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SUNFLOWER SEED OIL MEAL STUDIES
I THE EFFECTS OF METHODS OF
PROCESSING ON THE NUTRITIVE VALUE
OF SUNFLOWER SEED OIL MEAL
II THE SUPPLEMENTARY VALUE OF
SUNFLOWER SEED OIL MEAL IN
PRACTICAL CHICK STARTING RATIONS

by

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UNIVERSITY OF ALBERTA

September

1952

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NUTRITIVE VALUE OF SUNFLOWER SEED OIL MEAL
- II THE SUPPLEMENTARY VALUE OF SUNFLOWER SEED
OIL MEAL IN PRACTICAL CHICK STARTING RATIONS

A DISSERTATION

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

FACULTY OF AGRICULTURE
DEPARTMENT OF ANIMAL SCIENCE

by

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EDMONTON, ALBERTA,
SEPTEMBER, 1952.

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FACULTY OF AGRICULTURE
DEPARTMENT OF ANIMAL SCIENCE

The undersigned hereby certify that they have read and recommend to the School of Graduate Studies for acceptance, a thesis entitled "Sunflower Seed Oil Meal Studies I The Effects of Methods of Processing on the Nutritive Value of Sunflower Seed Oil Meal II The Supplementary Value of Sunflower Seed Oil Meal in Practical Chick Starting Rations", submitted by Alexander Baillie Morrison, B. Sc., in partial fulfilment of the requirements for the degree of Master of Science.

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ABSTRACT

Eight experiments were conducted to study the effects of methods of processing on the nutritive value of sunflower seed oil meal. The results obtained indicate that processing conditions employed in the manufacture of sunflower seed oil meal markedly influenced the nutritive value and chemical composition of the meal. The nutritive value was lowered as processing conditions became more severe. Marked variability in the chemical composition of raw, laboratory solvent extracted, sunflower seed oil meals prepared from different raw materials was noted. Low-temperature sunflower seed oil meal (processed at 200° - 220°F.) and regular-temperature sunflower seed oil meal (processed at 240° - 260°F.) are not complete single sources of amino acids for the chick, when fed at the twenty percent protein level. Rations containing low-temperature or regular-temperature sunflower seed oil meal as the only source of protein were improved for chick growth by the addition of vitamin-free casein and methionine. Regular processing temperatures of 240° - 260°F. resulted in a decrease in the liberation of lysine by acid hydrolysis, as compared to the liberation of lysine from a low-temperature meal processed at 200° - 220°F. Extraction of regular-temperature sunflower seed oil meal with ethanol or trichloroethylene increased its nutritive

value for chicks. Adding the trichloroethylene extract back to the extracted meal at twice the level originally present depressed the growth of chicks.

Five experiments were conducted to study the supplementary value of sunflower seed oil meal in practical chick starting rations. The results obtained indicate that low-temperature sunflower seed oil meal (processed at 200° - 220°F.) may satisfactorily replace one-third of the fish meal and meat meal, two-thirds of the soybean oil meal, or all of the meat meal in the practical chick starters used. Regular-temperature sunflower seed oil meal (processed at 240° - 260°F.) satisfactorily replaced one-third of the fish meal and meat meal mixture or two-thirds of the soybean oil meal in the rations used. When two and one-half percent fish meal was included in the ration, regular-temperature sunflower seed oil meal satisfactorily replaced one-third of the meat meal in the starter. When meat meal was the only source of supplementary protein in the ration, regular-temperature sunflower seed oil meal replaced all of the meat meal present without detrimental effect.

ACKNOWLEDGMENTS

The writer wishes to thank Professor L. W. McElroy, Head of the Department of Animal Science, for placing the facilities of the Department at his disposal, and to gratefully acknowledge the helpful advice given by Drs. D. R. Clandinin and A. R. Robblee, Associate Professors of Poultry Husbandry, during the course of this study, and in the preparation of the manuscript.

Thanks are extended to Co-op. Vegetable Oils Limited, Altona, Manitoba, for preparing sunflower seed oil meals. Acknowledgment is also made to Merck and Co. Limited, Montreal, Quebec; Lederle Laboratories Division, American Cyanamid Company, Pearl River, N.Y.; and Hoffmann-La Roche Inc., Nutley 10, N.J., for supplying the vitamins used during the course of the study.

The work was supported in part by a National Research Council Grant-in-Aid.

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INTRODUCTION

Commercial production of sunflower seeds in Canada was undertaken as a wartime emergency measure, in order to obtain a domestic source of edible vegetable oils. Commercial quantities of sunflower seed were first produced in 1943. Initially, production was scattered throughout southern Manitoba and Saskatchewan, but by 1945 had become centered around Altona, Manitoba, where a co-operative processing plant was established. By 1949, production had increased to the extent that approximately sixty thousand acres were seeded, yielding in the neighborhood of one thousand pounds of sunflower seeds per acre.

The most important by-product of the sunflower oil industry is sunflower seed oil meal, the high-protein residue remaining after expression of the oil from the partially decorticated sunflower seeds. Recent shortages of animal protein supplements have resulted in the use of increasing amounts of vegetable protein supplements in livestock and poultry rations, and, as a result, the use of sunflower seed oil meal in Canadian poultry rations has reached significant proportions. Unfortunately, however, little information is available concerning the nutritive value of sunflower seed oil meal for poultry.

Since processing variables have been shown to markedly influence the nutritive value of soybean oil meal (see Review of Literature), experiments were initiated at the University of Alberta during 1951 to study the possible effects of methods of processing on the nutritive value of sunflower seed oil meal. Part I of this report is concerned with the results of these studies. Studies were also conducted to determine the supplementary value of sunflower seed oil meal in practical chick starting rations. These are discussed in Part II of this report.

REVIEW OF LITERATURE

Studies on the nutritive value of soybean protein have been the subject of numerous investigations. As early as 1917, Osborne and Mendel found that raw soybeans supported a slow rate of growth in rats when used as the only source of protein in the ration. When water was added to ground raw soybeans and the resulting mixture cooked, a meal supporting an adequate rate of growth was produced. Hayward, Steenbock, and Bohstedt (1936-a) described experiments in which soybean oil meals prepared under varying conditions were fed to rats. They found that expeller meals processed at 112° to 130°C. and 140° to 150°C. for two and one-half minutes, or hydraulic meals processed at 105°C. and 121°C. for ninety minutes, possessed twice the nutritive value of ground raw soybeans, low temperature

expeller meals processed at 105°C. for two minutes, or hydraulic meals processed at 82°C. for ninety minutes. Hayward et al. (1936) reported that high temperature expeller soybean oil meal processed at 140° to 150°C. for two and one-half minutes, medium and high temperature hydraulic soybean oil meals processed at 105°C. and 121°C. for ninety minutes, and solvent extracted soybean oil meal processed at 98°C. for fifteen minutes supported twice the growth rate in chicks of either ground raw soybeans or low temperature expeller soybean oil meal processed at 105°C. for two minutes.

Previously, Mitchell and Smuts (1932) and Shrewsbury and Bratzler (1932) had reported that ground raw soybeans are deficient in cystine so far as their growth promoting value for the rat is concerned. Hayward, Steenbock, and Bohstedt (1936-b) found that the addition of 0.3 percent L-cystine to ground raw soybeans resulted in a similar increase in the nutritive value of the beans to that obtained by autoclaving the raw beans for one hour at fifteen pounds steam pressure. They suggested that heating the soybean protein causes the cystine fraction to become available to the rat. Johnson, Parsons, and Steenbock (1939) reported the apparent presence in raw soybeans of a sulfur-nitrogen complex which, although absorbable, is not utilized by the body. They concluded that autoclaving makes this portion available. About this time, Rose et al. (1936), Rose (1937),

Womack, Kemmerer, and Rose (1937), and Womack and Rose (1941) demonstrated the dispensibility of cystine and the indispensibility of methionine in the diet of the rat. They found that on a cystine deficient diet, body cystine arises from dietary methionine, while on a methionine deficient diet, cystine exerts a methionine-sparing action. That such a relationship prevails in the case of the chick has been ably demonstrated by Klose and Almquist (1941), Grau and Almquist (1943), and Almquist and Grau (1944, 1945).

As a result of rat feeding trials, Hayward and Hafner (1941) concluded that when fed at a level of approximately twenty-five percent of the diet, ground raw soybeans failed to induce growth in rats over a period of eight weeks. Addition of 0.3 percent L-cystine caused a definite increase in the nutritive value of the ration, while 0.3 percent DL-methionine produced an even greater response. Inclusion of 0.3 percent L-cystine and 0.3 percent DL-methionine stimulated no greater growth than did addition of methionine alone. Autoclaving the raw soybeans increased the nutritive value of the protein to about half-way between that of the cystine and methionine supplemented lots. Supplementation of cooked soybeans with either methionine or cystine markedly increased their nutritive value. Although ground raw soybeans supported some growth in chicks, the effects of supplementation with

methionine and cystine paralleled the results of the rat studies. The authors concluded that while the sulfur-amino acid fraction of the protein is unavailable in raw soybeans, autoclaving makes this portion available. This conclusion was supported by the findings of Mitchell, Hamilton, and Beadles (1945) who observed that the effects of heat treatment on soybeans were to render the protein more digestible and more completely utilizable in metabolism, the latter effect resulting from increased availability of cystine. Evans and McGinnis (1946) reported that autoclaving soybean oil meal affected the availability of methionine and cystine. Moderate autoclaving (100° to 120°C. for thirty minutes) increased methionine and cystine retention, whereas drastic autoclaving (130°C. for thirty or sixty minutes) decreased it. In a later report, the same workers (1948) confirmed their earlier results, and also demonstrated that excessive autoclaving causes partial destruction of cystine. Bouthilet et al. (1950) reported the presence of an undigested methionine-rich complex in the feces of chickens fed ground raw soybeans, which was not present in the feces of chickens fed autoclaved soybeans.

Another concept of the effects of methods of processing on the nutritive value of the soybean was suggested in 1944, when Bowman noted that aqueous extracts of soybeans contained a fraction which inhibited

the tryptic digestion of casein in vitro. Ham and Sandstedt (1944) described the nature and properties of a proteolytic inhibiting substance in a dilute acid extract of raw soybeans. The activity of the inhibitor was destroyed by autoclaving either the extract or the raw soybeans. Ham, Sandstedt, and Mussehl (1945) found that the proteolytic inhibiting factor present in unheated soybean oil meal retarded the growth of chicks when administered in rations containing either autoclaved soybean oil meal or animal protein feedstuffs as the source of supplementary protein. They demonstrated a marked decrease in proteolytic activity of the intestinal contents of chicks receiving a diet of raw soybean oil meal, as compared to the activity of the intestinal contents of chicks receiving a diet of autoclaved soybean oil meal. Almquist and Merritt (1951) found the effect of the trypsin inhibitor to be a general one, that of decreasing the rate of digestion of the entire soybean protein. Kunitz (1945) succeeded in crystallizing the inhibitor. He showed that it was protein in nature, and concluded that it inhibits the action of trypsin, and to some extent that of chymotrypsin. McGinnis and Menzies (1946) reported that the fraction of raw soybean flakes responsible for the poor nutritive value of raw soybeans may be inactivated by in vitro

papain digestion as well as by heating. Westfall and Hauge (1948) described experiments in which soybean flours heated at various temperatures were fed to mice. They concluded that the trypsin inhibitor is the chief cause of the poor utilization of the protein of inadequately heated soybean flours and suggested that measurement of the trypsin inhibitor content gives a reliable index of the nutritive value of soybean oil meals, provided heating is not prolonged beyond the point of total inactivation of the inhibitor. This view is supported by the findings of Borchers, Ackerson, and Mussehl (1948). Liener (1951) and Borchers and Ackerson (1951) presented data which indicate the presence in raw soybeans of a toxic principle not identical with the trypsin inhibitor.

Results of experiments conducted by Clandinin et al. (1947) showed that prolonged heating of solvent extracted raw soybean flakes in an autoclave at fifteen pounds steam pressure resulted in the production of meals of inferior nutritive value for chicks. The data indicated that meals of high nutritive value for the chick may be prepared by heating solvent extracted raw soybean flakes in the autoclave for a period of from four to thirty minutes at fifteen pounds steam pressure, while meals of inferior nutritive value were obtained by heating for

longer periods of time. Clandinin et al. (1948) observed that meals of equal nutritive value for chicks may be prepared by heating solvent extracted raw soybean flakes in the autoclave for four minutes at fifteen pounds steam pressure, or for forty-five minutes at four pounds steam pressure. Fritz, Kramke, and Reed (1947), working with turkey poults, concluded that for maximum biological value, ground raw soybeans should be autoclaved at fifteen pounds steam pressure for twenty to thirty minutes. Evans and McGinnis (1948) found that autoclaving raw soybean flakes at 100°C., 110°C., or 120°C. for thirty minutes increased the nutritive value of the protein for chicks. Autoclaving at 130°C. for either thirty or sixty minutes lowered the nutritive value.

Riesen et al. (1947) described experiments designed to study the liberation of amino acids from raw, properly heated, and overheated soybean oil meals. Subsequent to acid hydrolysis (alkaline hydrolysis in the case of tryptophan), less lysine, arginine, and tryptophan, as measured microbiologically, were liberated from overheated soybean oil meal than from either raw or properly heated soybean oil meal. In addition, the liberation of each of the essential amino acids by pancreatic digestion was increased by proper heat treatment and decreased by

excessive heat treatment. These investigators were of the opinion that in order to obtain a meal of maximum nutritive value for chicks, sufficient heat must be applied to not only destroy the trypsin inhibitor but also to alter the protein in such a way as to make it more readily attacked by proteolytic enzymes. They concluded that the quantity of amino acids determined microbiologically subsequent to acid hydrolysis does not necessarily provide a satisfactory measure of the growth promoting properties of a protein, but were of the opinion that enzymatic hydrolysis values may constitute a more reliable index of the relative nutritive value of different soybean oil meals. Ingram et al. (1949) reported that the quantity of amino acids determined microbiologically subsequent to in vitro enzymatic digestion constitutes a reliable index of the nutritive value of soybean oil meal. On the other hand, Clandinin and Robblee (1952) presented data which do not support this contention, particularly when one is concerned with meals processed under different conditions, and where overheating is a factor. Under any one set of conditions, however, they demonstrated that maximum in vitro enzymatic liberation would characterize a superior meal.

Roxas (1916) theorized that in the presence of heat a reaction occurs between reducing sugars and the

amino groups of amino acids. In studies with chicks, Stevens and McGinnis (1947) supplemented overheated soybean oil meal diets with lysine, autoclaved either alone or with cerelose for four hours at 120°C. Lysine autoclaved with cerelose for four hours at 120°C. was either destroyed or rendered unavailable for chick growth, whereas lysine autoclaved alone for four hours at 120°C. supplemented overheated soybean oil meal for chick growth as effectively as did unheated lysine. Evans and Butts (1948) suggested that when soybean oil meal is overheated, lysine is made biologically unavailable in two different ways. They theorized that part of the lysine is converted to a substance inactive for Leuconostoc mesenteroides P-60, while another portion is converted to a form resistant to in vitro enzymatic hydrolysis but available to this organism subsequent to acid hydrolysis of the soybean oil meal. Patton and Hill (1948) have shown that heating amino acids in the presence of reducing sugars renders the former nutritionally unavailable for micro-organisms. Patton, Hill and Foreman (1948) concluded that partial inactivation of free amino acids, amino vitamins and certain amino acids (basic and tryptophan especially) in intact proteins results from combination of the reactive amino groups with aldoses, their aldehyde degradation products, or polymers of the latter, under

the influence of heat. They concluded that this type of amino acid-carbohydrate reaction is responsible, at least in part, for the decrease in nutritive value brought about by overheating soybean oil meal.

Clandinin et al. (1951) demonstrated that the liberation of lysine by acid and enzymatic hydrolysis from a heated lysine-glucose mixture autoclaved at fifteen pounds steam pressure for varying periods of time was greatly decreased by the heat treatment. The liberation of lysine by enzymatic hydrolysis from a heated lysine-glucose mixture was less than the liberation of lysine by acid hydrolysis, suggesting the formation on heating of an enzymatic resistant, acid non-resistant linkage between lysine and glucose.

PART I

The Effects of Methods of Processing on the Nutritive Value of Sunflower Seed Oil Meal

Status of the Problem

As a background for this study, the effects of processing variables on the nutritive value of soybean oil meal have been indicated in the "Review of Literature". Results of preliminary experiments (Clandinin and Robblee, 1950) indicated that sunflower seed oil meals produced in Canada are of variable nutritive value for chicks. It therefore seemed advisable to study the effects of methods of processing on the nutritive value of sunflower seed oil meal.

Experiment 1

Object

To study the effects of processing temperatures on the nutritive value of sunflower seed oil meal.

Experimental

Three sunflower seed oil meals, made from the same original raw material but processed at different temperatures, were obtained from a commercial processing plant*. The meals were designated S1, S2 and S3. The

*

Co-op. Vegetable Oils Limited, Altona, Manitoba.

conditions under which the meals were processed are shown in Table 1. Meal S4 was prepared by autoclaving meal S1 for four hours at fifteen pounds steam pressure. The technique employed in autoclaving was the same as that used by Clandinin et al. (1947).

One hundred day-old Single Comb White Leghorn cockerel chicks were divided into five comparable lots of twenty chicks each and fed the rations shown in Table 2. The chicks were brooded in electrically heated starting batteries with raised screen floors. Feed and water were supplied ad libitum. The experiment was terminated at the end of twenty-eight days, at which time the chicks were weighed individually.

Table 1.- Processing conditions employed in the production of the sunflower seed oil meals

Sunflower Seed Oil Meal Number	Temperature in Cooker* Degrees F.	Temperature in Conditioner* Degrees F.	Autoclaved at 15 Pounds Hours
S1	200	220	--
S2	220	240	--
S3	240**	260**	--
S4	200	220	4

* The meals were processed for approximately thirty minutes in the cooker and three minutes in the conditioner.

** Usual conditions employed in commercial production of sunflower seed oil meal.

Results and Discussion

The results of the experiment are shown in Table 2. The growth of chicks fed the soybean oil meal control ration was greater than the growth of chicks fed any of the sunflower seed oil meal rations, indicating that solvent extracted soybean oil meal is a more complete supplementary source of amino acids for the chick than the sunflower seed oil meals used in this study. Sunflower seed oil meals processed at 200° - 220°F., (Lot 2), and at 220° - 240°F., (Lot 3), appeared to be of equivalent nutritive value for chicks. However, processing temperatures of 240° - 260°F. decreased the nutritive value of the meal (Lot 4). Autoclaving sunflower seed oil meal S1 for four hours at fifteen pounds steam pressure resulted in the production of a meal supporting a slow rate of growth in chicks (Lot 5). The slow rate of growth observed parallels the effects of overheating soybean oil meal reported by Clandinin et al. (1947).

Conclusions

- (1) Processing conditions employed in the production of sunflower seed oil meal were shown to affect the nutritive value of the meal. The nutritive value of the meal was lowered as processing conditions became more severe. From the results obtained, it would appear advisable to utilize

Table 2.- Effect of processing conditions on the nutritive value of sunflower seed oil meal

Ration and Lot Number	1	2	3	4	5
Ingredients	%	%	%	%	%
Ground yellow corn.....	59.5	63.5	63.5	63.5	63.5
Dehydrated alfalfa meal.....	3	3	3	3	3
Ground limestone.....	2	2	2	2	2
Bonemeal.....	1.5	1.5	1.5	1.5	1.5
Iodized salt.....	.5	.5	.5	.5	.5
Insoluble grit.....	1	1	1	1	1
Fish oil (2250A-300D).....	.5	.5	.5	.5	.5
Manganese sulfate (1/4 lb./ton).....	+	+	+	+	+
Vitamin mix (2 gm./kg.).....	+ *	+	+	+	+
Choline chloride (0.15%).....	+	+	+	+	+
Vitamin E (3 mg./kg.).....	+	+	+	+	+
Merck APF #8 (1 lb./ton)....	+	+	+	+	+
Soybean oil meal (solvent)...	32				
Sunflower seed oil meal S1***		28			
Sunflower seed oil meal S2***			28		
Sunflower seed oil meal S3***				28	
Sunflower seed oil meal S4***					28
Total.....	100	100	100	100	100
Protein (NX6.25) %.....	21.2	20.4	20.5	20.3	20.4
Number of chicks.....	19	20	19	19	20
Average weight at 28 days (gm.).....	281.9	235.6	237.1	178.3	80.6

* Calculated to supply the following levels per 100 gms. of ration: thiamine hydrochloride 0.3; riboflavin 0.6; calcium pantothenate 2.0; pyridoxine hydrochloride 0.4; nicotinic acid 5.0; para-amino benzoic acid 10.0; biotin 0.02; folic acid 0.05; vitamin K (Menadione) 0.05 milligrams.

** See Experimental for description of meals.

lower processing temperatures in the production of sunflower seed oil meal than those (240°- 260°F.) now used commercially.

- (2) Chicks fed rations containing sunflower seed oil meal as the source of supplementary protein grew at a slower rate than chicks receiving a ration containing soybean oil meal as the source of supplementary protein.

Experiment 2

Object

To study the effects of several processing variables on the nutritive value of sunflower seed oil meal.

Experimental

The processing variables studied in this experiment are shown in Table 3. Six sunflower seed oil meals processed under different conditions were obtained from a commercial processing plant*. In order to test the variability between expellers, sunflower seed oil meals S11, S12 and S13 were taken from three different Anderson expellers operating at the regular processing temperatures of 240°F. in the cooker and 260°F. in the conditioner.

* Co-op. Vegetable Oils Limited, Altona, Manitoba.

For those readers unfamiliar with oil seed technology, it would seem advisable to briefly outline the operations involved in the commercial production of sunflower seed oil meal. The sunflower seeds are first dried to approximately ten percent moisture. They are then partially dehulled. The sunflower "meats" next pass to a steam-jacketed cooker, located directly above the expeller. A revolving worm gear slowly moves them through the cooker, and into a conditioner, where they are further heated. The meats remain in the cooker approximately thirty minutes, and in the conditioner approximately three minutes. This preliminary heating increases the efficiency of expression of the oil. From the conditioner, the meats pass through the expeller. The pressure exerted by a revolving worm gear against a series of horizontal steel bars arranged in the form of a barrel mechanically removes most of the oil from the meats. Pressure in the expeller is maintained by a constriction at the end of the expeller barrel, known as the "choke". During expression of the oil, a considerable quantity of frictional heat is evolved. No provision is made for cooling the shaft of the expeller. The expeller barrel, however, is cooled by previously expressed sunflower oil, pumped over the barrel at the rate of fifty gallons per minute. The sunflower seed oil meal leaves the expeller in the form of "chips" which are later ground and sacked.

Meal S14 was processed in the same manner as meal S13 except that the choke on the expeller was opened one and one-half turns from the regular operating position. Meals S15 and S16 were both processed at a temperature of 200°F. in the cooker, and 220°F. in the conditioner. However, in the preparation of meal S16, the choke on the expeller was opened in a manner similar to that used in the preparation of meal S14.

Samples of the meals were analyzed for percentage moisture, crude protein, oil, and crude fibre. The methods of analysis for percentage moisture, crude protein, and crude fibre were essentially those of the Association of Official Agricultural Chemists (1945), while the method used for the determination of percentage oil was that of the American Oil Chemists' Society (1946).

Table 3.- Effect of processing conditions on the chemical composition of sunflower seed oil meals

Meal No.	Expeller No.	Temperature Degrees F.		Choke	Moisture %	Protein (NX6.25) %	Oil %	Crude Fibre %
		Cooker	Conditioner					
S11	1	240	260		3.4	40.9	4.2	14.9
S12	2	240	260		3.6	39.8	5.9	15.3
S13	3	240	260		3.3	42.7	5.2	12.6
S14	3	240	260	open	4.1	39.3	7.6	13.5
S15	3	200	220		4.3	38.3	7.2	14.2
S16	3	200	220	open	5.0	37.2	8.3	13.6

One hundred and forty day-old Single Comb White Leghorn cockerel chicks were divided into seven comparable lots of twenty chicks each, and fed the rations shown in Table 4. The experimental procedure followed was the same as that used in Experiment 1. The experiment was terminated after twenty-four days, when the chicks were weighed individually.

Results and Discussion

The results of chemical analysis of the six sunflower seed oil meals are shown in Table 3. A mutual interdependence in the percentage oil, crude fibre, crude protein, and moisture in the meals is evident. Opening the choke on the expeller increased the percentage oil in both the 240° - 260°F. meal (S14), and in the 200° - 220°F. meal (S16). In addition, lowering the processing temperatures from 240° - 260°F. to 200° - 220°F. increased the percentage oil in the meal. A combination of processing temperatures of 200° - 220°F. and open choke resulted in the production of a meal (S16) having the highest percentage oil of the series of six meals.

The average weights of the chicks fed the six meals are shown in Table 4. There appeared to be no difference in the nutritive value of sunflower seed oil meals produced by the three expellers, since chicks fed meals S11, S12, and S13 (Lots 2, 3, and 4, respectively) grew at the same rate. However, chicks fed meals S11,

Table 4.- Effect of processing variables on the nutritive value of sunflower seed oil meals

Ration and Lot Number	1	2	3	4	5	6	7
Ingredients	%	%	%	%	%	%	%
Ground yellow corn.....	39.5	34.5	34.5	34.5	34.5	34.5	34.5
Wheat bran.....	10	10	10	10	10	10	10
Wheat shorts.....	10	10	10	10	10	10	10
Dehydrated alfalfa meal...	5	5	5	5	5	5	5
Ground limestone.....	2	2	2	2	2	2	2
Bonemeal.....	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Iodized salt.....	.5	.5	.5	.5	.5	.5	.5
Insoluble grit.....	1	1	1	1	1	1	1
Fish oil (2250A-300D).....	.5	.5	.5	.5	.5	.5	.5
Manganese sulfate (1/2 lb./ton).....	+	+	+	+	+	+	+
Vitamin mix (2 gm./kg.)...	+	+	+	+	+	+	+
Choline chloride (0.15%)..	+	+	+	+	+	+	+
Vitamin E (3 mg./kg.).....	+	+	+	+	+	+	+
Merck APF #8 (1 lb./ton)..	+	+	+	+	+	+	+
Soybean oil meal (solvent)	30						
Sunflower seed oil meal S11**.....		35					
Sunflower seed oil meal S12**.....			35				
Sunflower seed oil meal S13**.....				35			
Sunflower seed oil meal S14**.....					35		
Sunflower seed oil meal S15**.....						35	
Sunflower seed oil meal S16**.....							35
Total.....	100	100	100	100	100	100	100
Protein (NX6.25) %.....	22.0	22.1	22.4	22.3	21.3	21.1	21.3
Number of chicks.....	20	19	20	20	20	20	20
Average weight at 24 days (gm.).....	253.7	172.6	160.0	167.9	235.6	240.7	257.6

* See Table 2 for description of vitamin mix.

** See Experimental for description of meals.

S12, and S13 did not grow at as fast a rate as chicks fed the soybean oil meal control ration (Lot 1). Meal S14, which was processed in a manner similar to meal S13 except that the choke on the expeller was opened one and one-half turns, supported a faster rate of growth than meal S13. This might be accounted for on the basis of a decrease in the amount of frictional heat damage produced during expression of the oil. Sunflower seed oil meal S15 (processed at 200° - 220°F.) supported a faster rate of growth than meal S13, and a rate of growth equivalent to that obtained with meal S14. The latter finding indicates that meals of equal nutritive value for chicks may be produced by opening the choke during production of the 240° - 260°F. meal, or by utilizing lower processing temperatures prior to expression of the oil. Chicks fed meal S16 (Lot 7), prepared by utilizing processing temperatures of 200° - 220°F. and opening the choke on the expeller, grew at a rate comparable to that of chicks fed the soybean oil meal control ration (Lot 1).

The results obtained thus indicate that the chemical composition and nutritive value of sunflower seed oil meal is affected by the processing temperatures and choke setting. Meals of superior nutritive value for chicks may be prepared by lowering the processing temperatures and/or opening the choke on the expeller.

Conclusions

- (1) The percentage residual oil in sunflower seed oil meals processed at 200° - 220°F. and 240° - 260°F. was increased by opening the choke on the expeller.
- (2) Sunflower seed oil meal processed at 200° - 220°F. contained more residual oil than did a meal processed at 240° - 260°F.
- (3) Opening the choke on the expeller resulted in the production of sunflower seed oil meals of superior nutritive value to that of meals processed under similar temperature conditions with the choke in the regular position.
- (4) Sunflower seed oil meal of equivalent nutritive value to solvent extracted soybean oil meal may be produced by lowering the processing temperatures and opening the choke on the expeller.

Experiment 3

Object

To study the effects of moist heat on the nutritive value of raw, laboratory solvent extracted, sunflower seed oil meals.

Experimental

Raw, partially decorticated sunflower "meats" were coarsely ground in a plate mill, bagged, and extracted with trichloroethylene in an improvised extractor. After extraction

of the oil, the raw sunflower seed oil meal was air-dried for three days, and stored at 37°C. until used, at which time organoleptic examination failed to detect the presence of trichloroethylene in the meal. Samples of the meal were heated in the autoclave at fifteen pounds steam pressure for the varying periods of time shown in Table 5. Eighty day-old Single Comb White Leghorn cockerel chicks were divided into four lots of twenty chicks each, and fed the rations shown in Table 6. The experimental procedure followed was the same as that used in Experiment 1.

Table 5.- Description of sunflower seed oil meals

Meal Number	Description of Meals
1L	Laboratory solvent extracted
2L	As 1L but heated at fifteen pounds steam pressure for thirty minutes
3L	As 1L but heated at fifteen pounds steam pressure for four hours

Results and Discussion

The average weights of the chicks at twenty-eight days are shown in Table 6. Chicks fed solvent extracted soybean oil meal (Lot 1) grew at a faster rate than chicks fed raw, laboratory solvent extracted, sunflower seed oil meal (Lot 2). This difference might be accounted for by the unexpected higher protein content of Ration 1 as compared to Ration 2. Generally speaking, however, protein levels

Table 6.- Effect of moist heat on the nutritive value of raw, laboratory solvent extracted, sunflower seed oil meals

Ration and Lot Number	1	2	3	4
Ingredients	%	%	%	%
Ground yellow corn.....	39.5	39.5	39.5	39.5
Wheat bran.....	10	10	10	10
Wheat shorts.....	10	10	10	10
Dehydrated alfalfa meal.....	5	5	5	5
Ground limestone.....	2	2	2	2
Bonemeal.....	1.5	1.5	1.5	1.5
Iodized salt.....	.5	.5	.5	.5
Insoluble grit.....	1	1	1	1
Fish oil (2250A-300D).....	.5	.5	.5	.5
Manganese sulfate (1/2 lb./ton).	+	+	+	+
Vitamin mix (2 gm./kg.).....	++	+	+	+
Choline chloride (0.15%).....	+	+	+	+
Vitamin E (3 mg./kg.).....	+	+	+	+
Merck APF#3 (1 lb./ton).....	+	+	+	+
Soybean oil meal (solvent).....	30			
Sunflower seed oil meal 1L**....		30		
Sunflower seed oil meal 2L**....			30	
Sunflower seed oil meal 3L**....				30
Total.....	100	100	100	100
Protein (NX6.25)%.....	22.1	20.4	20.4	20.4
Number of chicks.....	20	20	20	20
Average weight at 28 days (gm.).	255.8	232.5	214.8	110.6

* See Table 2 for description of vitamin mix.

** See Table 5 for description of meals.

in chick starting rations in excess of twenty percent are not considered to be beneficial from the growth promoting point of view.

The results obtained indicate that heating the raw, laboratory solvent extracted, sunflower seed oil meal for thirty minutes at fifteen pounds steam pressure (Lot 3) appeared to decrease the nutritive value of the meal for chicks. Heating the raw meal for four hours at fifteen pounds steam pressure resulted in the production of a meal of decidedly inferior nutritive value for chicks (Lot 4). It is of interest to note that Mitchell, Hamilton, and Beadles (1949) found that autoclaving raw, solvent extracted, sunflower seed oil meals for thirty minutes at twenty pounds steam pressure significantly depressed both the digestibility of the protein and its biological value.

Conclusion

- (1) Heating raw, laboratory solvent extracted, sunflower seed oil meal for thirty minutes at fifteen pounds steam pressure appeared to decrease its nutritive value for chicks, while heating for four hours at this steam pressure resulted in the production of a meal of inferior nutritive value for chicks.

Experiment 4

Object

To study the variability in the composition of sunflower seed oil meals prepared from different raw materials.

Experimental

Four samples of sunflower "meats" were obtained from different sources. Sample 1 was identical to that used in a preliminary study on variability in the nutritive value of sunflower seed oil meals (Crawford, 1950). Sample 2 consisted of raw material brought in from Manitoba in the spring of 1950. Sample 3 was obtained from Chicago in 1950, while sample 4 consisted of raw material procured at the same time as the meals used in Experiment 2 (January, 1952). Samples 1, 2 and 3 were kept in cold storage from time of purchase until used in this study.

Small amounts of each sample were coarsely ground in a plate mill and extracted with trichloroethylene. The method of extraction followed was the same as that used in Experiment 3. After extraction, the raw sunflower seed oil meals (designated as 1R, 2R, 3R, and 4R) were air-dried for three days, and stored at 37°C. until used, at which time no odor of trichloroethylene could be detected in any of the meals. Samples of the meals were analyzed for percentage crude protein, oil, moisture, and crude fibre, using the methods referred to in Experiment 2.

In addition, using the microbiological technique, a study was made of the liberation of essential amino acids (glycine excluded) from the meals by acid hydrolysis (alkaline hydrolysis in the case of tryptophan). The hydrolysis procedures, test organisms, and basal media employed were the same as those used by Clandinin (1949).

Results and Discussion

The composition of the raw sunflower seed oil meals is shown in Table 7. Meals 1R, 2R, and 3R contained

Table 7.- Composition of raw sunflower seed oil meals

Meal Number	Crude Protein (NX6.25) %	Moisture %	Oil %	Crude Fibre %
1R	47.1	7.2	1.2	13.9
2R	47.3	7.1	1.5	13.5
3R	47.7	6.8	2.0	8.2
4R	38.0	6.9	1.3	16.6

approximately the same amount of protein. On the other hand, meal 4R contained nearly ten percent less protein than the other three meals. There were no marked differences in the moisture and oil content of the four meals.

Considerable variation in the crude fibre content of the meals was observed. Meals 1R and 2R contained approximately the same amount of crude fibre. Meal 3R contained much less crude fibre than the other three meals, while meal 4R contained a very high level of crude fibre.

The results of the amino acid assays are shown in Table 8. The figures represent averages of two assays in

duplicate, and are expressed as percentage amino acid of nitrogen X 6.25. Results of an analysis of variance indicated that significant differences exist in the methionine, lysine, and arginine content of the meals.

Table 8.- Essential amino acid content* of raw sunflower seed oil meals

Meal Number**	1R	2R	3R	4R
Lysine	2.57	2.66	2.89	2.89
Arginine	8.81	8.83	8.45	8.97
Tryptophan	8.30	1.05	1.19	1.14
Methionine	1.63	1.61	1.47	1.39
Histidine	2.09	2.09	1.85	1.84
Threonine	3.31	3.55	3.40	3.64
Leucine	5.48	5.54	5.57	5.35
Isoleucine	3.73	3.84	3.69	3.69
Valine	3.59	3.63	3.54	3.36
Phenylalanine	4.13	4.18	4.10	3.96
Total	36.64	36.98	36.15	36.23

* Expressed as percentage amino acid of nitrogen X 6.25.

** See Experimental for description of meals.

In this connection, it is of interest to note that Kuiken and Lyman (1949) found differences of up to nineteen percent in the methionine content of twenty different strains of soybeans, although, in general, the amino acid

distribution in the protein was quite uniform between strains. A more detailed study of the variation in the amino acid composition of different varieties and strains of sunflower seeds grown under the same and different conditions would seem advisable.

Almquist (1947) reported that the lysine and methionine requirements of the chick are 0.9 percent and 0.5 percent of the diet, respectively. On the basis of amino acid values obtained in this study, it would therefore appear that raw sunflower seed oil meal, when fed at the twenty percent protein level, does not contain sufficient lysine and methionine to meet the requirements of the chick.

Conclusions

- (1) Considerable variation in the protein and crude fibre content of four sunflower seed oil meals prepared from different raw materials was observed.
- (2) A significant difference in the methionine, lysine, and arginine content of the meals was noted.
- (3) Results of amino acid assays appeared to indicate that, when fed at the twenty percent protein level, raw sunflower seed oil meal would not supply sufficient lysine or methionine to meet the requirements of the chick.

Experiment 5

Object

To determine the level of vitamin-free casein, in the presence of 0.4 percent DL-methionine, required to

adequately supplement a low-temperature sunflower seed oil meal (S1), a regular-temperature sunflower seed oil meal (S3), and a severely overheated sunflower seed oil meal (S4).

Experimental

Three hundred and twenty day-old Single Comb White Leghorn chicks (one hundred and sixty of each sex) were divided into sixteen comparable lots of twenty chicks each and fed the semi-purified rations shown in Table 9. The dextrin used was prepared by autoclaving moistened corn starch for eighty minutes at fifteen pounds steam pressure. After drying, the material was ground to a granular consistency in a plate mill. Vitamin additions were the same as those used in Experiment 1 except that Merck APF #3 was used as a source of vitamin B₁₂ instead of Merck APF #8.

Sunflower seed oil meals S1, S3, and S4, used in Experiment 1, served as the only source of protein in the rations. Since casein has been shown to be slightly deficient in sulphur-containing amino acids (Mitchell, 1924), 0.4 percent DL-methionine was included in rations where vitamin free casein was added. Additions of casein to the rations were made at the expense of dextrin. The experimental procedure followed was the same as that used in Experiment 1. The chicks were weighed in groups at weekly intervals. The experiment was terminated after twenty-one days, when the chicks were weighed individually.

Table 9.- Effect of casein - methionine supplementation on the nutritive value of sunflower seed oil meals

Ration and Lot Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ingredients	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Dextrin.....	47.5	47.5	44.1	41.1	38.1	35.1	49.25	45.85	42.85	39.85	36.85	47.50	44.10	41.10	38.10	35.10
Corn (mazola) oil.....	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Salts V*.....	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Fish oil (2250A-300D).....	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Vitamin mix (2 gm./kg.)...	+**	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Choline chloride (0.15%)..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Vitamin E (3 mg./kg.).....	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Merck APF #3 (1 lb./ton)...	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
DL - Methionine.....	0	0	.4	.4	.4	.4	0	.4	.4	.4	.4	0	.4	.4	.4	.4
Casein (vitamin-test).....	0	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
Sunflower seed oil meal S1***.....	43	43	43	43	43	43										
Sunflower seed oil meal S3***.....							41.25	41.25	41.25	41.25	41.25					
Sunflower seed oil meal S4***.....												43	43	43	43	43
Total.....	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Protein (calculated) %....	20.7						20.7					20.7				
Number of chicks.....	20	20	18	19	20	20	20	20	20	20	20	20	18	20	20	17
Average weight at 21 days (gm.).....	132.8	135.7	170.5	187.8	190.8	193.2	93.0	142.1	177.8	185.9	180.4	48.9	73.2	125.0	166.4	193.5

* Briggs et al. (1943)

** See Table 2 for description of vitamin mix.

*** See Experiment 1 for description of meals.

Results and Discussion

The average weights of the chicks at twenty-one days are shown in Table 9. It is evident that rations containing low-temperature sunflower seed oil meal (S1) were improved for chick growth by the addition of casein and methionine. The optimum level of supplementation appeared to be reached when six percent vitamin-free casein and 0.4 percent DL-methionine were added to the ration (Lot 4).

Chicks fed a ration containing regular-temperature sunflower seed oil meal (S3) as the only source of protein in the ration (Lot 7) did not grow as fast as the chicks fed low-temperature meal (Lots 1 or 2). These results are in agreement with those obtained in Experiment 1, and indicate the inferior nutritive value of regular -temperature sunflower seed oil meal for chicks, as compared to low-temperature sunflower seed oil meal. Rations containing regular-temperature sunflower seed oil meal were improved by supplementation with vitamin-free casein and methionine. The chicks in Lot 9 grew as fast as those in Lots 10 or 11, indicating that the optimum level of supplementation was reached when six percent vitamin-free casein and 0.4 percent DL-methionine were added to the ration. Thus, it would appear that neither low-temperature sunflower seed oil meal nor regular-temperature sunflower seed oil meal constitutes a complete source of amino acids for the chick when fed at the

twenty percent protein level. These results are at variance with those reported by Grau and Almquist (1945).

In agreement with the results obtained in Experiment 1, chicks receiving a ration which contained sunflower seed oil meal S4, (Lot 12) grew very slowly. Equivalent growth response to that obtained from rations 4 or 9 occurred when sunflower seed oil meal S4 was supplemented with twelve percent vitamin-free casein and 0.4 percent DL-methionine. In this connection, it is of interest to recall that Clandinin et al. (1947) found that heating solvent extracted raw soybean flakes in the autoclave for four hours at fifteen pounds steam pressure resulted in the production of a meal of inferior nutritive value for chicks, and that it required the addition of seven and one-half percent casein to a ration containing four-hour overheated soybean oil meal to restore a normal growth rate. The difference between the amount of casein required to restore normal growth in four-hour overheated soybean oil meal and that required to complete four-hour overheated sunflower seed oil meal is probably accounted for by the inherent deficiencies present in low-temperature sunflower seed oil meal, which are not present in properly heated soybean oil meal.

Determination of the amino acid deficiencies in low-temperature, regular-temperature, and severely overheated sunflower seed oil meal awaits the results of further studies.

Conclusions

- (1) Low-temperature sunflower seed oil meal and regular-temperature sunflower seed oil meal do not constitute a complete source of amino acids for the chick, when fed at the twenty percent protein level.
- (2) The optimum level of supplementation of regular-temperature sunflower seed oil meal appeared to be reached when at least six percent vitamin-free casein in conjunction with 0.4 percent DL-methionine was added to the ration. In the presence of 0.4 percent DL-methionine, a level of vitamin-free casein approaching six percent of the ration was required to supplement low-temperature sunflower seed oil meal.
- (3) Sunflower seed oil meal S4 (prepared by autoclaving sunflower seed oil meal S1 for four hours at fifteen pounds steam pressure) was of inferior nutritive value for chicks. The optimum level of supplementation of this meal appeared to be reached when twelve percent vitamin-free casein in the presence of 0.4 percent DL-methionine was added to the ration.

Experiment 6

Object

To determine the essential amino acid content (glycine excluded) of sunflower seed oil meals S1, S2, S3, and S4.

Experimental

A study was made of the liberation of essential amino acids (glycine excluded) from the meals by acid (alkaline hydrolysis in the case of tryptophan) and enzymatic hydrolysis. The hydrolysis procedures, test organisms, and basal media employed were the same as those used by Clandinin (1949).

Results and Discussion

The results of the amino acid determinations are summarized in Table 10. The results, expressed as percentage amino acid of nitrogen X 6.25, were calculated from the averages of two assays in duplicate. With the exception of lysine, the data show little difference in the liberation of essential amino acids subsequent to acid (alkaline hydrolysis for tryptophan) hydrolysis of meals S1, S2, and S3. Indirectly, the data suggest that rations containing meals S1 or S2 as the only source of supplementary protein would be marginal in lysine content for the chick. Hence, the slower rate of growth of chicks fed meal S3 as compared

to those fed meals S1 and S2 (See Experiment 1) may be the result of the slight destruction of lysine during the processing of meal S3.

While on the basis of growth results, (see Experiments 1 and 5), one might expect an appreciable decrease in the liberation of essential amino acids subsequent to acid hydrolysis of meal S4 (alkaline hydrolysis for tryptophan), such was not the case. Only depressed liberation of lysine, arginine, tryptophan, and possibly threonine was noted.

Table 10.- Essential amino acid content* of sunflower seed oil meals

Hydrolysis Meal Number***	Acid**				Enzymatic			
	S1	S2	S3	S4	S1	S2	S3	S4
Lysine	2.81	2.71	2.26	1.87	0.68	1.47	1.33	0.71
Arginine	8.26	8.03	8.02	6.43	6.22	8.20	8.64	6.13
Tryptophan	0.86	0.97	0.89	0.64	0.44	0.73	0.85	0.82
Methionine	1.33	1.34	1.32	1.49	0.91	1.22	1.42	1.15
Histidine	2.14	2.08	2.00	2.20	1.24	1.70	2.15	1.69
Threonine	3.30	3.10	3.11	2.99	2.02	2.72	2.70	2.18
Leucine	5.87	5.77	5.82	6.32	2.43	4.12	4.85	4.19
Isoleucine	3.81	3.73	3.69	3.86	1.78	2.56	3.00	2.73
Valine	4.76	4.61	4.57	4.87	1.69	2.89	3.39	3.07
Phenylalanine	3.94	3.94	3.97	4.11	1.67	3.02	3.47	3.22
Total	37.08	36.28	35.65	34.78	19.08	28.63	31.80	25.89

* Expressed as percentage amino acid of nitrogen X 6.25.

** Alkaline hydrolysis for tryptophan.

*** See Table 1 for description of meals.

There appears to be no relationship between the liberation of essential amino acids subsequent to enzymatic hydrolysis of meals S1, S2, S3 and S4 and their nutritive value. The results show greater liberation of essential amino acids from meal S3 than from meal S1, although meal S1 is unquestionably of superior nutritive value to meal S3. In addition, although sunflower seed oil meal S4 is of inferior nutritive value for chicks, the liberation of essential amino acids subsequent to enzymatic hydrolysis of meal S4 is as great as the liberation from meal S1. Thus, the data do not support the contention of Ingram et al. (1949) that enzymatic hydrolysis values constitute a reliable index of the nutritive value of a protein supplement. Although Clandinin and Robblee (1952) found that under a given set of conditions, maximum enzymatic liberation values characterize a superior soybean oil meal, such is evidently not the case so far as sunflower seed oil meal is concerned.

Conclusions

- (1) Processing temperatures of 240° - 260°F. (meal S3) resulted in a decrease in the liberation of lysine by acid hydrolysis as compared to the liberation of lysine from similar meals processed at 200° - 220°F. (meal S1) or 220° - 240°F. (meal S2).
- (2) Autoclaving meal S1 for four hours at fifteen pounds steam pressure resulted in depressed liberation by acid hydrolysis of lysine, arginine, tryptophan, and possibly threonine.

- (3) There was no relationship between the liberation of essential amino acids (glycine excluded) subsequent to enzymatic hydrolysis and the nutritive value of the sunflower seed oil meals used.

Experiment 7

Object

To study the effects of water treatment on the nutritive value of low-temperature and regular-temperature sunflower seed oil meal.

Experiment

Sunflower seed oil meals S1 and S3, used in Experiment 1, were used in this experiment. Samples of the meals were treated with water, using a method similar to that shown to markedly improve the nutritive value of linseed oil meal for chicks (McGinnis and Polis, 1946; Kratzer, 1947). Portions of the meals were mixed with two and one-half times their weight of water, soaked at room temperature for eighteen hours, dried at 60°C. for three days, and incorporated in the rations shown in Table 11. Twenty day-old Single Comb White Leghorn cockerel chicks were fed each ration. The experimental procedure followed was the same as that used in Experiment 1. The experiment was terminated at the end of twenty-two days, at which time the chicks were weighed individually.

Table 11.- Effect of water treatment on the nutritive value of sunflower seed oil meals

Ration and Lot Number	1	2	3	4	5
Ingredients	%	%	%	%	%
Ground yellow corn.....	39.5	39.5	39.5	39.5	39.5
Wheat bran.....	10	10	10	10	10
Wheat middlings.....	10	10	10	10	10
Dehydrated alfalfa meal.....	5	5	5	5	5
Ground limestone.....	2	2	2	2	2
Bonemeal.....	1.5	1.5	1.5	1.5	1.5
Iodized salt.....	.5	.5	.5	.5	.5
Insoluble grit.....	1	1	1	1	1
Fish oil (2250A-300D).....	.5	.5	.5	.5	.5
Manganese sulfate (1/4 lb./ton)	+	+	+	+	+
Vitamin mix (2 gm./kg.).....	+	+	+	+	+
Merck APF #8 (1 lb./ton).....	+	+	+	+	+
Choline chloride (0.15%).....	+	+	+	+	+
Vitamin E (3 mg./kg.).....	+	+	+	+	+
Soybean oil meal (solvent)....	30				
Sunflower seed oil meal S1**..		30			
Sunflower seed oil meal S3**..			30		
Sunflower seed oil meal S1 water treated***.....				30	
Sunflower seed oil meal S3 water treated***.....					30
Total.....	100	100	100	100	100
Protein (NX6.25) %.....	22.1	22.0	22.0	22.0	22.0
Number of chicks.....	17	19	19	20	19
Average weight at 22 days (gm.)	221.8	221.3	187.2	222.5	172.7

* See Table 2 for description of vitamin mix.

** See Table 1 for description of meals.

*** See Experimental.

Results and Discussion

The average weights of the chicks are shown in Table 11. Under the conditions of the experiment, chicks fed sunflower seed oil meal S1 (Lot 2) grew as rapidly as chicks fed the soybean oil meal control ration (Lot 1). These results appear to be at variance with those obtained in Experiment 1. However, the percentage protein in the rations used in this experiment was higher than in the rations used in Experiment 1, and the rations used in the two experiments were not identical in composition. In agreement with the results obtained in Experiment 1, the growth of chicks fed sunflower seed oil meal S3 (Lot 3) was less than that of chicks fed meal S1 (Lot 2).

Chicks fed water treated sunflower seed oil meals (Lots 4 and 5) grew at the same rate as chicks receiving the untreated meals (Lots 2 and 3). Hence, the water treatment used had no effect on the nutritive value of either low-temperature sunflower seed oil meal (S1) or regular-temperature sunflower seed oil meal (S3). Thus, it would appear that unlike linseed oil meal, sunflower seed oil meal does not contain a growth inhibiting principle which may be inactivated by water treatment.

Conclusion

- (1) Water treatment had no effect on the nutritive value of low-temperature and regular-temperature sunflower seed oil meal.

Experiment 8

Object

To study the effects of extraction with trichloroethylene and ethanol on the nutritive value of regular-temperature sunflower seed oil meal.

Experimental

Portions of regular-temperature sunflower seed oil meal (S3) were bagged and extracted in a soxhlet flask with trichloroethylene (meal E1) or 95 percent ethanol (meal E3). The extraction time was twenty-four hours. After extraction, the meals were air-dried for three days, and stored at 37°C. until used, at which time no odor of trichloroethylene or ethanol could be detected in the meals. The extracts were stripped of trichloroethylene and ethanol and stored in the refrigerator until used. In the preparation of meal E2, the trichloroethylene extract was added back to a portion of meal E1 at twice the level originally present in the unextracted meal. Meal E4 was prepared in a similar manner by adding the ethanol extract back to a portion of meal E3 at twice the level originally present in the unextracted meal.

One hundred and forty day-old Single Comb White Leghorn chicks (mixed sexes) were divided into seven comparable groups of twenty chicks each and fed the rations shown in Table 12. The experimental procedure followed was the same as that used in Experiment 1. The experiment was terminated after twenty-four days, at which time the chicks were weighed individually.

Table 12.- Effect of extraction with trichloroethylene and ethanol on the nutritive value of regular-temperature sunflower seed oil meal

Ration and Lot Number	1	2	3	4	5	6	7
Ingredients	%	%	%	%	%	%	%
Ground yellow corn.....	59.5	63.5	63.5	63.5	63.5	63.5	63.5
Dehydrated alfalfa meal...	3	3	3	3	3	3	3
Ground limestone.....	2	2	2	2	2	2	2
Bonemeal.....	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Iodized salt.....	.5	.5	.5	.5	.5	.5	.5
Insoluble grit.....	1	1	1	1	1	1	1
Fish oil (2250A-300D).....	.5	.5	.5	.5	.5	.5	.5
Manganese sulfate (1/4 lb./ton).....	+	+	+	+	+	+	+
Vitamin mix (2 gm./kg.)...	++	+	+	+	+	+	+
Merck APF #8 (1 lb./ton)...	+	+	+	+	+	+	+
Soybean oil meal (solvent)	32						
Sunflower seed oil meal S1**		28					
Sunflower seed oil meal S3**			28				
Sunflower seed oil meal E1**				28			
Sunflower seed oil meal E2**					28		
Sunflower seed oil meal E3**						28	
Sunflower seed oil meal E4**							28
Total.....	100	100	100	100	100	100	100
Protein (NX6.25) %.....	20.7	20.7	20.1	20.8	20.1	21.1	19.7
Number of chicks.....	20	19	20	20	20	20	19
Average weight at 24 days (gm.).....	190.7	150.3	107.3	126.0	83.5	129.6	115.2

* See Table 2 for description of vitamin mix.

** See Experimental for description of meals.

Results and Discussion

The results of the experiment are shown in Table 12. In agreement with the results obtained in Experiment 1, chicks fed the soybean oil meal control ration (Lot 1) grew at a faster rate than those fed the sunflower seed oil meal rations (Lots 2 - 7). The chicks receiving sunflower seed oil meal S3 (Lot 3) grew at a slower rate than those receiving sunflower seed oil meal S1, (Lot 2) again demonstrating the inferior nutritive value of regular-temperature sunflower seed oil meal.

The increased rate of growth of the chicks in Lots 4 and 6, as compared to those in Lot 3, indicates that extraction of sunflower seed oil meal S3 with trichloroethylene or ninety-five percent ethanol resulted in an increase in the nutritive value of the meal for chicks.

Adding the trichloroethylene extract back to the extracted meal at twice the level originally present resulted in a depressed rate of growth of the chicks in Lot 5, as compared to those in Lots 3 or 4. The chicks in Lot 7, however, appeared to grow as fast as those in Lot 6, indicating that the ethanol extract did not contain any growth inhibiting factor(s).

The results suggest, though not conclusively, the presence of a growth-inhibiting principle in regular-temperature sunflower seed oil meal which may be extracted

by trichloroethylene. The possibility that residual trichloroethylene caused the depressed growth observed in Lot 5 seems slight, since the analytical method outlined by Sallee (1952) indicated a level of less than .01 percent trichloroethylene in the extract.

Conclusions

- (1) Extraction of regular-temperature sunflower seed oil meal with trichloroethylene or ninety-five percent ethanol increased the nutritive value of the meal for chicks.
- (2) Adding the trichloroethylene extract back to the extracted meal at twice the level originally present depressed the growth of chicks.

PART II

The Supplementary Value of Sunflower Seed Oil Meal in
Practical Chick Starting RationsStatus of the Problem

Comparatively few references on the nutritive value of sunflower seed oil meal for chicks are to be found in the literature. Pettit et al. (1944) reported the results of experiments in which meat meal in chick starting rations was replaced by sunflower seed oil meal. Sunflower seed oil meal satisfactorily replaced its protein equivalent of meat meal in amounts up to fourteen percent of the ration, representing a total substitution of the meat meal. Grau and Almquist (1945) concluded that when fed at the twenty percent level, sunflower seed protein constitutes a complete single source of amino acids for the chick. Kondra and Hodgson (1948) observed that a chick starter containing two percent sunflower seed oil meal, seven and one-half percent meat meal, two percent fish meal, and two percent skimmilk powder supported a normal rate of growth in chicks to seven weeks of age. Replacement of the skimmilk powder, fish meal, and half of the meat meal by ten percent sunflower seed oil meal, resulted in a slow rate of growth. McGinnis, Hsu, and Carver (1948) reported that the nutritive value of a chick starting ration containing thirty-one percent sunflower seed oil meal was improved by the addition of

0.6 percent DL-lysine monohydrochloride. Nikolaiczuk, Brisson, and Mani (1948) concluded that sunflower seed oil meal provides an incomplete protein for the growth of chicks, since its nutritive value was improved by the amino acid assortment of meat meal. O'Neil (1948) found sunflower seed oil meal satisfactorily replaced one-third of the total animal protein in a chick starting ration. Gartley, Slinger, and Hill (1950) reported that growth and feed efficiency of turkey poults were not affected when soybean oil meal was progressively replaced by sunflower seed oil meal in levels up to twelve percent of the ration.

In view of the scarcity of information concerning the nutritional value of sunflower seed oil meal in practical chick starting rations, experiments were initiated to study the supplementary value of sunflower seed oil meal in practical chick starters.

Experimental (General)

Two sunflower seed oil meals (meals S1 and S3) that differed in their processing history (see Part I, Experiment 1) were used in the experiments reported herein. Meal S3 was produced in a commercial processing plant, using regular processing temperatures of 240° - 260°F. and was shown to be of inferior nutritive value to meal S1, which was produced in the same plant using considerably lower processing temperatures (200° - 220°F.).

Two hundred and thirty-eight day-old New Hampshire chicks (mixed sexes), divided into seven comparable lots of thirty-four chicks were used in each experiment. The chicks were brooded in electrically heated starting batteries with raised screen floors. Feed and water were supplied ad libitum. The experiments were terminated after twenty-eight days, at which time the chicks were weighed individually.

The rations used in each experiment were formulated so as to contain the same levels of protein, calcium, and phosphorus. Percentage adjustments were made at the expense of wheat.

The experiments were repeated using Single Comb White Leghorn chicks, but since the results obtained were essentially the same as those found with the New Hampshire chicks, the data are not presented in this report.

Experiment 1

Object

To determine the effect on chick growth of replacing the meat meal and fish meal in a practical chick starter with low-temperature or regular-temperature sunflower seed oil meal (meal S1 or S3 respectively).

Experimental

The rations used in the experiment are shown in Table 13. Fish meal and meat meal, in the proportion of one part of fish meal to two parts of meat meal supplied the supplementary protein in the basal ration (Lot 1). In the various treatments, successive two percent portions of fish meal and four percent portions of meat meal were replaced by either sunflower seed oil meal S1 (Lots 2-4) or sunflower seed oil meal S3 (Lots 5-7).

Results and Discussion

The average weights of the chicks at twenty-eight days are shown in Table 13. Chicks fed rations in which one-third of the fish meal and meat meal (two percent fish meal and four percent meat meal) was replaced by either sunflower seed oil meal S1 (Lot 2) or sunflower seed oil meal S3 (Lot 5) grew at a faster rate than chicks fed the basal ration (Lot 1). This finding might be explained on the basis of the supplementary action of different proteins.

Replacement of two-thirds of the fish meal and meat meal by low-temperature (200° - 220°F.) sunflower seed oil meal (Lot 3) did not appear to adversely affect chick growth. However, replacement of two-thirds of the fish meal and meat meal by regular temperature (240° - 260°F.) sunflower seed oil meal (Lot 6) resulted in the production of a ration which supported a slower rate of growth.

Replacement of all of the fish meal and meat meal by sunflower seed oil meal S1 resulted in a decrease in the nutritive value of the ration for chicks (Lot 4). Similarly, chicks fed a ration in which all of the fish meal and meat meal was replaced by sunflower seed oil meal S3 (Lot 7) did not grow as fast as chicks fed the basal ration.

Chicks fed ration 4 grew at a faster rate than chicks fed ration 7, indicating the inferior nutritive value of regular-temperature sunflower seed oil meal, as compared to low-temperature sunflower seed oil meal.

On the basis of the results obtained, it would not appear advisable to replace with regular-temperature sunflower seed oil meal more than one-third of the fish meal and meat meal in a chick starter of the type used in this study.

Conclusions

- (1) Chicks fed a practical chick starter in which one-third of the fish meal and meat meal was replaced by low-temperature sunflower seed oil meal or regular-temperature sunflower seed oil meal grew at a faster rate than chicks fed the unaltered ration.
- (2) Low-temperature sunflower seed oil meal satisfactorily replaced up to two-thirds of the fish meal and meat meal in the practical chick starter used. Replacement of two-thirds of the fish meal and meat meal by regular-temperature sunflower seed oil meal resulted in a decrease in the nutritive value of the ration.

Table 13.- Replacement of fish meal and meat meal in a practical chick starter by sunflower seed oil meals S1 and S3

Ration and Lot Number	1	2	3	4	5	6	7
Ingredients	%	%	%	%	%	%	%
Ground wheat.....	30.25	27.25	23.75	20.25	27.25	23.75	20.25
Ground oats.....	10	10	10	10	10	10	10
Ground barley.....	10	10	10	10	10	10	10
Ground corn.....	25	25	25	25	25	25	25
Fish meal (76% protein).....	6	4	2	0	4	2	0
Meat meal (55% protein).....	12	8	4	0	8	4	0
Sunflower seed oil meal S1*.....		8	16	24			
Sunflower seed oil meal S3*.....					8	16	24
Alfalfa meal.....	4	4	4	4	4	4	4
Bonemeal.....	0	1	2.5	3.5	1	2.5	3.5
Ground limestone....	1.5	1.5	1.5	2	1.5	1.5	2
Iodized salt.....	.5	.5	.5	.5	.5	.5	.5
Fish oil (2250A-300D)	.25	.25	.25	.25	.25	.25	.25
Manganese sulfate (1/4 lb./ton).....	+	+	+	+	+	+	+
Riboflavin premix**.	.5	.5	.5	.5	.5	.5	.5
Merck APF #8 (1 lb./ ton).....	+	+	+	+	+	+	+
Total.....	100	100	100	100	100	100	100
Protein (NX6.25)%...	20.0	19.7	19.8	20.1	20.0	20.3	20.5
Number of chicks....	33	34	33	31	34	32	33
Average weight at 28 days (gm.)....	298.5	324.3	291.0	255.8	320.3	240.7	188.9

* See Experimental (General) for description of meals.

** Contained one gram riboflavin per ten pounds wheat middlings.

- (3) Low-temperature sunflower seed oil meal was of superior supplementary and nutritive value to regular-temperature sunflower seed oil meal.

Experiment 2

Object

To determine the effect on chick growth of replacing the meat meal in a practical chick starter containing two and one-half percent fish meal with low-temperature or regular-temperature sunflower seed oil meal (meal S1 or S3, respectively).

Experimental

The rations used in this experiment (Table 14) were designed to show the effect on chick growth of replacement of successive six percent portions of meat meal by low-temperature sunflower seed oil meal (Lots 2 - 4) or by regular-temperature sunflower seed oil meal (Lots 5 - 7). Two and one-half percent fish meal was included in each ration.

Results and Discussion

The average weights of the chicks at twenty-eight days are shown in Table 14. Chicks fed a ration in which one-third of the meat meal was replaced by sunflower seed oil meal S1 (Lot 2), appeared to grow at a faster rate than chicks fed the basal ration (Lot 1). Replacement of two-thirds or all of the meat meal in the basal ration with sunflower seed oil meal S1 did not decrease the nutritive value of the ration (Lots 3 and 4, respectively). Chicks fed a ration in which one-third of the

Table 14.- Replacement of meat meal in a practical chick starter by sunflower seed oil meals S1 and S3

Ration and Lot Number	1	2	3	4	5	6	7
Ingredients	%	%	%	%	%	%	%
Ground wheat.....	28.25	25.25	22.25	19.25	25.25	22.25	19.25
Ground oats.....	10	10	10	10	10	10	10
Ground barley.....	10	10	10	10	10	10	10
Ground corn.....	25	25	25	25	25	25	25
Fish meal..... (76% protein)	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Meat meal..... (55% protein)	18	12	6	0	12	6	0
Sunflower seed oil meal S1*.....		7	14	21			
Sunflower seed oil meal S3*.....					7	14	21
Alfalfa meal.....	4	4	4	4	4	4	4
Iodized salt.....	.5	.5	.5	.5	.5	.5	.5
Fish oil (2250A-300D)	.25	.25	.25	.25	.25	.25	.25
Ground limestone....	1	1	1	1	1	1	1
Bonemeal.....		2	4	6	2	4	6
Manganese sulfate (1/4 lb./ton).....	+	+	+	+	+	+	+
Riboflavin premix**.	.5	.5	.5	.5	.5	.5	.5
Merck APF #8 (1 lb./ton).....	+	+	+	+	+	+	+
Total.....	100	100	100	100	100	100	100
Protein (NX6.25)%...	21.6	20.8	20.3	20.4	20.7	20.4	20.6
Number of chicks....	31	31	33	32	32	31	31
Average weight at 28 days (gm.).....	306.6	323.7	316.6	300.6	306.1	279.8	278.0

* See Experimental (General) for description of meals.

** Contained one gram riboflavin per ten pounds wheat middlings.

meat meal was replaced with sunflower seed oil meal S₃ (Lot 5) grew at as fast a rate as chicks receiving the basal ration. However, replacement of two-thirds or all of the meat meal by sunflower seed oil meal S₃ decreased the nutritive value of the ration for chicks (Lots 6 and 7, respectively).

The results of this experiment would appear to indicate that in the presence of two and one-half percent fish meal, regular-temperature sunflower seed oil meal may satisfactorily replace up to one-third of the meat meal in a practical chick starter of the type used in this study.

Conclusions

- (1) Low-temperature sunflower seed oil meal satisfactorily replaced all of the meat meal in a practical chick starter containing two and one-half percent fish meal.
- (2) Regular-temperature sunflower seed oil meal replaced up to one-third of the meat meal in a practical chick starter containing two and one-half percent fish meal. Replacement of two-thirds or all of the meat meal by regular-temperature sunflower seed oil meal, however, resulted in a decrease in the nutritive value of the ration for chicks.

Experiment 3

Object

To determine the effect on chick growth of replacing the soybean oil meal in a practical chick starter containing two and one-half percent fish meal with low-temperature or regular-temperature sunflower seed oil meal (meal S1 or S3, respectively).

Experimental

The rations fed are shown in Table 15 and were formulated in such a way as to show the effect on chick growth of replacement of successive seven percent portions of soybean oil meal by either sunflower seed oil meal S1 (Lots 2 - 4) or sunflower seed oil meal S3 (Lots 5 - 7). Two and one-half percent fish meal was included in each ration.

Results and Discussion

The results of the experiment are shown in Table 15. Chicks fed rations in which up to two-thirds of the soybean oil meal was replaced by either sunflower seed oil meal S1 or sunflower seed oil meal S3 (Lots 2 and 3, and 5 and 6, respectively), grew as fast as chicks fed the basal ration (Lot 1). Replacement of all of the soybean oil meal by sunflower seed oil meal S1 or S3 (Lots 4 and 7) decreased the nutritive value of the ration for chicks. These results are at variance with those reported by Nikolaiczuk, Brisson, and Mani (1948) who found that sunflower seed oil meal is

Table 15.- Replacement of soybean oil meal in a practical chick starter by sunflower seed oil meals S1 and S3

Ration and Lot Number	1	2	3	4	5	6	7
Ingredients	%	%	%	%	%	%	%
Ground wheat.....	27.75	27.75	27.75	27.75	27.75	27.75	27.75
Ground oats.....	10	10	10	10	10	10	10
Ground barley.....	10	10	10	10	10	10	10
Ground corn.....	20	20	20	20	20	20	20
Fish meal (76% protein).....	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Soybean oil meal (solvent).....	21	14	7		14	7	
Sunflower seed oil meal S1*.....		7	14	21			
Sunflower seed oil meal S3*.....					7	14	21
Alfalfa meal.....	4	4	4	4	4	4	4
Iodized salt.....	.5	.5	.5	.5	.5	.5	.5
Fish oil (2250A-300D)	.25	.25	.25	.25	.25	.25	.25
Ground limestone....	2	2	2	2	2	2	2
Bonemeal.....	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Riboflavin premix**.	.5	.5	.5	.5	.5	.5	.5
Manganese sulfate (1/4 lb./ton).....	+	+	+	+	+	+	+
Merck APF #8 (1 lb./ton).....	+	+	+	+	+	+	+
Total.....	100	100	100	100	100	100	100
Protein (NX6.25)%...	20.2	19.7	20.0	20.0	20.4	19.9	19.9
Number of chicks....	32	33	29	31	31	31	31
Average weight at 28 days (gm.).....	325.0	320.0	332.0	305.9	339.8	316.9	276.0

* See Experimental (General) for description of meals.

** Contained one gram riboflavin per ten pounds wheat middlings.

superior to soybean oil meal as a source of protein for the chick. On the other hand, Gartley, Slinger, and Hill (1950) reported that the growth of turkey poultts was adversely affected when twenty-eight percent sunflower seed oil meal completely replaced soybean oil meal in a turkey starting ration.

Conclusion

- (1) Low-temperature sunflower seed oil meal or regular-temperature sunflower seed oil meal satisfactorily replaced up to two-thirds of the soybean oil meal in a practical chick starter ration containing two and one-half percent fish meal.

Experiment 4

Object

To study the replacement value of low-temperature and regular-temperature sunflower seed oil meals (meals S1 and S3) in a practical chick starting ration containing meat meal as the only protein supplement.

Experimental

The rations fed in the experiment are shown in Table 16. They were similar to those used in Experiment 2, except that no fish meal was included in the rations and successive seven percent increments of meat meal were replaced with sunflower seed oil meal S1 (Lots 2 - 4) or sunflower seed oil meal S3 (Lots 5 - 7).

Table 16.- Replacement of meat meal in a practical chick starter by sunflower seed oil meals S1 and S3

Ration and Lot Number	1	2	3	4	5	6	7
Ingredients	%	%	%	%	%	%	%
Ground wheat.....	27.75	23.92	20.09	16.25	23.92	20.09	16.25
Ground oats.....	10	10	10	10	10	10	10
Ground barley.....	10	10	10	10	10	10	10
Ground corn.....	25	25	25	25	25	25	25
Meat meal (55% protein).....	21	14	7		14	7	
Sunflower seed oil meal S1*.....		8.5	17	25.5			
Sunflower seed oil meal S3*.....					8.5	17	25.5
Alfalfa meal.....	4	4	4	4	4	4	4
Iodized salt.....	.5	.5	.5	.5	.5	.5	.5
Fish oil (2250A-300D)	.25	.25	.25	.25	.25	.25	.25
Ground limestone....	1	1	1	1	1	1	1
Bonemeal.....		2.33	4.66	7	2.33	4.66	7
Riboflavin premix**.	.5	.5	.5	.5	.5	.5	.5
Manganese sulfate (1/2 lb./ton).....	+	+	+	+	+	+	+
Merck APF #8 (1 lb./ton).....	+	+	+	+	+	+	+
Total.....	100	100	100	100	100	100	100
Protein (NX6.25)%...	19.2	19.2	19.3	19.9	19.3	19.8	19.8
Number of chicks....	33	32	31	34	33	31	34
Average weight at 28 days (gm.).....	169.4	203.6	226.5	228.0	198.9	195.6	171.1

* See Experimental (General) for description of meals.

** Contained one gram riboflavin per ten pounds wheat middlings.

Results and Discussion

The average weights of the chicks at twenty-eight days are shown in Table 16. The plane of nutrition in this experiment was lower than in Experiment 2, possibly because of omission of the two and one-half percent fish meal from the rations. Chicks fed rations in which successive seven percent increments of meat meal were replaced with sunflower seed oil meal S1 (Lots 2, 3 and 4, respectively) grew at a faster rate than chicks fed the basal ration (Lot 1). Since meat meal has been shown to be deficient in methionine for the chick (March, Biely, and Young, 1950) the supplementary value of sunflower seed oil meal S1 might be related to its higher methionine content.

Replacement of up to two-thirds of the meat meal by sunflower seed oil meal S3 (Lots 5 and 6) increased the nutritive value of the ration. The chicks in Lot 7, receiving a ration in which all of the meat meal was replaced by sunflower seed oil meal S3, grew as fast as the chicks in Lot 1.

Conclusions

- (1) Low-temperature and regular-temperature sunflower seed oil meal satisfactorily replaced all of the meat meal in a practical chick starter in which meat meal constituted the only protein supplement.
- (2) Low-temperature and regular-temperature sunflower seed oil meal exerted a supplementary effect in chick starter rations containing meat meal as the only other protein supplement.

Experiment 5

Object

To study the replacement value of low-temperature and regular-temperature sunflower seed oil meals (meals S1 and S3) in a practical chick starter containing soybean oil meal as the only protein supplement.

Experimental

The rations fed are shown in Table 17. They were similar to those used in Experiment 3, except that the two and one-half percent fish meal in each ration of that experiment was omitted and nine percent portions of soybean oil meal were replaced by either sunflower seed oil meal S1 (Lots 2 - 4) or sunflower seed oil meal S3 (Lots 5 - 7).

Results and Discussion

The results of the experiment are shown in Table 17. Sunflower seed oil meals S1 and S3 satisfactorily replaced two-thirds of the soybean oil meal (Lots 3 and 6, respectively) in the basal ration (Lot 1). Replacement of all of the soybean oil meal by sunflower seed oil meal S1 (Lot 4) decreased the nutritive value of the ration, while replacement of all of the soybean oil meal by sunflower seed oil meal S3 (Lot 7) resulted in the production of a ration of decidedly inferior nutritive value for chicks. In agreement with the results obtained in the four preceding experiments, sunflower seed oil meal S1 was of superior nutritive value to sunflower seed oil meal S3.

Table 17.- Replacement of soybean oil meal in a practical chick starter by sunflower seed oil meals S1 and S3

Ration and Lot Number	1	2	3	4	5	6	7
Ingredients	%	%	%	%	%	%	%
Ground wheat.....	24.25	24.25	24.25	24.25	24.25	24.25	24.25
Ground oats.....	10	10	10	10	10	10	10
Ground barley.....	10	10	10	10	10	10	10
Ground corn.....	20	20	20	20	20	20	20
Soybean oil meal (solvent).....	27	18	9		18	9	
Sunflower seed oil meal S1*.....		9	18	27			
Sunflower seed oil meal S3*.....					9	18	27
Alfalfa meal.....	4	4	4	4	4	4	4
Iodized salt.....	.5	.5	.5	.5	.5	.5	.5
Fish oil (2250A-300D)	.25	.25	.25	.25	.25	.25	.25
Ground limestone.....	2	2	2	2	2	2	2
Bonemeal.....	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Riboflavin premix**..	.5	.5	.5	.5	.5	.5	.5
Manganese sulfate (1/4 lb./ton).....	+	+	+	+	+	+	+
Merck APF #8 (1 lb./ton).....	+	+	+	+	+	+	+
Total.....	100	100	100	100	100	100	100
Protein (NX6.25)%....	20.6	19.6	20.7	21.0	20.4	20.2	21.4
Number of chicks.....	33	33	34	33	34	33	34
Average weight at 28 days (gm.).....	301.2	302.5	297.9	269.9	290.1	296.0	165.6

* See Experimental (General) for description of meals.

** Contained one gram riboflavin per ten pounds wheat middlings.

Conclusion

- (1) Low-temperature and regular-temperature sunflower seed oil meal satisfactorily replaced up to two-thirds of the soybean oil meal in a practical chick starter containing soybean oil meal as the only protein supplement.

GENERAL DISCUSSION

Part I

The results obtained indicate that processing variables markedly influence the nutritive value of sunflower seed oil meal. It would appear that, while efficient expression of the oil is obtained, processing conditions now in use commercially do not result in the production of meals of maximum nutritive value for the chick. Lower processing temperatures result in an increase in the nutritive value of the meal, but also increase the percentage residual oil. Opening the choke on the expeller also increases both the nutritive value of the meal and the percentage residual oil. Since most of the heat-damage appears to occur in the expeller, the feasibility of utilizing a water-cooled shaft in the expeller would seem worthy of investigation. While still allowing for maximum efficiency of expression of the oil, this might decrease the amount of frictional heat-damage produced next to the expeller shaft. In this connection, it is of interest to note that sunflower seed oil meal "chips" leaving an expeller which is operating at the regular temperatures and choke setting, appear scorched on the side next to the expeller shaft. Since sunflower seed oil meal represents an important by-product of the sunflower oil industry, the economic feasibility of utilizing proper processing conditions should be considered by the industry.

Although excessive processing temperatures result in the production of sunflower seed oil meals of inferior nutritive value, the mode of action is, as yet, not understood. It is possible that the effects of heat-damage parallel those observed in overheated soybean oil meal by Clandinin et al. (1947). Since the analytical data (Experiments 4 and 6) indicate that sunflower seed oil meal is marginal in lysine and methionine content for the chick, slight destruction or inactivation of lysine and/or methionine during processing might account for the slower rate of growth of chicks fed regular-temperature sunflower seed oil meal as compared to those fed low-temperature sunflower seed oil meal. The results of Experiment 5 would seem to indicate that the problem is essentially amino acid in nature, since the addition of vitamin-free casein and methionine appeared to completely overcome the effects of excessive heat treatment.

The results of Experiment 8 suggest the presence of a "toxic" factor in the trichloroethylene extractable portion of regular-temperature sunflower seed oil meal. The effects of processing temperatures on the trichloroethylene-soluble portion of the meal need further investigation.

The results of Experiment 6 show that the liberation of essential amino acids by enzymatic hydrolysis was greater from regular-temperature sunflower seed oil meal than from

low-temperature sunflower seed oil meal. It would seem, therefore, that one effect of heat on sunflower seed oil meal is to denature the protein and thus render it more readily attacked by proteolytic enzymes in vitro.

Part II

The results of the five experiments reported in Part II further emphasize the desirability of utilizing lower processing temperatures in the production of sunflower seed oil meal. A meal processed at 200° - 220°F. was consistently of higher nutritive value for chicks than a similar meal processed at the regular temperatures of 240° - 260°F.

Regular-temperature sunflower seed oil meal was a reasonably satisfactory protein supplement for use in chick starting rations, although not found to be of as high nutritive value as reported by Nikolaiczuk, Brisson, and Mani (1948). The results indicate that regular-temperature sunflower seed oil meal may satisfactorily replace one-third of a fish meal and meat meal mixture (composed of one part of fish meal to two parts of meat meal); or two-thirds of the soybean oil meal in the chick starters used. In general agreement with this finding O'Neil (1948) reported that sunflower seed oil meal replaced up to one-third of the animal protein in chick starting rations without detrimental effect. When two and one-half percent fish meal was included in the ration, regular-temperature sunflower seed oil meal

satisfactorily replaced one-third of the meat meal in the ration. However, when meat meal was the only protein supplement in the ration, regular-temperature sunflower seed oil meal replaced all of the meat meal in the chick starter. The lower plane of nutrition that had to be achieved by the sunflower seed oil meal supplemented groups in the latter experiment probably accounts for this finding.

On the other hand, low-temperature sunflower seed oil meal replaced two-thirds of the fish meal and meat meal mixture, all of the meat meal, and two-thirds of the soybean oil meal in the chick starters used, without having any adverse effects on chick growth.

GENERAL SUMMARY

Part I

Eight experiments were conducted to study the effects of methods of processing on the nutritive value of sunflower seed oil meal. The results of the experiments are summarized below.

Processing conditions employed in the manufacture of sunflower seed oil meal markedly influenced the nutritive value of the meal. The nutritive value was lowered as processing conditions became more severe.

Processing variables were also shown to influence the chemical composition of sunflower seed oil meal. Lowering the processing temperatures from $240^{\circ}\text{F.} - 260^{\circ}\text{F.}$ to $200^{\circ}\text{F.} - 220^{\circ}\text{F.}$, or opening the choke on the expeller increased the percentage residual oil in the meal.

Excess heat was shown to affect the nutritive value of raw, laboratory solvent extracted, sunflower seed oil meal. Heating the raw, extracted meal for thirty minutes at fifteen pounds steam pressure appeared to decrease its nutritive value for chicks, while heating for four hours at fifteen pounds steam pressure resulted in the production of a meal of inferior nutritive value.

Marked variability was observed in the protein and crude fibre content of raw, laboratory solvent extracted, sunflower seed oil meals prepared from four different raw materials. Significant differences were also noted in the methionine, lysine, and arginine content of the meals.

Low-temperature sunflower seed oil meal (processed at 200° - 220°F.), and regular-temperature sunflower seed oil meal (processed at 240° - 260°F.), are not complete sources of amino acids for the chick when fed at the twenty percent protein level. The optimum level of supplementation of the above meals appeared to be reached when six percent vitamin-free casein in conjunction with 0.4 percent DL-methionine was added to rations containing low-temperature or regular-temperature sunflower seed oil meal as the only source of protein in the ration. A sunflower seed oil meal prepared by autoclaving low-temperature sunflower seed oil meal for four hours at fifteen pounds steam pressure was of inferior nutritive value for chicks. The optimum level of supplementation of this meal appeared to be reached when twelve percent vitamin-free casein and 0.4 percent DL-methionine were added to the ration.

Regular processing temperatures of 240° - 260°F. resulted in a decrease in the liberation of lysine by acid hydrolysis as compared to the liberation of lysine from low-temperature meal processed at 200° - 220°F. Autoclaving low-temperature sunflower seed oil meal for four hours at fifteen pounds steam pressure resulted in depressed liberation of lysine, arginine, tryptophan, and possibly threonine subsequent to acid hydrolysis (alkaline hydrolysis for tryptophan). No relationship between the liberation of essential amino acids by enzymatic hydrolysis and the nutritive value of the sunflower seed oil meals was observed.

Water treatment had no effect on the nutritive value of regular-temperature or low-temperature sunflower seed oil meal.

Extraction of regular-temperature sunflower seed oil meal with trichloroethylene or ethanol increased its nutritive value. Adding the trichloroethylene extract back to the extracted meal at twice the level originally present depressed the growth of chicks.

Part II

The results of the experiments reported in Part II indicate that low-temperature sunflower seed oil meal satisfactorily replaced two-thirds of the fish meal and meat meal mixture, all of the meat meal, or two-thirds of the soybean oil meal in the practical chick starters used.

Regular-temperature sunflower seed oil meal satisfactorily replaced one-third of the fish meal and meat meal mixture, or two-thirds of the soybean oil meal in the starters used. When two and one-half percent fish meal was included in the starter, regular-temperature sunflower seed oil meal replaced one-third of the meat meal in the ration. When fish meal was omitted from the starter, regular-temperature sunflower seed oil meal replaced all of the meat meal in the ration used.

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