the naphthas used. If about a 5 per cent solution of Methyl Alcohol in naphtha is used for extraction, the fines will settle almost immediately. The alcohol dissolves the lime soaps and therefore removes the protective colloid of the suspension and the fines settle out. This method makes it necessary to recover any water distilled off from the system, so that the alcohol which it will contain can be recovered by distillation.

The final requisite for the solvent extraction system was for the plant to be profitable. The profits possible from such a plant are very easily demonstrated. In the beginning of this paper it was pointed out that one-quarter million tons of meat scraps, an animal by-product, with an average fat content of 11.44 per cent, were produced last year in the state of Ohio. For economical and practical reasons, it is most desirable to reduce the fat content to about 3 per cent in the extracted material; the costs for this extraction, including labor, steam, power, depreciation and maintenance, interest on investment and so forth, would be as a figure $4 per ton.

If the one-quarter million tons of meat scraps at 11.44 per cent fat had been extracted to 3 per cent fat, the yield of fat would have been 174 pounds per ton or a total of 43,500,000 pounds. Assuming a value of 6 cents per pound for this fat, the return per ton from the extraction would have been $10.44. The value of the protein has not changed; though the weight of material has been reduced, the protein percentage has risen in proportion. The net profit from the extraction would therefore be the return of $10.44 less $4, cost of extraction, or $6.44 per ton. For the state of Ohio alone, this represents a clear profit of $1,610,000.

The above figures only show the profit available from extraction after the material had been processed with some other means of fat recovery. Had the material been extracted after cooking, eliminating a handling and operating cost, the profits would have been higher.

The material after extraction will not decompose for an almost unlimited time. With high fat contents, a process of fat hydrolysis is going on continually, liberating fatty acids which are very detrimental for animal and poultry feeding, but with low fat contents, this action is inhibited. The fatty acid content, based on the weight of the material, is reduced appreciably on extraction due to the reduction in fat content. It is the fatty acid content that is particularly harmful to animals and poultry. Fat does very little to aid the growth of an animal, so that a low fat and consequent low fatty acid content feed should show beneficial results. Today finds many of the larger feed mills preferring low fat content meat scraps for blending into animal and poultry feed.

The right of existence of solvent extraction for the recovery of fat from animal by-products has been shown. Though handicapped and deterred in the past, it should soon take its rightful place and be in step with progressing industry.

THE NUTRITIVE VALUE OF SOYBEAN OIL MEAL PREPARED BY THE DIFFERENT METHODS OF OIL EXTRACTION

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Abstract

This article is primarily a review of the literature pertaining to the subject. Solvent extracted, hydraulic, and expeller soybean oil meals all contain, if properly processed, protein of high biological value, similar to that of milk protein. Solvent extracted meal has a higher percentage of protein. Since expeller and hydraulic meals contain more oil than solvent extracted soybean oil meal, they naturally have a slightly higher vitamin A and D potency, but the amounts of these vitamins contained in any type of soybean meal or even in the whole soybean are not significant. Levine's assays reveal that solvent process soybean oil meal contains roughly 5.8 I. U. of vitamin B per gram of solids compared to 1.9 I. U. for hydraulic meal. According to results of formal experiments, the vitamin G content of soybeans is not materially affected by any of the common methods of processing. Krayhill reports that expeller and hydraulic pressed soybean oils contain more "leithin" (total phospholipid) than hexane extracted soybean oil. Therefore his results indicate that our domestic solvent extracted meal contains slightly more "leithin" than expeller meal. "Leithin" in soybean oil meal may be valuable as an antioxidant to stabilize the vitamin A contained in mixed feeds.

We have heard much recently about the use of soybean oil meal or its protein in plastics, paper coatings, paper sizing and for glue, and we know there has been an appreciable volume of soy flour used in dog foods and in edible foods such as meat products and baked goods. The outlet through these channels for the residue of the soybean remaining after oil extraction is not to be discounted; but the fact remains that about 95 per cent of the total output of the residue from the soybean processing plants in this country has been in the form of soybean oil meal which is used as a protein supplement in feeds for farm livestock and poultry.

In this country we are now using three methods for extracting oil from the soybean, namely, the hydraulic, the expeller, and the solvent processes. The resulting oils and meals are known according to the method of extraction employed. In addition the hydraulic and expeller meals are frequently spoken of as "Old Process" soybean oil meal and the solvent meal as the "New Process" soybean oil meal. I imagine that most of you are fairly well acquainted with the machinery and general operations involved in the hydraulic and expeller methods of oil extraction since both methods have been used in this country for many years. However, the first extensive use of the continuous method of solvent extraction in this country dates back only four years, when the Archer-Daniels-Midland Company began processing soybeans in their newly installed unit at Chicago. If you are interested in this development and the many details involved in operating this type of processing equipment, I suggest that you read the article by Schmidt on this subject (1934).

The soybean contains less oil than most oil bearing seeds such as flaxseed, cottonseed and the peanut, and when we apply average prices for its two principal products, soybean oil and soybean oil meal, on the basis of the average yield of each from the same unit quantity of beans, we find that the
meal represents a value equal to, if not greater than, the sales value of the oil. In other words, soybean oil meal is not necessarily a by-product of the soybean as is the case with the meals of the flaxseed, cottonseed and peanut. It is evident that in processing soybeans the industry needs to take precautions to manufacture the most nutritious meal possible as well as to extract the largest possible quantity of a high grade oil. A method of processing which cannot be used to produce efficiently both a high grade soybean oil and a high grade soybean oil meal will be definitely handicapped in its operations. When we consider the close interrelationship between the two principal products of the soybean, I think perhaps a group of oil chemists can see some justification for including on its program a paper in which it is intended to present the facts at our disposal regarding the nutritive value of soybean oil meal prepared by the different methods of oil extraction.

**Effect Upon Protein**

Soybean oil meal is used in feeds for livestock and poultry primarily as a protein supplement to grains and grain by-products, and therefore we shall consider first the effects of the methods of oil extraction on the quantity and quality of the proteins contained in the different kinds of soybean oil meal. In general, if the various protein supplements available on the market are at all comparable insofar as quality is concerned, the buyer will give preference to a supplement that furnishes protein at the least cost per unit of protein. It is the quantity of protein that has some importance in marketing the different kinds of soybean oil meal. In this regard, then, it is of interest to note that when the oil is extracted with the solvent commonly used in this country—that is, commercial hexane—more oil can be removed from the soybean than by the mechanical methods of oil extraction, and consequently the solvent extracted soybean oil meal will contain more protein than the hydraulic and expeller meals. In fact the processors employing the solvent method of oil extraction have found it possible to safely guarantee 44 per cent of protein in their meal, whereas 41 per cent has been the usual guarantee for hydraulic and expeller soybean oil meals.

Although I have discussed first the quantity of protein contained in different kinds of soybean oil meal, I admit that we are most interested in the quality of protein of the different meals. The term “quality” thus used refers to the biological completeness of the protein as measured by the presence and amount of the various essential amino acids and also the assimilability and the availability of these amino acids for use in the animal body. Osborne and Clapp (1907) in their analysis of glycinin, the principal protein of the soybean, found the content of amino acids for this protein to be similar to the values reported for casein, the principal protein of milk. This indicated that the protein of soybeans was of high quality since milk proteins have always been regarded as such. However, when the raw soybean was put to the test of supplying the proper protein to produce growth of animals and to sustain life, it failed miserably. Osborne and Mendel (1917) were the investigators who reported this failure of raw soybeans to support growth, and these workers also demonstrated that the growth promoting properties of raw soybeans were increased to expectation when they were previously cooked. They concluded from their experiments that heating or cooking of the raw soybeans made the bean or ground whole soybean more palatable and the proteins more digestible to the animal. These were evidently the principal reasons for the phenomenal increase in growth promoting properties.

Many interesting developments have taken place since that time. For instance, with the advent of commercial processing of soybeans, research workers began to notice that some lots of soybean oil meal had a high feeding value. Other lots, manufactured by the same process of oil extraction, had an inferior feeding value, in terms of rapidity and efficiency of gains, as that of raw soybeans. Hayward, Steenbock and Bohstedt (1936) have reviewed all of these developments, and it was these research workers who first experimented with the different processes of oil extraction to determine the optimum amount of heat necessary in each respective process to give the protein of soybean oil meal a high biological value and to determine the cause of this increase in biological value when the optimum amount of heat was used. They found that a most satisfactory soybean oil meal in terms of protein efficiency could be produced by each of the three methods of oil extraction. Some of the principal points of interest in this regard are contained in the following quotation from their first article:

“Raw soy beans were found to contain protein of low nutritive value as determined by the grams of growth per gram of protein eaten. Commercial soybean oil meals such as the expeller meal processed at low temperatures, 105° C., for 2 minutes or the hydraulic meal cooked at 82° C. for 90 minutes contained proteins similar in nutritive value to the raw soy beans. On the other hand, commercial soy bean oil meals which had been prepared at medium and high temperatures such as expeller meals processed at 112 to 130 and 140 to 150° C. for 2½ minutes or hydraulic meals cooked at 105 and 121° C. for 90 minutes contained proteins which had about twice the nutritive value of the raw soy beans or low temperature meals. These expeller and hydraulic meals prepared at medium temperatures, respectively, were light brown in color while the meals prepared at high temperatures were brown in color. Heating the extracted soy beans at 98° C. for 15 minutes, as in the commercial solvent method of oil extraction, was also found to be an effective method of heat treatment. This solvent meal, however, was light colored. When the ground whole soy bean was autoclaved in the laboratory until the meal was brown in color, the protein had a high nutritive value. These results together with the fact that the commercial solvent meal was found to contain a very efficient protein, suggest that brown color can only be used as an index of the probable efficiency of the proteins of commercial soy bean oil meals produced by the expeller and hydraulic processes.”

In their second article Hayward, Steenbock and Bohstedt (1936) conclude on the basis of the results of many feeding tests in which they supplemented the raw soy bean and a properly heated soy bean oil meal with various proteins and with the amino acid l-cystine, that heating of the soy bean caused such a phenomenal increase in its biological value largely because the heat caused the methionine-cystine fraction of the protein to become available.

It was also at the University of