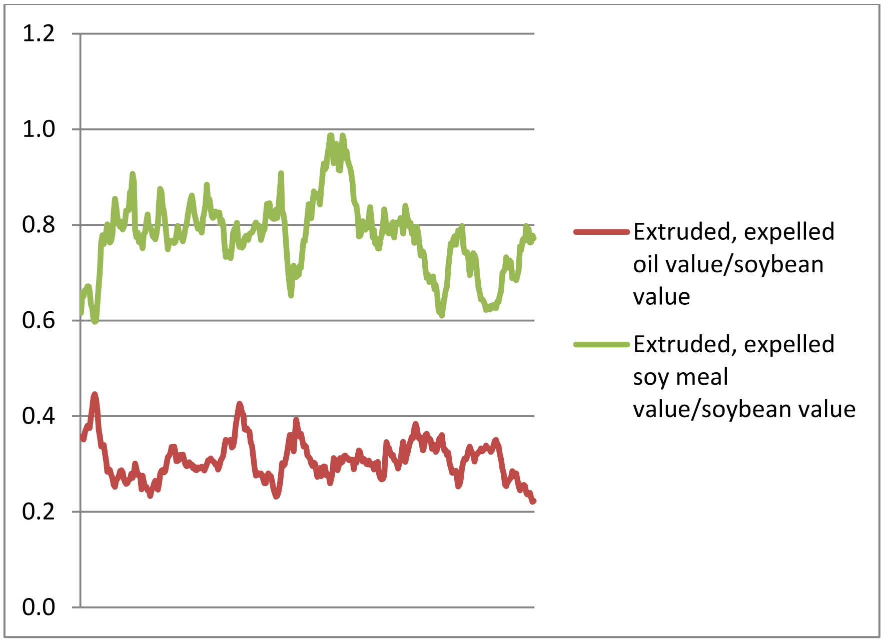


So far, we have considered feeding soybeans containing all of their oil (full-fat), or with most of it removed (de-oiled). It may be advantageous to remove some or most of the oil in soybeans for other purposes. Using solvents, such as hexane, nearly all of the soy oil can be isolated from soybean meal. Alternatively, mechanical expellers, or presses, use physical force (non-chemical) to remove most of the oil, while leaving some residual oil behind in the meal. Both procedures also employ heating of some sort to improve oil extraction, deactivate anti-nutrients and enhance animal performance. Using data from the last 30 years, soybean oil has always been more valuable than soybean meal on an equivalent unit mass basis (see below)[12].

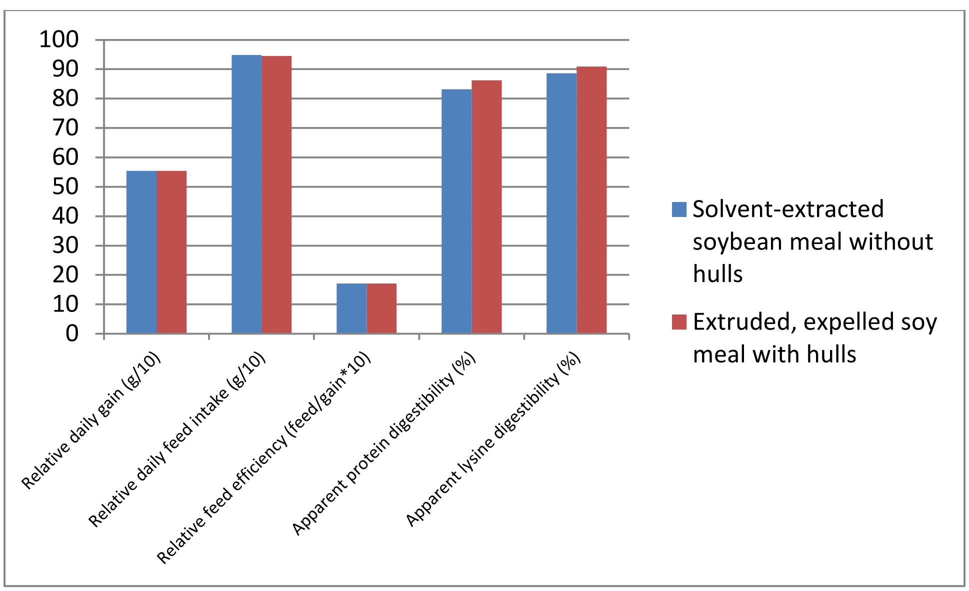


However, in absolute terms, soybeans yield much more protein-containing meal than oil (see below)[13]. Therefore, when removing soybean oil for other purposes, it is important to maintain a high-quality meal for use as a dietary ingredient for animal production. Quality can be enhanced by using appropriate thermal processing, as discussed above, and by leaving some residual soy oil in the meal to serve as an energy source.

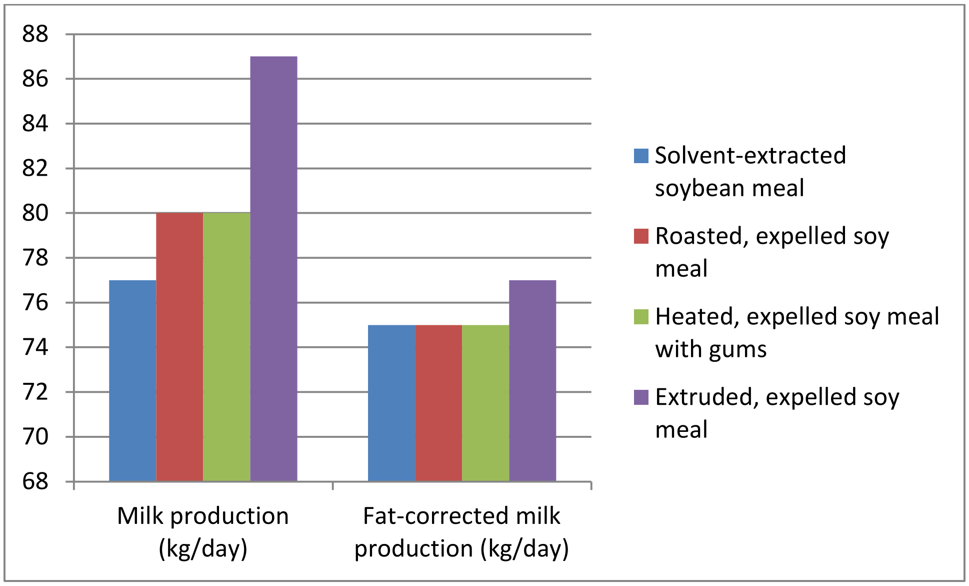
Also, note the correcting and stabilizing market nature of the two products (see below). For many times during the past 30 years, when the price of soy oil has increased, the price of soy meal has decreased. The opposite relationship can also be observed below. This is important to note for risk management strategies.



In terms of residual oil in the meal, extruded, expelled soy meal supported similar, and somewhat higher, nursery pig performance compared to animals fed solvent-extracted (completely de-oiled), soybean meal (see below)[14]. This has important practical considerations, as diets formulated with extruded, expelled soy meal do not require supplemental fats or oils. In addition, this study compared extruded, expelled soy meal with the hulls remaining, while solvent-extracted soybean meal had the hulls removed before feeding. Soy hulls would be expected to hinder growth and digestibility performance in nursery pigs, and yet, following extrusion and expelling, this effect was not realized.



Similarly, dairy cattle performance was enhanced when extruded, expelled soy meal was fed versus meals that were roasted and heated (see below)[15].



Recommendations

The conversion of soybean protein and oil to animal products for human consumption should involve the following:

- Sourcing of raw soybeans with as much protein and oil as possible
- Utilization of equipment that is able to support activities in developing countries
- Utilization of equipment that could separate oil from protein-containing meal
- Optimization of thermal processing for anti-nutrients, and to improve animal production

References

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[11]Speers, 1971, Evaluation of Full Energy Soybeans in Layer Rations, University of Minnesota Research Report

[12]Monthly commodity soybean oil and meal data during 1984-2014 from Chicago Board of Trade via indexmundi.com

[13]Value of extruded, expelled meal and oil, relative to value of raw soybeans, during 1984-2014 from Chicago Board of Trade via indexmundi.com. A common factor, each for extruded, expelled meal and oil, was applied to estimate their values relative to Chicago Board of Trade prices. The absolute amount of meal and oil obtained following high-shear, dry extrusion and mechanical oil pressing was determined, and used in the calculations.

[14]Woodworth, Tokach, Goodband, Nelssen, O'Quinn, Knabe, and Said, 2001, J. Anim. Sci., 79:1280, http://www.journalofanimalscience.org/content/79/5/1280.full.pdf, accessed August 11, 2014

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