EVALUATION OF THE NUTRITIONAL VALUE OF FULLFAT SOYBEAN FOR CHICKENS

By:

SAMUEL ASUQUO OFFIONG

Thesis

Submitted to the Post-graduate School, Ahmadu Bello University, Zaria, in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY in Animal Science.

Department of Animal Science,

Faculty of Agriculture,

Ahmadu Bello University,

Zaria.

September, 1984.

DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

S. A. Offiong
(Name and Signature of candidate)

Date: 26th Sept 1984

CERTIFICATION

This thesis entitled "EVALUATION OF THE NUTRITIONAL VALUE OF FULLFAT SOYBEAN FOR CHICKENS" by SAMUEL ASUQUO OFFIONG, meets the regulations governing the degree of DOCTOR OF PHILOSOPHY of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

SUPERVISORS

Professor J. M. Olomu (Major Supervisor)
Head, Dept. of Poultry and Swine
National Animal Production Research Institute
Ahmadu Bello University
Zaria.

Professor S. Nuru
Director
National Animal Production Research Institute
Ahmadu Bello University
Zaria.

Professor N. N. Umunna
Head, Dept. of Animal Science
Faculty of Agriculture
Ahmadu Bello University
Zaria.

Professor G. E. Osuide
Dean, Post-graduate School
Ahmadu Bello University
Zaria.

AHMADU BELLO UNIVERSITY, ZARIA.

14th February 1985

ACKNOWLEDGEMENT

The author is grateful to Dr. J. M. Olomu, Professor and Head of Department of Poultry and Swine, National Animal Production Research Institute, Shika, Ahmadu Bello University, Zaria, who guided him throughout the research which culminated in the writing of this thesis. He painstakingly criticised every stage of the preparation of the manuscript.

My sincere thanks go to Messrs Liman Manman, Magaji Gyet and Sule Agbonika for the care and management of the birds in the experiments. I am grateful to Messrs M. O. Owoshagba and S. A. Bello for laboratory analysis and to Mr. S. A. Olorunju, Biometrician, for statistical analysis of the data. I am also grateful to Mr. Chinedum I. Nmaju of the Publication and Information Unit of the Institute for typing the final manuscript. The encouragement which I received from my wife, Nkoyo, contributed in no small way to the success of this work, for which I remain grateful.

Finally, I am grateful to Professor Saka Nuru, Director, National Animal Production Research Institute, Shika, Ahmadu Bello University, Zaria, for placing the facilities of the institute at my disposal.

ABSTRACT

Experiments were designed and conducted to study the nutritive value of fullfat soybean for chickens. The study examined the utilization of raw, roasted, autoclaved and cooked fullfat soybean by broiler chickens and the utilization of raw and cooked fullfat soybean by pullets and laying chickens.

Results showed that broiler chickens fed rations containing fullfat soybean cooked in boiling water or autoclaved for 30 minutes at 15 lb pressure per square inch (p.s.i) i.e. 1.0546 kg/cm^2, grew more rapidly than chicks fed rations containing raw fullfat soybean. Autoclaving or cooking fullfat soybeans for 30 minutes in boiling water was more beneficial than roasting or cooking for 15 minutes. No further advantage was obtained by cooking fullfat soybean for 45 minutes. Older chicks between the ages of 6-9 weeks were more able to utilize raw, roasted or fullfat soybean cooked for only 15 minutes in boiling water.

The rations which contained raw fullfat soybean caused significant enlargement of the pancreas. Cooking for 30 or 45 minutes in boiling water or autoclaving for 30 minutes at 15 lbs p.s.i. reduced the effect on the pancreas. The feeding of raw, roasted or fullfat soybean cooked for 15 minutes had no significant effect on the relative weights of the heart, liver and the spleen or on the relative weights of the thyroid.

Elimination of maize by increasing the level of fiillfat soybean to serve as main energy source in the ration, tended to lower the metabolizable energy of such rations and when fed, resulted in reduced growth performance. Results indicated that although adequately cooked fullfat soybean could replace commercial soybean meal in the rations of chicks, provided such rations were adequate in ME and protein, it could not probably replace maize completely without adversely affecting growth rate and efficiency of feed utilization.

The use of fullfat soybean in the rations for pullets indicated that raw or cooked fullfat soybean could be used in the rations to raise egg type pullets from 8-20 weeks of age without adversely affecting body weight and feed intake. However, when the rations were formulated with fullfat soybean level as high as 37.00% to replace maize as energy source, the ME of such rations became suboptimal. The protein tended to be higher than normal for pullets. Feeding of such rations resulted in reduction of body weight and resulted in delay in onset of laying.

The inclusion of raw fullfat soybean at 20.40% level in the rations of laying chickens did not significantly affect egg production, egg weight or mortality. However, attempts to use fullfat soybean to replace maize as energy source resulted in reduction of ME content of the ration. Feeding of such rations containing either raw or cooked fullfat soybean reduced egg production and raised age at 50% production. Results indicated that although cooked or raw fullfat soybean could replace commercial soybean meal in iso-caloric equi-protein rations of laying birds, it probably cannot replace maize in the rations without adversely affecting performance of the birds.

TABLE OF CONTENTS

	Pages
DECLARATION	ii
CERTIFICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v - vi
TABLE OF CONTENTS	vii - x
LIST OF TABLES	xi - xii
INTRODUCTION	1
REVIEW OF LITERATURE	3
Action of Trypsin Inhibitor (TI) in soybean	3
Other deleterious factors in soybean	5
Hemaglutinin in raw soybean	7
Enzyme in raw soybean	7
Effect of heat on the nutritive value of raw soybean ..	8
Effect of heat on the metabolizable energy of fullfat soybean	14
Effect of raw soybean meal on fat absorption	17
Effect of amino acid supplementation on the nutritive value of FFSB	18
Mode of action of unheated soybean on tissue utilization of methionine and cystine	21
Effect of age on the utilization of raw soybean diets by chickens	23
SECTION 1	28
Determination of gross chemical and amino acid composition of fullfat soybean	28
Experimental	28
Results and Discussion	28
Determination of the metabolizable energy of fullfat soybean	31
Experimental	31
Results and Discussion	33

Pages

SECTION 2 37

Evaluation of the nutritive value of fullfat soybeans 37

Status of the problem 37

Source and preparation of soybean 37

3 Roasting 38

Cooking 38

Autoclaving 38

EXPERIMENT WITH BROILER CHICKENS 39

Birds and Management 39

TRIAL I 40

Objective 40

Experimental.. 40

Results and Discussion ,. 42

TRIAL 2 45

Objective 45

Experimental 45

Results and Discussion 47

TRIAL 3 49

Objective 49

Experimental.. 49

Results and Discussion 51

TRIAL 4 58

Objective 58

Experimental , ... 58

Results and Discussion 60

TRIAL 5 63

Objective 63

Experimental 63

Results and Discussion 64

Pages

TRIAL 6 68

Objective 68

Experimental 69

Results and Discussion 71

TRIAL 7 74

Objective 74

Experimental 74

Results and Discussion 75

SECTION 3 79

Pullet Experiment.. 79

Objective 79

Experimental 79

Results and Discussion 80

SECTION 4 86

Experiment with Laying Hens 86

Objective 86

Experimental 86

Results and Discussion 89

GENERAL DISCUSSION 94

Broiler Experiments. 94

Effect of Heat Treatment 94

Effects on Organ weights 103

Use of FFSB in rations without maize 105

Experiment with laying pullets 106

Experiment with laying hens 108

Fullfat soybean - its potential as an energy source.. 111

Pages

SUMMARY OF RESULTS AND CONCLUSIONS 114

Broiler feeding trials 114

Layers feeding trials. 116

REFERENCES 118

APPENDICES 131

1. Analysis of variance of 4-week body weight gain of broiler chickens (Experiment 1) 131

2. Analysis of variance of 9-week body weight gain of broiler chickens (Experiment 2) 132

3. Analysis of variance of 5-week body weight gain of broiler chickens (Experiment 3) 133

4. Analysis of variance of 9-week body weight gain of broiler chickens (Experiment 134

5. Analysis of variance of effect on relative organ weights of broiler chickens 0-6 weeks of age ..

6. Analysis of variance of 5-week body weight gain of broiler chickens (Experiment 136

7. Analysis of variance of 9-week body weight gain of broiler chickens (Experiment 137

8. Analysis of variance of 5-week body weight gain of broiler chickens (Experiment 138

9. Analysis of variance of 9-week body weight gain of broiler chickens (Experiment 139

10. Analysis of variance of age (days) to 5% Production (Pullet Experiment) 140

11. Analysis of variance of age (days) to 50% Production (Layers Experiment) 141

12. Analysis of variance of percentage Hen Day Production (Layers Experiment) 142

13. Monthly egg production of layers fed on diets containing raw and cooked FFSB diets and cooked FFSB diets in which maize had been eliminated. .. 143

LIST OF TABLES

TABLE		PAGE
1.	Proximate analysis of soybean for dry matter, crude protein, fat, ash and fibre.	29
2.	Amino acid composition of 3 samples of fullfat soybean representing early maturing, intermediate and late maturing varieties.	30a
3.	Gross energy (GE), Classical metabolizable energy (ME) nitrogen corrected metabolizable energy (ME_n) and efficiency of utilization of raw and 30 minutes cooked FFSB diets by broiler chickens (5-6 weeks).	35
4.	Classical or Apparent metabolizable energy (ME) of r raw and cooked fullfat soybeans.	36
5.	Composition of main diets used in Trial 1.	41
6.	Effect of raw, roasted, boiled and autoclaved fullfat soybean (FFSB) on the performance of broiler chickens (0-4 weeks) Trial 1.	43
7.	Composition of (Main or Basal) diets used in Trial 2.	46
8.	Effect of raw, roasted and boiled fullfat soybean (FFSB) on the performance of broiler chickens (6-9 weeks) Trial 2.	48
9.	Composition of finisher diets in Trial 3.	50
10.	Effect of cooking time on the nutritive quality of fullfat soybean (FFSB) for broiler chickens (0-5 weeks) Trial 3.	52
11.	Effect of raw, roasted, autoclaved and cooked fullfat soybean on the relative organ weight (g/100 g live body weight) of broiler chickens (0-6 weeks).	55
12.	Effect of cooking time on the nutritive quality of fullfat soybean (FFSB) for broiler chickens (6-9 weeks) Trial 3.	57
13.	Composition of diets used in Trial 4.	59
14.	Effect of elimination of maize in fullfat soybean diet on the performance of broiler chickens (0-5 weeks) Trial 4.	61

TABLE PAGE

15. Composition of diets used in Trial 5. 64

16. Effect of eliminating maize in fullfat soybean diet on the performance of broiler chickens (6-9 weeks of age) Trial 5. 66

17. Composition of diets used in Trial 6. 70

18. Effect of maize level in fullfat soybean diets on the performance of broiler chickens (0-5 weeks) Trial 6. 72

19. Composition of diets used in Trial 7. 76

20. Effect of maize level in fullfat soybean diets on the performance of broiler chickens (6-9 weeks) Trial 7. 78

21. Composition of diets - Pullet Trial 81

22. Effect of fullfat soybean and eliminating maize in FFSB diets on the development of egg type pullets (8-20 weeks). 83

23. Composition of main diets in experiment with laying birds. 88

24. Effect of raw and boiled FFSB and replacement of maize with FFSB on the performance of layers. 90

INTRODUCTION

Legume seeds have been important as valuable protein sources for farm animals, particularly the monogastric species. Soybean in particular has played a significant role in sustaining the poultry industry in most of the advanced countries of the world, such as the United States of America, Great Britain, Canada, etc.

Commercially processed soybean meal has been used as a primary protein source. In Nigeria, although soybean is produced, little attention is paid to commercial processing of soybean to produce both soybean meal and soybean oil. As a result, large quantities of soybean may be available for use in poultry feeds. It would therefore be worth while to assess the nutiritonal value of fullfat soybean in poultry rations. However, raw soybean contains certain anti-nutritional factors which must be removed if its nutritive properties are to be fully explored. This fact, coupled with growing shortage of supplementary protein sources world wide, lends impetus to any attempt to explore methods of rendering available protein sources such as soybean suitable for use in livestock production. In the circumstance of Nigeria's economy and the low level of industrialization therefore, where few or no processing plants exist for soybean extraction to make soybean meal available as a by-product, and in view of the established need of the poultry industry for protein supplement, an evaluation of the effect of simple easily applicable processing methods on the

nutritive value of fullfat soybean becomes necessary.

The need to explore the use of fullfat soybean in poultry rations is further strengthened by the fact that soybean, because of its high fat and protein content, may play an important role in serving as a good source of energy, replacing part of the often scarce cereal grain as well as serve as an important protein source in diet formulation for poultry.

The object of this study therefore was to evaluate the nutritive value for chickens of feeding fullfat soybean both as a protein and energy source. Raw, roasted, cooked and autoclaved fullfat soybeans were evaluated to determine the treatment method that enhanced the nutritional value of fullfat soybean the most for chickens.

REVIEW OF LITERATURE

Soybean (Glycine Max) is one of the oldest crops in cultivation dating back to 2838 BC (Oyenuga, 1968). It is cultivated primarily for its oil bearing seeds which are used widely for human consumption or as a concentrate for farm animals or for the extraction from them of oil, leaving soybean oil meal. As a legume, soybean contains a number of anti-nutritional factors which make the feeding of raw soybeans harmful to all monogastric animals unless the seeds are properly processed to destroy these factors.

Action of Trypsin Inhibitor (TI) in Soybean

One of the earliest references to the effect of heat in improving the nutritional value of soybean was the work of Osborne and Mendel (1917), following the feeding of soybean as the sole source of protein to rats. The rats in the experiment did not grow as well as those on cooked soybean diets. Analysis of soybean protein by Kunitz (1945), showed that it contained a protein with the characteristic ability to combine with the enzyme trypsin to form a complex, thereby inhibiting the enzyme activity. Carrol, Hensley and Graham (1952) measured digestion in the various parts of the intestines of rats by using chromic oxide as a marker and observed that 77% of unheated soybean meal was digested compared to 85% for autoclaved soybean meal. Most digestion of the unheated soybean meal was reported to occur in the distal part of the intestine. The high level of unabsorbed nitrogen in the distal part of the intestinal tract was high in enzymic activity which was thought to be of pancreatic origin.

Salman and McGinnis (1968) reported higher trypsin activity and lower amylase activity in pancreatic homogenates from fasted birds previously fed unheated soybean meal. The levels of enzymes were maintained fairly constantly during feeding in contrast to the variations observed when autoclaved soybean meal was fed after 16 hours fasting period. Earlier, Applegarth, Furuta and Lepkovsky (1964) had shown that pancreata from chicks fed unheated soybean meal were completely depleted of zymogen and this was attributed to a loss of zymogen granules as a result of the decrease in proteolytic activity following feeding of unheated soybean meal.

Of interest was the work of Salman and McGinnis (1968) which indicated an increase in the synthesis of digestive enzymes in the pancreata of chicks adapted to unheated soybean meal as well as an increase in the rate of release of zymogen from the pancreas.

The influence of raw soybean diet on the chicks intestinal proteolysis had earlier been studied by Alumot and Nitsan (1961) in order to explain the growth retarding effect. These workers observed that in chicks up to 3 weeks of age, intestinal proteolysis was almost completely inhibited. However, from the 4th week proteolysis increased, approaching the normal at 6 weeks. Hypertrophy of the pancreas developed in the raw soybean group which was associated with increased enzyme production to overcome the inhibitor. These workers considered the chick growth retardation by antitrypsin to be due to unavailability of protein, especially in the first 3 weeks of life, and increased protein requirement by the stimulated pancreas. They explained that in some way, the pancreas reacted to the presence of the trypsin inhibitor in the intestines and so secreted more enzyme

to compensate for the effect of the inhibitor. Hypertrophy, they concluded, was a result of the increased activity of the pancreas.

An evidence that amino acid supplementation may overcome the deleterious effects of unheated soybean was earlier given by Fisher and Johnson (1958). These workers observed good growth when raw soybean ration was supplemented with fourteen essential amino acids for poultry which perhaps indicated the effectiveness of essential amino acid supplementation to overcome the depression caused by unheated raw soybean meal.

Khayambashi and Lyman (1966) reported that soybean trypsin inhibitor (SBTI) produced a significant growth depression in rats and that supplementation of the diet with methionine, threonine and valine completely prevented the deleterious effects, which probably indicated that amino acids other than methionine could play a supplementary role in improving the nutritional value of raw soybean meal.

Other deleterious factors in soybean

Kornberg and Davies (1955) reported that other inhibitory factors found in soybean, in addition to trypsin inhibitor are saponins as well as hemagglutinins. In addition soybean contains the enzymes urease and lipoxidase. Lipoxidase oxidises unsaturated fatty acids releasing peroxides which interact with other compounds to cause harmful effects in animals. Urease hydrolyses urea to ammonia (NH_3) and carbon dioxide (CO_2). Its activities in mammals are largely confined to the gastro-intestinal tract.

Soybean contains other anti-nutritional factors, one of which is soyin. This factor appears to be primarily responsible for appetite

depression at least in rats (Liener, 1953). Liener (1953) was probably the first worker to observe that in addition to SBTI, there was yet another toxic protein in association with SBTI. Following experiments with rats, he observed that soyin is an appetite reducer associated with the feeding of raw soybean meal diets. However, as is the case with SBTI, soyin is a heat labile factor and can be destroyed by proper heat treatment to prevent any deleterious effect on the animal when soybeam meal is fed.

Apart from these factors already mentioned, raw soybean contains goitrin. Thss factor acts principally by inhibiting the organic binding of iodine in the thyroid and interferes with the synthesis of thyroxine. As a result, the anterior pituitory is stimulated to produce a thyroid stimulating hormone which acts on the thyroid gland causing hypertrophy and hyperplasia. Olomu (1974) quoted Josefsson (1972) who reported that growth depression may result as a consequence of this action.

Patton, Wilgus and Harshfield (1939) were probably the first workers to produce goitre in chickens by feeding raw soybean meal. Later, Wilgus, Gassner, Patton and Gustafson (1941) demonstrated the presence of a goitrogenic substance in soybean by producing goitre following the feeding of soybean to rats. Sharpless, Pearson and Prato (1939) had earlier shown that the substance could be inactivated by heat while Wilgus et al,(1941) demonstrated that it could also be destroyed by fat solvents.

Although goitre has been produced by feeding soybean to rats (Wilgus et al, 1941), and Patton et al (1979) reported the production of goitre experimentally in chickens, practical diets containing soybean

meal have not been known to cause goitre in chickens. Clandinin, Bayly and Caballero (1966), observed that although thyroid enlargement occurred when goitrin was fed, the animal appeared to reach physiological equilibrium with respect to thyroxine hormone production rate at increased thyroid to body weight ratio.

Hemagglutinin in raw soybean

The presence of hemagglutinins in soybean has been demonstrated. This substance causes non-specific interference with nutrient absorption in the intestines by combining with the cells of the intestines (Liener 1977). Heat treatment may not always destroy all the hemagglutinins in soybean and this may result in vomitting and diarrhoea in some subjects (Korte 1973). The presence of hemagglutinins may also interfere with the absorption of certain amino acids (Korte, 1973).

Enzyme in raw soybean

Soybean as most other legume, contains the enzyme urease which upon hydrolysis yields ammonia (NH_3) which the body has to detoxify to render it harmless. In the process energy is expended. Where soybean is well heated to destroy the enzyme, less NH_3 is formed during digestion and so energy is reserved and utilized for growth and other body activities rather than for detoxication of NH_3 from hydrolysis of urease.

Urease activity in legume seeds can be used to test the effectiveness of cooking soybean (Bird, Boucher, Caskey, Hayward and Hunter 1947), or as an indicator of enzyme destruction. Attempts have been made to establish a relationship between urease activity in soybean and the degree of processing. The intensity of heat treatment required

for development of high nutritive value of soybean meal appears to be the same as that required for destruction of the enzyme urease. Inadequately heated soybean meal could be determined by measuring their urease content (Bird et al, 1947).

Urease activity is demonstrated by increase in acidity. Hayward (1967) showed that there was definite relationship between protein efficiency, protein denaturation and urease activity. He further demonstrated that raw soybean had a pH rise of about 2.0 which fell rapidly as the meal was toasted. A pH rise of 0.2 was associated with adequately cooked soybean meal. Hayward (1967) recommended a pH range of 0.05 to 0.2 for properly cooked soybean. However, Rackis (1966) recommended that a pH range of 0.05 to 0.15 should be associated with properly processed soybean meal. In large scale commercial processing of soybean, based upon the above studies, urease activity test has been used as a measurement of proper processing because the level of heat that destroys urease also destroys SBTI.

From the literature, it has been shown that soybean contains a number of anti-nutritional factors which make feeding it in the raw form detrimental to chickens. Most of these factors are heat labile and as a result, once raw soybean is properly heated it could be used as a dietary component for chickens.

Effect of heat on the nutritive value of raw soybean

Since the initial report of Osborne and Mendel (1917) that heating improved the nutritional value of soybeans for monogastric animals, many attempts have been made to determine optimum heating conditions that would destroy all the harmful components in soybean,

but at the same time preserve its nutritional properties. Many processing methods have been used among which are roasting, infra-red cooking (Featherstone and Rogler, 1966), heating in the autoclave (Renner and Hill, 1960) and heating in the oven at a high temperature of 288-357°C (Simovic, Summers and Bilanski, 1972).

Processing heat appears to be able to destroy or at least inactivate one or more of the anti-nutritional factors known to be present in raw soybean as propounded by Borchers, Ackerson, Sandstedt and Kirmett (1948). Featherstone and Rogler (1966), Salman and McGinnis (1968) and Simovic et al, (1972) all showed that in addition to improving protein utilization and the performance of chicks, heat treatment of soybean prevented pancreas hypertrophy.

In addition to destroying most of the toxic principles, Hayward and Hafner (1941) reported that proper heat treatment rendered the sulphur amino acids in soybean more available to the animals. Melnick, Oser and Weiss (1946) observed that methionine was released earlier from heat treated soybean meal than from raw soybean meal. The late release of methionine when raw soybean meal was fed would not allow optimum supplementation by other amino acids for proper utilization. These workers observed that for a protein to be properly utilized, the amino acids it contains must be liberated during digestion at the rate that allows mutual supplementation with other amino acids.

Reisen, Clandinin, Elvehjem and Cravens, (1947) made an extensive study of the liberation of essential amino acids from raw, properly heated and overheated soybean oil meal and reported that the amount of each essential amino acid liberated by pancreatic hydrolysis was increased by proper heat treatment and decreased by excessive heat.

These workers observed that the liberation of essential amino acids from raw soybean oil meal in the presence of sufficient pancreatin to give at least the same active enzyme concentration as used in the properly heated meal was not as complete as with the properly heated meal except in the case of lysine. This result was probably an indication that trypsin inhibitor was not the only factor involved in raw soybean. Riesen et al, (1947) observed that the liberation of methionine and lysine was decreased by prolonged heating. Clandinin, Cravens, Elvehjem and Halpim (1947) observed that time and temperature were important in the processing of soybean meal. They reported that the heating of solvent extracted soybean meal in the autoclave for 4-15 minutes at 15 lbs pressure yielded a meal of excellent quality for chicks. These workers further observed that increasing the heating time beyond 15 minutes caused a drastic decrease in nutritional quality of the product. For improvement in performance, diets containing such overheated soybean meal had to be supplemented with methionine, lysine and vitamins. In a review of the utilization of heated soybean protein by chickens, Ewing (1963) reported that the improved utilization of lysine when heated soybean was fed was not brought about by increased absorption, but that the heat treatment increased the utilization of this amino acid after absorption. Several other feeding experiments have been conducted to evaluate the effect of heat on the nutritive property of soybean protein. Hayward (1967) reported that moist heat treatment, such as in boiling or autoclaving, had been most effective in enhancing the nutritive value of soybean protein. In contrast, dry heat treatment, such as in roasting, was less effective. The author reported that over-heating impaired the nutritional value of soybean by rendering one or more of the essential

amino acids, particularly lysine, less available. Renner, Clandinin and Robblee (1953), on their part, studied the effect of moist heat and reported that it was capable of improving the nutritive value of soybean meal and suggested that large amounts of moisture could prevent the detrimental effect of overheating.

Although heat treatment had been seen generally to improve the nutritive value of soybean meal, the response of the chick would appear to depend upon the amount of the inhibitor that the heat has been able to destroy during processing. Rackis, McGhee and Booth (1975) reported that at least 79% of the inhibitor must be destroyed before maximum protein utilization could be observed. A major criterion commonly used to evaluate the effect of heat treatment of soybean meal is the rate and extent of protein digestion. In experiment with chickens, Evans, McGinnis and St. John (1947) reported that the digestibility of the protein of raw soybean oil meal was only about 80% that of heated soybean meal. However, on the contrary, in rat experiments, although Hayward, Steenbock and Bohstedt (1936) recorded a slower rate of digestion for the raw soybean protein, the difference in digestibility between raw and heated soybean protein was relatively small. In their own study, Nesheim and Garlich (1964) reported digestibility co-efficients of 55% and 85% for unheated and autoclaved soybean meal respectively and observed a poor nitrogen retention which was associated with the low level of methionine in the unheated soybean diet. In feeding experiments involving autoclaved and unheated soybean meal, Salman and McGinnis (1968) observed that protein digestibility values of the autoclaved soybean meal was high compared with values obtained with unheated soybean meal. The size of the pancreas was

twice as large when unheated soybean meal was fed compared with the size of the birds fed autoclaved soybean meal.

In experiments in which ground soybean and extracted dehulled soybean flakes were used, Renner and Hill (1960) reported that optimum heat treatment as indicated by the rate and efficiency of chick growth was achieved by 10, 40 and 60 minutes heating at 107°C. The differences between these treatments were not statistically significant. However, unheated flakes and the overheated flakes promoted significantly less rapid and less efficient growth. These workers then supported the concept that the low nutritive value of raw soybean was due to its poor digestion and absorption. Working with field beans, Goatcher and McGinnis (1973) observed that increase in the nutritive value of beans in general with autoclaving was probably due to increased digestibility of the protein as a result of inactivation of toxic factors known to be present in legumes.

Time-temperature relationship was investigated by Simovic et al, (1972) in two experiments. Temperatures varying from 288 to 357°C and time from 30 seconds to 3 minutes were investigated. An optimum treatment time was found at each temperature used, indicating that shorter treatment time could be used provided the total heat input was similar. It was not possible to reduce treatment time to less than 30 seconds since it would require temperatures beyond 357°C, which would char the beans. They observed that at the high temperature used, moisture level of the beans had little or no effect on the processing temperature as measured by weight gain and efficiency of feed utilization.

The degree of heat treatment can either improve the nutritive

value of soybean or impair it according to whether it was optimal or excessive. Ewing (1963) discussed the biochemical changes occuring in soybean oil meal protein as a result of autoclaving and the effect of these changes on cystine and methionine metabolism by the chick. According to Ewing (1963), autoclaving or steaming (100°C for 30 minutes) of raw soybean oil meal increased the percentage of the cystine and methionine present in the meal that was retained and metabolized by the growing chick. Steaming apparently increased the digestibility of the soybean oil meal protein probably by destruction of the TI. However, more drastic autoclaving (130°C for 60 minutes) reduced the percentage of the cystine and methionine present in the meal. The growth response produced by autoclaving raw soybean oil meal at 100°C for 30 minutes was more than twice as good as the response produced by a supplementation with methionine. From these results, Ewing (1963) considered that autoclaving probably improved the nutritive value of raw soybean by affecting the availability of nutrients other than cystine and methionine. More recently, Arnold, Summers and Bilanski (1971) attempted to develop an on farm soybean heat treater suitable for use in processing of small quantities of soybean. Feeding trials carried out indicated that fullfat soybean when properly treated with their machine, could be well utilized by chickens. These workers recorded marked improvement in weight gain and efficiency of feed utilization and decrease in pancreas size with the heated sample as compared to the untreated sample.

In an attempt to make maximum use of energy content in experiment with chicks, Simovic, Summers and Bilanski (1972) used heat treatment to enhance the energy of raw soybean. They observed that heat treatment

increased the availability of oil in the beans which was demonstrated by enhanced feed utilization. The authors reported that the heat treated soybean meal diets were higher in energy than the control or raw soybean diet. They observed that the temperature required for maximum gain varied and maximum or similar weight gain were achieved at several temperatures within a particular time treatment. From these observations the authors concluded that shorter or longer heating time could be used provided the temperature was adjusted to provide the necessary heat input. However, as Woodly, Summers and Bilanski (1972) pointed out, the optimum time-temperature relationship may not always coincide exactly.

The body of evidence thus indicates that the nutritive value of raw soybean is enhanced by proper heat treatment. Temperature of heating and the extent of heat treatment were important considerations in the heat treatment of soybean.

Effect of heat on the metabolizable energy of fullfat soybean for chickens.

The beneficial effect of heat on the nutritive value of soybean and soybean oil meal for chickens, rats and other monogastric species has been well established. Quite a major part of this beneficial effect is due to the improvement in the metabolizable energy of soybean. This improvement enhances the overall utilization and governs the metabolic sum of the processes of digestion, absorption and utilization of the diet in energy units (Hill and Anderson 1958; Anderson, Hill and Renner 1958).

Renner and Hill (1960) reported that subjecting raw soybean to 10, 40 and 60 minutes heating at 107°C at 4 lb pressure in the

autoclave improved its metabolizable energy and this resulted in corresponding increase in body weight. Untreated raw soybean group and the 120 minutes 15 lb pressure overheated group weighed less. Renner and Hill (1960) also observed that moist heat treatment for 10 and 40 minutes at 4 lb increased the percentage of apparent absorbability of soybean oil in both soybean flakes and soybean diets with corresponding improvement in body weight. The poor nutritive value of raw soybean was found to be due to its poor digestion and absorption. The authors concluded that metabolizable energy values were good indicators of heat treatment. Underheating resulted in low metabolizable energy values while overheating of soybean resulted in depression of metabolizable energy.

In experiments with laying hens, Hill and Renner (1963) tested the effect of graded levels of heat treatment (Autoclaving for 10, 40 and 60 or 120 minutes at 107°C) on the utilization by adult hens as measured by the metabolizable energy and fat absorbability. They reported that the metabolizable energy values of the unheated materials were significantly lower than those of the optimally heated samples while prolonged heating reduced the energy value of the extracted flakes but had little or no deleterious effect on the energy value of the ground soybean. Absorption of dietary fat was impaired in unheated flakes probably because of the heat labile factor in raw soybean which interferes with fat absorption and utilization (Brambila, Nesheim and Hill, 1961). This effect was abolished by heat while egg production was reduced by feeding unheated soybean.

Renner and Hill (1960) also reported that the samples of soybean flakes which promoted most rapid and most efficient growth also contained

the highest metabolizable energy value per gram. All the soybean samples heated at 107°C for 10, 40 and 60 minutes were of similar values as measured by the rate and efficiency of growth, although the maximal ME value was obtained with the sample heated for 10 minutes at 107°C. The ME values of the heated soybean samples were significantly greater than those of the unheated samples.

Metabolizable energy values provide information on overall utilization of the soybean without an indication of whether the meal portion or the oil portion was efficiently utilized. Renner and Hill (1960) therefore contended that the apparent ME of the heated soybean was the same as the ME value of its parts i.e. the oil and the meal. In this experiment the heat treatment which produced maximal rate and efficiency of chick growth also produced maximal utilization as measured by ME value which they found to be consistent with the concept that the growth retarding effect characteristic of unheated soybean and soybean flakes was due to their poor digestibility. The authors associated improvement in ME values entirely to increased fat absorbability. The unheated material interferred with fat utilization and the utilization of soybean oil from the ground soybean was markedly poorer than if it were added to the diet as such.

The body of evidence in the literature indicates that proper heat treatment enhances the ME value of fullfat soybean meal for chickens. Since the energy value of a feed ingredient is only important if that energy is available when the ingredient is fed, the level of heat application should enhance the ME value without deleterious effect on the protein of fullfat soybean or reducing the utilization of its ME content.

Effect of raw soybean meal on fat utilization

In addition to the well known inhibitory action of raw soybean on protein absorption, it has been reported that raw soybean meal possesses a heat-labile factor which depresses fat absorption in young chicks as shown by increased faecal excretion of lipids (Brambila, Nesheim and Hill, 1961; Nesheim, Garlich and Hopkins, 1962). Garlich and Nesheim (1965) reported that dietary addition of sodium taurocholate restored normal fat excretion which led them to conclude that raw soybean probably caused a deficiency in bile acids in the young chicks which in turn was responsible for poor fat absorption. In their study, Sklan, Budowski, Ascarelli and Hurwitz (1973) observed that the most striking effect of raw soybean was the markedly higher secretion of bile constituents, namely bile acids, phospholipids and cholesterol as well as total fatty acids into the duodenum of chicks, followed by a correspondingly faster disappearance of the same components between the duodenum and the upper jejunum. Scott et al, (1969) reported that dietary lipids enter the duodenum and become emulsified upon contact with bile salt as a pre-requisite for lipid absorption. However, as the bile constituents disappear rapidly from the duodenum soon after they have been secreted, emulsification appears to be prevented, resulting in increased faecal excretion of lipids in young chicks when raw soybean is fed as reported by Brambila et al, (1961), Nesheim et al,(1962). Serafin and Nesheim (1970) reported an increased turnover of bile constituents in raw soybean fed birds. This raw soybean effect namely increased bile secretion into the duodenum, was considered to be part of a general stimulatory action by raw soybean on all digestive

secretions (Sklan et al; 1973). In effect raw soybean increased pancreatic secretion resulting in influx of water and protein into the intestines. The authors concluded that the mechanism by which this stimulating action was accomplished appeared to be related to the presence of TI factors in raw soybean.

The investigation of Nesheim, et al, (1961) on fat digestibility in chicks revealed that 2 week old chicks absorbed only 49% of dietary soybean oil while 3 week old chicks could absorb 73%. Soybean oil in diets containing completely heated meal was over 94% absorbed. From this study, it appeared that there was effect of age of the chick on the degree of digestibility of soybean oil resulting from dietary raw soybean oil meal. Digestibility was poorer in very young chicks. Most of the effect on digestibility caused by raw soybean oil meal disappeared by the time the chicks were 4 weeks old. From this the authors concluded that the TI in raw soybean oil meal may be involved in the poor fat digestibility because the addition of crude Trypsin concentrate or crystalline trypsin was seen to cause a marked improvement in absorbability.

Effect of amino acid supplementation on the nutritive value of FFSB.

The use of heat in the processing of soybean was mostly designed to remove any depression in nutritive value caused by the presence of soybean Trypsin inhibitor (SBTI) and other anti-nutritional principles so as to enhance the utilization of its protein. Many workers have attempted to indirectly improve the nutritive value of raw soybean by supplementing diets containing raw soybean meal with amino acids. Almquist, Mecchi, Kratzer and Grau (1942) reported little or no

response following supplementation of raw soybean meal diet with cystine or choline. Hill et al., (1953) using a mixture of all essential amino acids did not obtain satisfactory growth response in chicks. In their own study, Hayward and Hafner (1941) reported that 0.3% methionine supplementation of raw or cooked soybean meal was effective in improving performance of chicks while 0.3% cystine was not as effective. The authors concluded that methionine at that level could replace cystine but not vice versa. Fisher and Johnson (1957) noted that supplemental methionine could improve egg production of birds on raw soybean meal diets containing vitamin B. Ogundipe (1980) reported that Yates (1963) did not support this observation although he observed that supplemental methionine could improve the utilization of raw soybean meal diet but would not prevent hypertrophy of the pancreas. The result reported by Booth, Robbins, Ribelin and De Eds (1960) also indicated that supplementation of soybean meal diets with methionine plus threonine, valine and tryosine resulted in improvement in nutritional value.

In a rat experiment, Khayambashi and Lyman (1966) reported that supplementation of diets containing SBTI with methionine, threonine and valine completely prevented the growth depressing effect of SBTI. They found that the rats in the experiment fed on SBTI containing diets supplemented with the amino acids had more intestinal protease activity and a high concentration of insoluble nitrogen in the small intestines and greatly enlarged pancreas.

In their own experiment, Yen, Jensen, Hymowitz and Baker (1973) compared the nutritional value of trypsin inhibitor variant soybean varieties and used supplemental DL methionine to determine the effect

of such supplementation on the utilization of the varieties by chickens. There was a significant interaction between methionine addition and protein source on pancreas weight which was increased by methionine supplementation when the raw soybeans were fed, but not when heated soybean meal was fed. Methionine addition resulted in increased weight gain, feed intake and efficiency of feed utilization and protein retention. The authors reported that methionine addition corrected the first limiting amino acid deficiency of the heated soybean diet. The improved performance and nitrogen retention seemed to have resulted from the increased availability of methionine for maximum growth rather than from the synthesis of pancreatic enzymes. This was reflected in the greater protein retention, unaltered whole body composition and no significant change in pancreas weight. They observed that in the case of raw soybean meal diets, methionine addition caused increased pancreas weight and change in body composition. The authors explained that if increased pancreas weight represented increased pancreas function, then the effect of methionine addition to diets containing raw soybean may have been mediated through the pancreas.

Ogundipe and Adams (1974) also reported the beneficial effect of supplemental methionine for layers. These workers found that 0.5% supplemental methionine improved body weight of egg type pullets at 20 weeks of age. Methionine (0.5%) addition to raw soybean based diet also improved significantly the subsequent hen day egg production of birds.

There is abundant evidence of the beneficial effect of supplementing soybean meal based diets with amino acids particularly methionine, which is the first limiting amino acid in such diets. The improvement

in body weight of growing birds and in egg production of layers, points to the need and value of supplementing soybean based diets with this essential amino acid.

Mode of action of unheated soybean on tissue utilization of methionine and cystine.

In spite of the knowledge that heat treatment was necessary for optimum utilization of raw soybean, the mode of action whereby the trypsin inhibitor in unheated soybean exhibited its effect on tissue utilization of methionine and cystine was not investigated until the classic work of Kwong and Barnes (1963). Biochemically, oxidation of carbon chain of methionine is known to be involved in the conversion of methionine to cystine. These workers reported that the metabolic defect caused by trypsin inhibitor in raw soybean was exhibited in an increased oxidation of methionine and this was related to an increased conversion of methionine to cystine. They also reported specific increase in requirement for cystine. They observed that this metabolic defect was responsible, at least in part, for growth depression when unheated soybean was fed. Kwong and Barnes (1963) also reported a decrease in apparent absorbability of nitrogen when unheated soybeans were fed which was accounted for by increased metabolic faecal nitrogen. In the chicken, much larger nitrogen and sulphur excretion in the faeces were observed when unheated soybeans were fed and the workers concluded that incomplete absorption of protein might be a major contributor to the low nutritive value of raw soybean for this species.

These authors therefore supported the hypothesis of Hayward and Hafner (1941) that the defect in cystine utilization for protein

synthesis was the primary defect in unheated soybean. Methionine supplementation acted both to provide more cystine and also make up the specific deficiency of methionine in the protein.

In observations with rats, Yen et al., (1973) noted that trypsin inhibitor from raw soybean caused an increase in pancreatic biosynthesis of cystine from methionine and the cystine subsequently incorporated into pancreatic enzyme. In chicks methionine addition to raw soybean diets could similarly result in increased pancreatic enzyme synthesis and result in improved intestinal proteolysis and chick performance without really preventing pancreatic hypertrophy. Niam, Gertler and Birk (1982) reviewed the work of Barnes and Kwong (1965) who suggested cystine deficiency to be the reason for endogenous loss of sulphur amino acids leading to an inbalance in metabolic acid pool and growth depression. It would appear that methionine (converted in vivo to cystine) is not the only amino acid limiting the nutritional value of raw soybean. Earlier, Booth et al., (1960) had observed that tyrosine, threonine and valine added to raw soybean diets resulted in supplementary effect on growth. Niam et al. (1982) suggested that another possible reason for growth depression caused by feeding raw soybean, was the delay in amino acid absorption as observed in rats and that this could explain the low nitrogen retention that resulted from the feeding of unheated soybean meal diet to chicks. Melnick et al., (1946) had also reported the late release and absorption of methionine when raw soybean meal was fed.

In the light of the fore-going observations, it would appear that methionine addition could play an important role in correcting the specific deficiency of methionine in soybean protein as well as

providing more cystine for tissue synthesis.

Bajjalieh, Orf, Hymowitz and Jensen (1978) suggested that with raw soybean meal, methionine supplementation appreciably corrected the deficiency of methionine and in addition probably counteracted the effect of trypsin inhibitor through an increase in the pancreatic biosynthesis of cystine from methionine and the cystine subsequently incorporated into pancreatic enzyme. This increased pancreatic synthesis should improve intestinal proteolysis and overall performance though it would not prevent pancreas enlargement.

Evidence is presented of the metabolic defect caused by TI in raw soybean which resulted in increased conversion of methionine to cystine. Methionine supplementation has been seen to improve intestinal proteslysis and improved growth has resulted but without preventing pancreas enlargement.

Effect of age on the utilization of raw soybean diets by chickens

When Saxena, Jensen and McGinnis (1963) studied the utilization of raw soybean meal diets by chickens, they observed the curious manner in which the meal was utilized by chickens of different ages. They reported that although raw soybean meal caused marked growth depression, lower feed efficiency, pancreatic hypertrophy and poor nitrogen retention in young chicks, it was completely ineffective in causing any of these deleterious effects in older birds. Chickens that were about 6 weeks old or more did not appear to be affected by the toxic factor in raw soybean which depressed growth in younger birds. But the pancreas enlargement was still evident even in the older birds. However, this effect was greatly reduced in the birds

about 12 weeks old and completely absent in adult birds. Poor nitrogen retention which had been reported in chicks fed raw soybean diet (Lyman, 1957) was not reported in hens. In fact results showed that hens fed raw soybean meal diets retained an equivalent amount of nitrogen as the ones fed the heated soybean meal diet (Saxena, et al., 1963). The feeding of raw soybean meal did not affect either serum protein or the albumin to globulin ratio as determined by paper strip electophoresis.

The effect of the raw soybean factor on performance of hens was also assessed by Saxena et al., (1963). Egg production by hens fed raw soybean meal diets was not different from that of the hens fed heated soybean meal diets. No differences were observed either in efficiency of feed utilization. It appeared that as the chick grew older it became less sensitive to the growth depressing effect of raw soybean meal diet that caused physiological changes in the young bird. Saxena et al., (1963) considered that the deleterious factors present in raw soybean meal escaped digestion in young birds but was susceptible to hydrolysis by the enzymes produced by the older bird. They observed that this toxic fraction in raw soybean that is not digested by young chicks caused pancreatic hypertrophy by blocking the release of enzymes in young birds. When they injected such young chicks fed on raw soybean diet intra-peritoneally with pilocarpine, to stimulate the pancreas, they failed to release the pro-enzyme material in response. Examination of the pancreas of such chicks showed an accumulation of zymogen material in the acinar cells. From these observations the authors hypothesized that raw soybean meal had an active principle which could not be digested by young chicks because of a lack of a specific enzyme.

In their own study on the influence of raw soybean on the chicks intestinal proteolysis, Alumot and Nitsan (1961) showed that up to 3 weeks of age, intestinal proteolysis was almost completely inhibited by the TI. However, from the 4th week, proteolysis increased and approached normal at 6 weeks of age. These facts indicated that chicks up to 3 weeks of age were unable to fully digest the protein in raw soybean because of its toxic principle. Bornstein and Lipstein (1963) also reported suppression of intestinal proteolysis this time in 8 week old birds by raw soybean diet, although proteolysis returned to normal after about 21 to 28 days period. From these results the authors considered that birds required a period of acclimatization or adaptation to adjust to raw soybean diet. Ogundipe (1980) also reported that the sensitiveness of poultry to raw soybean meal diet had been shown to decrease with age up to the onset of egg production. But for egg production, Yates (1963) suggested that if raw soybean diet was to be fed it should be started before egg production commenced.

In their own study on the use of raw soybean by chickens, Hill and Renner (1963) reported that raw soybean did not support satisfactory egg production. Perhaps the lower ME reported in the raw soybean diet used in their experiment as compared to that in the heated soybean meal diet failed to meet the energy requirement for egg production. Rogler and Carrick (1964) in their study of the utilization of raw and heated unextracted soybean for layers, observed a reduction in egg production when raw soybean was used. However, Carver, McGinnis, Clary and Evans (1946) had earlier reported that raw soybean meal diet supported excellent egg production when the diet contained 13% protein. Griminger and Fisher (1960) and

Fisher and Griminger (1961) also reported that satisfactory egg production could be maintained on diets containing raw soybean as a major source of protein.

From these reviews, the harmful nature of raw soybean to chickens would appear to be an age dependent factor. However, there appears to be some controversy about the theory of sensitivity with age. Even some earlier workers (Fisher, Johnson and Ferdo, 1957) had indicated that sensitivity of chickens to the growth inhibitor factor in raw soybean did not show until after 14 weeks of age. Investigations by Salman and McGinnis (1968) found no improvement in digestibility of unheated soybean by chicks up to 6 weeks of age and the digestibility coefficient for the unheated soybean meal was always lower than those of the heat treated soybean meal. Wood, Summers, Moran and Pepper (1971) used white leghorn male chicks to determine the least critical age at which unextracted raw and extracted fullfat soybean might be incorporated in diets up to 6 weeks of age. The pattern of nitrogen utilization and fat digestibility, pancreas weight and feed to gain ratio were determined up to 6 weeks of age. These workers observed that chicks receiving raw soybean meal diet showed significantly poorer body weight gain throughout the experimental period. Two physiological factors were affected namely, appetite and nitrogen utilization with its associated phasic pancreatic hypertrophy. Similarly, when the chicks were changed from the control to experimental diets at varying ages up to 5 weeks of age, the pattern was the same. Sensitivity to raw soybean in terms of feed refusal when the diet was changed was maximal between 3 and 5 weeks of age. There was poor nitrogen utilization resulting in poor weight gain.

The authors concluded that the depression resulting from raw soybean intake did not favour its inclusion in the diet before 4 weeks of age. However, such a phenomenon would be in disagreement with the observations of Bornstein and Lipstein (1963), who reported that age had no effect on the degree of sensitivity to the inhibitory properties of raw soybean meal.

In contrast to the report of Carver et al.,(1946), Grimminger and Fisher (1960), Saxena et al., (1963), other workers like Renner and Hill (1963), Rogler and Carrick (1964), Opundipe and Adams (1974) reported a reduction in egg production when ground raw soybean meal diets were fed.

There appears to be a concensus that sensitivity of birds to raw soybean meal diets decreases with age. In effect, much of the reports of the deleterious effects of feeding raw soybean meal diets have been in birds below the age of 6 weeks. However, some controversy appears to exist with regard to the ability of the laying hen to utilize raw soybean meal diets without adversely affecting performance. Reduction in egg production has been reported in some of the work reviewed while satisfactory egg production has also been reported. It would appear that further work is necessary to establish a definite concensus in this area as has been the case with chicks.

SECTION 1

(i) Determination of gross chemical and amino acid composition of fullfat soybean.

(ii) Determination of the metabolizable energy of fullfat soybean.

I. Determination of gross chemical and amino acid composition of fullfat soybean

Experiment

The proximate composition of three samples of soybean was determined by AOAC methods (1975). Amino acids were determined with the Technicon T.S.M. amino acid analyzer. Amino acid analyses were conducted in 6 N hydrolysates prepared in duplicates of 1 gram samples. The samples were from soybean grown in Shika under similar agronomic conditions. These samples represented early maturing, intermediate and late maturing soybean varieties.

Results and Discussion

The proximate analysis of soybean obtained in this study is presented in Table 1. The average dry matter content of 93.84% falls within the range of values (84.8 - 95.8%) reported in the literature. Percentage ash, and fibre values are also within the range of values in the literature (Ewing 1963, Gohl 1975). Except for sample 3, the dry matter content of samples 1 and 2 were essentially similar.

In terms of percentage fat, percentage ash and percentage fibre, all the samples were essentially similar.

Table 1. Proximate analysis of soybean for dry matter, crude protein, fat, ash and fibre.

Sample	Dry Matter %	Crude Protein %	Fat %	Ash %	Fibre %
1	93.84	39.31	19.55	5.39	7.61
2	93.71	40.12	19.20	5.61	7.57
3	94.04	40.31	19.07	5.65	7.59
Mean	93.86	39.94	19.27	5.55	7.59

The average crude protein content (% N x 6.25) of 39.94% is within the range of crude protein values of soybean (38-40%) given in the literature (Ewing, 1963, Scott, Nesheim and Young 1969). However, it departs remarkably from the data given by Oyenuga (1968) who reported variations of between 23.2 to 50.2% in the protein content of samples analysed by the U.S.A. department of Agriculture. This author also reported the value of about 44.08% for some Nigerian samples which appears to be higher than the 39.94% protein determined in the present study or the 40% reported by Ewing (1963), although lower than the 50.2% reported for some U.S.A. samples. Several variations, however, occur in the chemical composition of soybean. Most of the variations in protein level have been attributed to environmental factors and

cultivar differences (Oyenuga, 1968).

The amino acid profile of FFSB determined in this study is presented in Table 2. The analysis shows methionine to be the most limiting amino acid in FFSB protein. This is in agreement with the literature which cites methionine as the most limiting amino acid in protein of soybean and other leguminous plants (Scott et al., 1969; McOsker 1962; Ewing 1963). The analysis shows that soybean is rich in such essential amino acids as arginine, lysine, leucine and phenylalanine to make soybean protein an important ingredient in the diet of monogastric aminals. However there were considerable variabilities between the 3 varieties of soybean in respect of methionine, leucine, tyrosine and phenylalanine contents.

Table 2. Amino acid composition of 3 samples of fullfat soybean representing early maturing, intermediate and late maturing varieties.

	Sample 1 (Early maturing)	Sample 2 (Intermediate)	Sample 3 (Late maturing)
Lysine	3.55	3.01	2.88
Histidine	1.57	1.30	1.34
Arginine	2.87	2.53	2.83
Aspartic acid	4.99	4.56	4.56
Threonine	1.74	1.51	1.40
Serine	2.41	2.04	2.12
Glutamic acid	7.25	6.63	7.15
Proline	2.07	2.08	1.95
Glycine	1.87	1.53	1.52
Alanine	1.81	1.56	1.54
Cystine	-	-	-
Valine	1.91	1.57	1.81
Methionine	0.56	0.54	0.78
Isoceucine	1.67	1.40	1.83
Leucine	3.80	2.83	2.71
Tyrosine	1.61	1.35	1.20
Phenylalanine	2.28	1.99	2.20

Values expressed as %N on air dry basis.

II. Determination of the metabolizable energy of fullfat soybean

Experimental

Procedure for determining the ME is outlined. It involved the use of a basal diet which was devoid of soybean. This basal diet was used to make up the experimental diets by ingredient substitution at the expense of the basal diet. Thus with the basal diet constituting the control, the other dietary treatments consisted of (a) 80% basal + 20% fullfat soybean (b) 60% basal + 40% fullfat soybean for each of the raw and cooked FFSB treatments. There were therefore a total of 5 diets in the experiment. The birds used had been reared on a common ration up to 5 weeks of age. They were then divided into groups of 10 birds each on the basis of body weight equalizing both mean weight and weight distribution among the groups. The birds were placed in special metabolism cages fitted with droppings trays for exreta collection.

Each experimental ration was fed to triplicate lots of birds for 3 days acclimatization period. At the end of this period, the birds were starved overnight and the droppings trays were cleared out ready for excreta collection. Then weighed quantities of each diet were given. Water was provided ad libitum. Feed intake data were recorded for each group. Excreta was collected at 24 hours intervals for 3 consecutive days. The excreta samples were weighed and placed immediately in plastic containers and frozen after each collection. Total excreta collection method was used.

At the end of collection, the excreta collected were dried in the laboratory oven at 105°C for 72-84 hours. After the dry weights were taken, the 3 days collections for each replicate were ground

together and samples from these were used to determine the gross energy values using the adiabatic oxygen bomb calorimeter. Gross energy values of the feeds were also determined. The feed and excreta samples were also assayed for nitrogen using the AOAC (1975) method.

From the data the classical or apparent metabolizable energy (AME) values of the basal and the substituted diets were calculated from the equation:

$$AME/_g \text{ feed} = \frac{(f_i \times GE_f) - (E \times GE_e)}{F_i}$$

where F_i = Feed intake (g)

E = Excreta output (g)

GE_f = Gross energy of feed (kcal/g)

The ME of the test ingredient was then calculated using a simple algebraic equation.

If ME of the basal diet "X" was "a" kcal/kg and that of 20% substituted FFSB diet "y" was "b" kcal/kg, then the equation becomes:

$$100\ X = a \text{ kcal}$$

$$X = \frac{a \text{ kcal}}{100}$$

$$80\ X + 20\ y = b \text{ kcal}$$

$$80 \times \frac{a}{100} + 20\ y = b \text{ kcal}$$

$$0.8a\ X + 0.2\ y = b \text{ kcal}$$

$$y = \frac{b - 0.8a}{0.2}$$

Corrections were made for retained nitrogen. Nitrogen corrected apparent metabolizable energy (AME_n) was calculated from the equation:

AME_n = Classical ME - 8.22 (gN/g feed-gN/g excreta) according to the method of Hill and Anderson (1958).

Results and Discussion

The gross energy (GE), the classical ME and the ME corrected for nitrogen equilibrium are presented in Table 3, for the basal ration and the substituted rations. The classical metabolizable energy values (ME) determined for raw and FFSB cooked for 30 minutes are presented in Table 4. The classical ME of 3629.44 kcal/kg for raw FFSB was lower than the ME of 4039.50 determined for cooked FFSB. Cooking might have improved the ME probably by improving oil availability and absorbability. The value of 3629.44 kcal/kg determined for the raw FFSB is slightly lower than the value of 3750 kcal/kg reported by Gohl (1975), although this author did not indicate if the value of 3750 kcal/kg was classical ME or ME corrected for nitrogen equilibrium. Efficiency of utilization of GE as ME or ME_n of the basal and the 2 FFSB substituted rations did not appear to show much variations.

Correction for retained nitrogen as a procedure in ME determination studies had been adopted since Armby and Fries (1918) first used the method although some controversy still remains as to its usefulness. In support of this approach, Leeson, Boorman, Lewis and Shrimpton (1974) argued that during feeding to measure the ME of a feedstuff, net nitrogen retention occurs, which means that a proportion of the protein is retained in the carcass as protein, while the remainder is catabolished

to provide energy with the excretion of nitrogen. Hill and Henderson (1958) argued that had nitrogen not been retained it would have appeared as uric acid. However, Sibbald and Slinger (1963) questioned the validity of correcting for nitrogen. They argued that correction does little to improve the usefulness of uncorrected ME values. According to Leeson et al., (1974) some workers have tended to avoid the controversy by quoting both corrected and uncorrected values. In the present experiment, correction for retained nitrogen did little to improve utilization.

Table 3. Gross energy (GE), Classical metabolizable energy (ME), nitrogen corrected metabolizable energy (ME_n) and efficiency of utilization of raw and 30 minutes cooked FFSB diets by broiler chickens (5-6 weeks).

Dietary treatment	Gross energy kcal/kg	Classical Metabolizable energy (ME) kcal/kg	Metabolizable energy corrected for nitrogen (ME_n) kcal/kg	*Efficiency of utilization of classical (ME)%	*Efficiency of utilization of nitrogen corrected metabolizable energy (ME_n)%
Basal Ration (BR)	4248.49	3452.14	3446.47	81.25	81.12
80% BR + 20% Cooked FFSB	4423.98	3569.62	3561.73	80.68	80.50
80% BR + 20% Raw FFSB	4399.20	3487.60	3484.40	79.27	79.20

*Efficiency of utilization % = $\frac{ME \text{ or } ME_n}{GE} \times 100$

Table 4. Classical or Apparent metabolizable energy (ME) of Raw and Cooked fullfat soybean by broiler chickens 5-6 weeks.

Type of FFSB	Classical or Apparent metabolizable energy ME (kcal/kg)
Raw untreated	3629.44
Cooked (30 minutes)	4039.50

SECTION 2

EVALUATION OF THE NUTRITIVE VALUE OF FULLFAT SOYBEANS

Status of the problem

The biological value of the protein of soybean oil meal is fairly high. The crude protein content of soybean is about 40% (Ewing, 1963). It is rich in such amino acids as arginine, tryptophan and lysine, etc to form a good source of essential amino acids for poultry and other monogastric animals. It is however somewhat low in methionine. Unfortunately, soybean protein intrinsically contains trypsin inhibitor, hemagglutinins, urease, goitrogenic substances and other anti-nutritional factors as already mentioned, which tend to make the feeding of unheated soybean detrimental to monogastric species of animals. These factors are heat labile. It was then considered necessary to investigate heat processing methods that will destroy most or all of these factors.

Source and preparation of soybean

Most of the soybean used in these trials were grown at Shika. Some quantities were also procured from Kachia area of Kaduna state and some from Benue State.

Three heat treatment methods were used in the preparation of the beans for the initial feeding experiments. These were roasting, boiling in hot water and autoclaving.

Roasting

This was done by heating the raw fullfat soybeans (FFSB) in an open pan containing sand and constantly stirring the beans and sand together until the beans were brown without becoming charred. In this method, the heating time could not be accurately regulated. The criterion for proper roasting was that the beans should become brown without being charred as already mentioned. The roasted beans were then ground for incorporation in the feed.

Cooking

The raw FFSB was poured into a large tank of water which was boiling. The beans were then allowed to cook for 15, 30 or 45 minutes as the case may be. The cooked beans were spread thinly over a wide area of a concrete floor to dry before being ground for incorporation in the feed.

Autoclaving

For autoclaving, the soybean was first ground. Then the ground material was spread about ½-1 inch thick in shallow trays and autoclaved for 30 minutes at 15 lbs pressure p.s.i., i.e. 1.0546 kg/cm². Distilled water was provided in a separate tray to provide a moist atmosphere within the autoclave during processing. The ground autoclaved FFSB was then air dried before incorporation in the feed.

SECTION 2

EXPERIMENT WITH BROILER CHICKENS

Birds and management

Ross type broiler chickens were used in all trials. Forty or fifty chicks were used per replicate and three replicates were used for each dietary treatment. The chicks were randomised at day old for broiler starter experiments and at 6 weeks for broiler finisher experiments in such a way that the number and mean weights of all lots of chicks within a trial were similar. In making up the pens for testing the finisher diets, the birds were always randomised into similar weight groups such that each treatment lot contained equal numbers of males and females so as to eliminate possible sex effect on the results.

The birds were brooded on deep litter, with wood shavings as the litter material, in open-sided houses in equal size pens (3.05 x 1.22 metres per pen), separated by wooden partitions and wire netting. Hurricane lanterns provided continuous lighting during the brooding period (4 weeks). Feed and water were supplied ad libitum. Weekly weight gains, feed intake and mortality for the corresponding period were kept according to treatment groups. Feed efficiency was calculated at the end of each trial. The birds were generally innoculated against Newcastle disease and infectious bursal disease. The trials were either for the starter or finisher periods that is, 0-5 weeks of age (except for trial 1 which was terminated at 4 weeks of age) or 6-9 weeks of age respectively.

At the end of the experiment the data collected were subjected to analysis of variance. Significance of treatment differences were determined by applying the Duncan's Multiple Range Test (Steel and Torrie, 1960) at ($P<0.05$).

TRIAL I

Objective

The objective of this trial was to test the effect of roasting, autoclaving and boiling on the nutritive value of raw soybean for starting broiler chickens (0-4 weeks) as measured by growth characteristics and efficiency of feed utilization.

Experimental

There were 9 diets (Table 5). Diet 1 served as the control and contained groundnut cake(GNC) and Fish meal (FM) as the main supplementary protein sources. Each of the raw, roasted, 30 minutes cooked and autoclaved FFSB was tested at two levels namely 39% and 11%. Thirty-nine percent FFSB replaced all the FM and GNC in 4 of the experimental diets while 11% FFSB replaced only FM in the remaining 4 diets. The composition of the diets in this trial is shown on Table 5. All diets contained 23% crude protein and metabolizable energy of 3000 kcal/kg diet as recommended by Olomu and Offiong (1980). The ME/crude protein ratio for all diets was about 130.

One thousand and eighty (1080) day old Ross broiler chicks of mixed sexes were used in this trial. The birds were randomly

Table 5. Composition of main diets used in trial 1.

Ingredients	1 Control %	2 FFSB %	3 Diets %
Maize	54.60	37.70	53.05
Fullfat soybean	-	39.00	11.00
Groundnut cake	26.75	-	27.65
Wheat offal	6.00	19.75	3.70
Fish meal	6.20	-	-
Palm oil	2.95	-	1.00
Bone meal	2.00	2.00	2.00
Periwinkle shell	1.00	1.00	1.00
Common salt	0.30	0.30	0.30
Premix*	0.20	0.20	0.20
DL-Methionine	-	0.05	0.10
Calculated Composition			
Metabolizable energy (kcal/kg)	3000.	3000.	3000.
Protein %	23.04	23.04	23.04
ME/P ratio	130.1	130.2	130.2
Fat %	5.98	10.04	5.76
Fibre %	2.84	4.83	3.01
Calcium %	1.34	1.23	1.19
Total phosphorus %	0.84	0.92	0.75
Available phosphorus %	0.60	0.55	0.49
Lysine %	1.11	1.21	1.01
Methionine %	0.41	0.35	0.37
Cystine %	0.32	0.35	0.33

*Supplied per kg diet: Vitamin A 10,000 IU; vitamin D_3 2000 ICU; Vitamin E.5 IU; vitamin K 2.24 mg; riboflavin 5.5 mg, vitamin B_{12} 10 mg; calcium pantothenate 10 mg; niacin 25 mg; choline chloride 350 mg, folic acid 1 mg; manganese 56 mg; zinc 50 mg; copper 10 mg; iron 20 mg; cobalt 1.25 mg; amprolium 125 mg and tetracycline 100 mg.

distributed into 27 equal weight groups of 40 birds per group. Three such weight groups were alloted to each dietary treatment.

The treatments used are outlined in Table 6. Each group of birds was placed in pens measuring 3.05 x 1.22 metres per pen. Continuous lighting was provided with hurricane lamps throughout the experimental period. The birds were innoculated against Newcastle disease at day old and Gumboro (infectious bursal disease) at 1 week and 3 weeks of age. The trial was terminated when the birds were 4 weeks old.

Results and Discussion

The results of this trial are presented in Table 6. Inclusion of 39% FFSB in the diet in the raw and roasted forms significantly depressed the growth rate of chicks as compared to those of the birds on the control diet (Group 2 and 3 vs 1). Cooking improved performance although the performance was still significantly lower than the control (Group 4 vs 1). Autoclaving, on the other hand, resulted in performance not significantly different from the control (Group 5 vs 1), indicating satisfactory heat application by this method.

At the 11% level of inclusion, cooked and autoclaved FFSB groups were similar to the control group (Groups 8, 9 and 1) in growth rate. Raw and roasted FFSB (Groups 6 and 7) significantly depressed growth rate as compared to those of cooked, autoclaved and control groups.

Except in the case of autoclaved FFSB treatments (Groups 5 and 9), performance tended to be poorer when 39% FFSB was fed alone as the main supplementary protein than when 11% FFSB was fed in combination with GNC as supplementary protein sources at least in terms of growth

Table 6. Effect of raw, roasted, boiled and autoclaved fullfat soybean (FFSB) on the performance of broiler chickens (0 - 4 weeks).

Dietary treatment	FFSB %	Wt.Gain (g)	Feed Intake g/Bird	Feed Efficiency g feed/g gain	Feed cost/ kg gain (₦)
1. Control	-	383^{ab}	751^{bc}	1.96^{b}	0.64^{b}
2. Raw	39.0	215^{de}	635^{f}	3.0^{a}	0.72^{ab}
3. Roasted	39.0	201^{e}	667^{ef}	3.32^{a}	0.68^{ab}
4. Cooked (30 mins.)	39.0	305^{c}	789^{ab}	2.59^{b}	0.80^{a}
5. Autoclaved	39.0	397^{a}	830^{a}	2.08^{b}	0.71^{ab}
6. Raw	11.0	238^{d}	566^{g}	2.37^{b}	0.68^{bc}
7. Roasted	11.0	276^{c}	675^{def}	2.45^{b}	0.57^{c}
8. Cooked (30 mins)	11.0	353^{b}	700^{de}	1.98^{b}	0.50^{c}
9. Autoclaved	11.0	357^{b}	722^{de}	2.02^{b}	0.58^{c}
SEM*		21	30	0.171	0.079

Column values with same superscripts or no superscript are not significantly different ($P>0.05$).

*SEM = Standard error of means.

rate (Groups 2, 3, 4 vs Groups 6, 7, 8). 11% FFSB with GNC appeared to complement each other, resulting in improved performances in those diets in which they were both components.

Cooking and autoclaving at the 39% level of inclusion, improved intake which was significantly depressed by raw and roasted FFSB below the level of the other treatments. At the 11% level of inclusion, cooking and autoclaving also improved feed intake although the improvement was not significantly better than the roasted FFSB group. Raw FFSB (Group 6) depressed feed intake significantly as compared to the other treatment groups. Raw and roasted FFSB treatments at the 39% level of inclusion depressed feed conversion but the efficiency of feed utilization was not significantly affected in the other groups by dietary treatments. At the 39% level of including FFSB in the diets, autoclaving reduced feed cost per kg gain below the level of feed cost obtained on the 30 minutes cooked FFSB diet (Group 5 vs Group 4) although the difference was not significant. Feed cost per kg gain was also similar for the raw and roasted FFSB treatments (Group 2 and 3) and were not significantly different from the control group. At the 11% level of inclusion autoclaving and cooking FFSB in boiling water for 30 minutes showed similar feed cost per kg gain which was significantly lower than that obtained on the control diet(Group 1). Raw FFSB treatment (Group 6) showed the highest feed cost per kg gain at this level although not significantly better than the other treatments at the same level of inclusion.

In this preliminary study, autoclaving proved a satisfactory method of processing FFSB. However, the primary aim of the study was its emphasis on processing methods of low technology which would

have a ready appeal at the local level. For this reason alone, autoclaving as a processing method was not considered highly feasible because of the sophistication attached to it.

TRIAL 2

Objective

This trial was an attempt to assess the response of broiler chickens at the finisher stage (6-9 weeks old) to raw, roasted and cooked fullfat soybean.

Experimental

The general features of the experimental procedure used were as outlined under materials and methods for broiler chickens. Seven diets were used in the trial. Five hundred and sixty (560) Poss type broiler chickens were used in the trial. The chickens were divided into 14 similar groups of 40 birds each and two groups were placed on each experimental ration. The composition of the diets used are outlined in Table 7. The diets contained 20% crude protein and ME of 3000 kcal/kg diet (Olomu and Offiong, 1980). FFSB treated in various ways was tested at two levels (35% and 12.5%) for comparison with the control diet in which Blood meal (BLM) and Groundnut cake (GNC) were the main sources of supplementary protein. Thirty-five percent (35%)FFSB replaced both BLM and GNC in 3 of the experimental diets; while 12.5% replaced only BLM in the remaining 3 diets. The treatments that were applied are outlined in Table 8. The diets were fed ad libitum. Continuous lighting was provided throughout the experimental period. The trial lasted between the period 6 to 9 weeks of age.

Table 7. Composition of (Main or basal) diets used in Trial 2.

Ingredient	1 Control %	2,4 & 6 FFSB %	3,5 & 7 Diets %
Maize	58.00	46.15	48.35
Fullfat soybean	-	35.00	12.50
Groundnut cake	21.00	-	18.00
Wheat offal	10.25	15.00	15.00
Blood meal	5.00	-	-
Palm oil	2.00	-	2.30
Bone meal	2.25	2.25	2.25
Periwinkle shell	1.00	1.00	1.00
Common salt	0.30	0.30	0.30
Premix*	0.20	0.20	0.20
DL-Methionine	-	0.10	0.10
Calculated Composition			
Metabolizable energy (kcal/kg)	3000.2	3000.1	3000.1
Protein (%)	20.6	20.6	20.6
Fat (%)	6.61	9.12	8.87
Fibre (%)	2.36	3.66	3.24
Calcium (%)	1.25	1.30	1.27
Total phosphorus (%)	0.79	0.90	0.87
Available phosphorus (%)	0.54	0.56	0.56
Lysine (%)	1.10	1.10	0.94
Methionine (%)	0.26	0.38	0.35
Cystine (%)	0.32	0.33	0.30

*See table 5 for composition of the Premix

Results and Discussion

Results of this trial is summarized in Table 8. At 35% level of inclusion, raw FFSB significantly depressed rate of growth of birds as compared to the control group (Group 2 vs 1). Roasted FFSB at this level was not significantly different from the control while cooked FFSB was significantly better than the control. At 12.5% level of inclusion, raw and roasted FFSB were statistically similar to the control in growth rate, although there was slight depression by raw FFSB treatment. Cooked FFSB was significantly better than raw FFSB but not better than roasted FFSB at this level of inclusion. As in trial I, combining FFSB with GNC resulted in better growth rate of the birds than feeding FFSB alone as the only source of supplementary protein (Group 5 vs Group 2 and Group 6 vs Group 3), except in the case of cooked FFSB in which performances were similar (Groups 4 and 7) irrespective of whether FFSB was fed alone as the only supplementary protein or in combination with GNC. No significant differences occurred in feed intake. Efficiency of feed utilization was similar in all treatments except in the 35% raw FFSB group in which efficiency was significantly poorer than the other groups. At 35% level of inclusion, feed cost per kg gain was lower when FFSB was cooked for 30 minutes than when it was included in the diet as raw FFSB and was similar to that on the control diet (Group 1). Feed cost per kg gain was also lower at 12.5% level of inclusion when FFSB was cooked or roasted than when it was fed raw although it was not significantly different from that of the raw FFSB treatment.

Table 8. Effect of raw, roasted and boiled fullfat soybean (FFSB) on the performance of broiler chickens (6-9 weeks).

Dietary treatment	FFSB %	Wt.Gain (g)	Feed Intake g/bird	Feed Efficiency g feed/ g gain	Mortality %	Feed cost/ kg gain (₦)
1. Control	-	819^{b}	2636	3.22^{a}	0	0.79^{b}
2. Raw	35.00	585^{a}	2570	4.39^{b}	0	1.12^{a}
3. Roasted	35.00	751^{b}	2635	3.51^{a}	0	0.90^{b}
4. Cooked (30 mins)	35.00	901^{c}	2703	3.00^{a}	0	0.91^{b}
5. Raw	12.50	762^{b}	2598	3.41^{a}	0	0.89^{b}
6. Roasted	12.50	814^{bc}	1711	3.33^{a}	0	0.76^{b}
7. Cooked (30 mins)	12.50	901^{c}	2600	2.88^{a}	0	0.76^{b}
SEM		45	104	0.32	0	0.08

Column values bearing the same superscript or no superscript are not significantly different (P>0.05).

Generally there was no significant difference in feed cost per kg gain between the control (Group 1) and the other treatments except the raw FFSB diet (Group 2) which had the highest feed cost per kg gain. Results indicated that heat generally improved the nutritional value of raw FFSB for broilers. Although raw FFSB depressed growth at 35% level of inclusion, general performance indicated that during the finishing (6-9 weeks) stage, broiler chickens may not be so sensitive to raw FFSB especially when the lower levels of inclusion are compared.

TRIAL 3

Objective

The two previous trials had indicated that cooking for 30 minutes was effective in improving the nutritional value of FFSB. This trial was therefore undertaken to determine the optimum cooking time that was required to effectively improve the nutritional value of FFSB for broiler chickens during both the starter (0-5 weeks) and finisher (6-9 weeks) periods.

Experimental

The cooking times evaluated were 15, 30 and 45 minutes. The FFSB was thus cooked in boiling water for 15, 30 or 45 minutes as previously described. The cooked FFSB was spread out to dry at room temperature and ground before incorporation into the diet. The composition of the starter diet is similar to diets 2 in trial 1 (Table 5) - raw, roasting, 15, 30 and 45 minutes cooking being the differences in the treatment of FFSB in the experiment. FFSB autoclaved at 15lbs pressure p.s.i i.e. 0.0546 kg/cm^2 for 30 minutes was also tested.

Table 9. Composition of finisher diets used in Trial 3.

Ingredients	Control Diet[1] %	FFSB Diets[2] %
Maize	[illegible]	42.50
Fullfat soybean	–	35.00
Soybean meal	27.21	-
Wheat offal	11.99	18.60
Fish meal	1.98	-
Palm oil	1.98	-
Bone meal	2.20	2.20
Periwinkle shell	1.00	1.00
Common salt	0.30	0.30
Premix*	0.20	0.20
DL-Methionine	-	0.20
Calculated Composition		
Metabolizable energy (kcal/kg)	3000	3000
Protein	20.2	20.2
Fat (%)	5.35	9.27
Fibre (%)	3.61	4.6
Calcium (%)	1.44	1.28
Total phosphorus (%)	0.83	0.93
Available phosphorus (%)	0.56	0.58
Lysine (%)	1.14	1.12
Methionine (%)	0.26	0.48
Cystine (%)	0.29	0.37

[1]See Table 5 for the composition of the premix.

The same control diet was used as in Trial 1 and the broiler chicks were managed as described in Trial 1.

To study the effects of the dietary treatments on organ weights, the birds were fed the experimental diets up to 6 weeks of age. At the end of this period, 6 chicks, made up of 3 males and 3 females from each replicate, were randomly selected from each experimental group and killed by cervical dislocation. The pancreas, liver, heart, thyroid and spleen were removed and weighed. The organ to body weight ratios (relative organ weight) were then calculated.

In the finisher diet, commercially-processed soybean meal (SBM) and FM were the main sources of supplementary protein in the control diet, while FFSB alone was the source of protein in the experimental diets. Each of the treatments was tested at 35%. The composition of the diets used during the finishing stages is presented in Table 9. The procedure for alloting the birds to treatment was a outlined in the general experimental procedure. One thousand and fifty (1,050) birds were used in the trial and there were 3 replicates of 50 birds each per treatment.

Results and Discussion

(a) Effects on performance characteristics

The effect of feeding raw, roasted and autoclaved FFSB, and FFSB cooked for 15, 30 and 45 minutes on average weight gain, feed intake, efficiency of feed utilization, mortality and feed cost per kg gain are summarized in Table 10 for broiler starter chicks.

Table 10: Effect of cooking time on the nutritive quality of fullfat soybean (FFSB) for broiler chickens (0-5 weeks)

Dietary treatment	Weight gain (g)	Feed intake g/Bird	Feed efficiency g/feed/g gain	Mortality %	Feed cost per kg gain (₦)
1. Control	779.5^{a}	1596^{ab}	2.04^{d}	4.20	0.58^{d}
2. Raw FFSB	357.8^{d}	1376^{bc}	3.83^{b}	6.88	0.99^{b}
3. Roasted FFSB	357.2^{d}	1260^{c}	3.58^{b}	4.20	0.92^{b}
4. Autoclaved FFSB	776.0^{a}	1590^{ab}	2.10^{d}	4.8	0.61^{d}
5. 15 Minutes cooked FFSB	298.2^{e}	1353^{bc}	4.52^{a}	5.7	1.17^{a}
6. 30 Minutes cooked FFSB	644.1^{b}	1664^{a}	2.58^{c}	4.0	0.66^{d}
7. 45 Minutes cooked FFSB	442.9^{c}	1530^{abc}	3.45^{b}	4.2	0.87^{bc}
SEM	27	153	0.27	0.8	0.071

Column values bearing the same superscript or no superscript are not significantly different ($P>0.05$).

In the starter period (0-5 weeks), raw, roasted and 15 minutes cooking depressed growth rate significantly below the control group (Groups 2, 3 and 4 vs 1). Forty-five (45) minutes cooking (Group 7) also depressed growth rate significantly below the control but not as did the raw, roasted and 15 minutes cooked FFSB. The better performance of the raw FFSB group (Group 2) over the 15 minutes cooked FFSB group (Group5) was unexpected because the heat input of 15 minutes cooking time should have improved utilization of FFSB in diet 5 over the utilization of the raw FFSB in diet 2. Thirty minutes cooking and autoclaving significantly improved growth rate above those obtained for the raw, roasted, 15 and 45 minutes cooking (Groups 6 and 4 vs 2, 3, 5 and 7). The growth rate obtained on the 30 minutes cooked FFSB diet was, however, still significantly less than that of the control (diet 6 vs 1), but autoclaving was similar to the control. Feed intake on raw, roasted, 15 and 45 minutes cooked FFSB diets were similar, but were all significantly lower than feed intake on the 30 minutes cooked FFSB diet. Autoclaving was generally similar to the control.

Efficiency of feed utilization was better on the control, autoclaved, FFSB and 30 minutes cooked FFSB diets (Groups 1, 4 and 6). Each of these was significantly better than raw, roasted, and 45 minutes cooked FFSB diets which were similar (Groups 1, 4 and 6 vs 2, 3 and 7). Fifteen (15) minutes cooked FFSB had the poorest feed efficiency value. Mortality was high generally but was not significantly affected by treatments.

Feed cost per kg of gain was lowest in the control group (Group 1). Of the 6 experimental groups feed cost per kg gain was lowest on 30 minutes cooked FFSB group and autoclaved FFSB group and highest on

the 15 minutes cooked FFSB group (Group 6 and 4). Surprisingly feed cost per kg gain for the 45 minutes cooked FFSB, the raw and roasted FFSB (Groups 7, 2 and 3) were similar.

(b) Effects on organ weights

Data on the relative weights of the organs are shown in Table 11. There was no interaction between sex and treatment as far as the pancreas weights were concerned. Autoclaving FFSB for 30 minutes at 15 lbs pressure p.s.i., i.e. 1.0546 kg/cm² and cooking for 30 and 45 minutes before including in the rations significantly decreased relative pancreas weights. (Groups 4, 6 and 7). Roasting (Group 3) was not as effective. Raw FFSB (Group 2) and 15 minutes cooked FFSB (Group 5) significantly increased the relative pancreas weights. No pattern was established in the relative heart weights of the chicks. Raw and roasted FFSB produced similar relative heart weights. Also autoclaving and cooking FFSB for 15 minutes produced similar relative heart weights. Cooking FFSB for 30 and 45 minutes respectively were similar to raw and roasted FFSB in this respect (Groups 6, 7 and Groups 2, 3).

Although raw, roasted and 15 minutes cooked FFSB (Groups 2, 3 and 5) increased the relative liver weights, the differences in the treatment means were not significant. The relative spleen weights were not affected by treatment. No effect of treatment was observed in the relative thyroid weights, although slight increases were noticeable in the relative thyroid weights of 30 and 45 minutes cooked FFSB treatments (Group 6 and 7). Relative thyroid weights, of Groups 2, 3, 4 and 5 were similar to that of the control group. The results obtained with broiler finishers are shown in Table 12.

Table 11. Effect of raw, roasted, autoclaved and cooked fullfat soybean on the relative organ weights (g/100 g live body weight) of broiler chicks (0-6 weeks).

Treatment	Relative organ weights g/100g body weight					
	Body weight (g)	Pancreas	Heart	Liver	Spleen	Thyroid
1. Control	603.0	0.316^{d}	0.504^{a}	2.653	0.137	0.072^{b}
2. Raw FFSB	385.0	0.573^{a}	0.459^{b}	3.089	0.133	0.058^{b}
3. Roasted FFSB	465.8	0.463^{b}	0.441^{b}	3.141	0.156	0.060^{b}
4. Autoclaved FFSB	537.5	0.358^{cd}	0.432^{c}	2.755	0.145	0.074^{ab}
5. 15 minutes cooked FFSB	482.5	0.516^{b}	0.443^{c}	3.037	0.129	0.058^{b}
6. 30 minutes cooked FFSB	582.3	0.305^{d}	0.445^{b}	2.258	0.136	0.089^{a}
7. 45 minutes cooked FFSB	587.5	0.375^{c}	0.456^{b}	2.630	0.128	0.093^{a}
SEM	-	0.079	0.057	0.304	0.035	0.029

Column values bearing the same superscript or no superscript are not significantly different ($P>0.05$).

At the finisher stage (6-9 weeks) raw, roasted and 15 minutes cooked FFSB, depressed growth rate significantly below those of the control, 30 and 45 minutes cooked FFSB groups, with the raw FFSB being the poorest. Thirty and 45 minutes cooked FFSB were similar and improved growth rate significantly more than the control (Groups 5 and 6 vs 1). The effect of the 30 minutes cooking on growth rate was thus similar to that observed in Trial 2. No significant differences occurred in feed intake values. However, in the efficiency of feed utilization, 30 and 45 minutes cooked FFSB were similar and significantly better than the control (Groups 5 and 6 vs 1). Roasted FFSB and 15 minutes cooked FFSB were similar, while raw FFSB had the poorest efficiency value. Treatments had no effect on mortality. Feed cost per kg gain was lowest for the 30 minutes and 45 minutes cooked FFSB and significantly lower than that on the control group (Groups 5 and 6 vs Group 1).Feed cost per kg gain was similar for the control, roasted and 15 minutes cooked FFSB groups (Groups 1, 3 and 4). Feed cost per kg gain was highest for raw FFSB (Group 2) which seemed to indicate the poorest utilization when FFSB was included raw in the diet.

From these results, it became clear that cooking FFSB below 30 minutes was not beneficial at least in terms of weight gain of broiler chickens during 0-5 weeks of age. However as the birds entered the 6-9 weeks of age the deleterious effect of undercooking was not so severe as evidenced by growth rate results of birds fed roasted and 15 minutes cooked FFSB (Groups 3 and 4) in comparison to the control (Group 1). However, the cooking time of 30 and 45 minutes were similar and significantly more beneficial during 6-9 weeks of age than 15 minutes although 45 minutes cooking time did not appear so beneficial during 0-5 weeks of age.

Table 12. Effect of cooking time on the nutritive quality of fullfat soybean (FFSB) for broiler chickens (6-9 weeks).

Dietary treatment	Wt. Gain (g)	Feed intake g/bird	Feed Efficiency g feed/g gain	% Mortality	Feed cost per kg gain ₦
1. Control	883^{b}	2501	2.82^{c}	0	0.81^{b}
2. Raw FFSB	582^{d}	2332	4.00^{a}	0	1.04^{a}
3. Roasted FFSB	709^{c}	2401	3.38^{b}	0	0.87^{b}
4. 15 Min. cooked FFSB	744^{c}	2345	3.15^{b}	0	0.82^{b}
5. 30 Min. cooked FFSB	950^{a}	2421	2.54^{d}	0	0.66^{c}
6. 45 Min. cooked FFSB	947^{a}	2326	2.45^{d}	0	0.64^{c}
SEM	19	134	0.14	-	0.08

Column values bearing the same superscripts or no superscript are not significantly different ($P>0.05$).

TRIAL 4

Objective

The purpose of this trial was to assess the performance of broiler chickens in the starter period, when they were fed on fullfat soybean diet containing no maize. This was an attempt to utilize fullfat soybean in replacing maize in the diet.

Experimental

There were 10 diets in this trial. The composition of the main diets is shown in Table 13. There were 2 control diets. One control diet (Diet 1) contained soybean meal (SBM) and Fish meal (FM) as the main supplementary protein sources without added methionine. The other (Diet 2) contained only SBM + added methionine but without FM. Diet 3 contained FFSB replacing all the SBM in control diet 1. Diet 4 contained FFSB without fishmeal but with added methionine. Diet 5 and 6 were similar to 3 and 4 respectively except that while diets 3 and 4 contained raw FFSB, diets 5 and 6 contained FFSB cooked in boiling water for 30 minutes. All these six diets were isocaloric and isonitrogenous. In addition to these, four other diets were included in the trial. In these diets, maize was eliminated. In diet 7 (with cooked FFSB) and diet 9 (with raw FFSB), the protein levels were retained at 23% but the energy level was 1835 kcal/kg diet. In diets 8 and 10 with cooked and raw FFSB respectively, the energy level was 3000 kcal/kg diet, while protein level was 32.6%. It was not possible to formulate rations containing 23% crude protein and ME of 3000 kcal/kg diet as contained in the first 6 diets.

Table 13 Composition of diets used in trial 4.

Ingredients	Control diets		FFSB Diets			
	1 %	2 %	3&5 %	4&6 %	7&9 %	8&10 %
Maize	53.00	49.05	43.60	33.10	-	-
Soybean meal	28.50	43.35	-	-	-	-
Fullfat soybean	-	-	28.70	43.50	30.30	73.60
Palm oil	3.00	3.90	-	-	-	-
Wheat offal	5.00	-	17.20	19.70	66.00	22.70
Fish meal	7.50	-	7.50	-	-	-
Bone meal	1.75	2.50	1.75	2.50	2.50	2.50
Periwinkle shell	0.75	0.50	0.75	0.50	0.50	0.50
Common salt	0.30	0.30	0.30	0.30	0.30	0.30
Premix*	0.20	0.20	0.20	0.20	0.20	0.20
DL-Methionine	-	0.20	-	0.20	0.20	0.20
Calculated Composition						
Metabolizable Energy(kcal/kg)	3000	3000	3000	3000	1835	3000
Protein %	23.2	23.2	23.2	32.2	23.2	32.6
Fat %	6.71	7.99	7.94	10.4	5.14	15.06
Fibre %	3.45	4.15	3.64	4.50	8.64	6.13
Calcium %	1.14	1.21	1.39	1.21	1.23	1.29
Total phosphorus %	0.73	0.85	0.96	1.03	1.43	1.19
Available phosphorus %	0.48	0.58	0.62	0.63	0.78	0.69
Lysine %	1.66	1.75	1.36	1.30	1.25	1.9
Methionine %	0.38	0.49	0.40	0.52	0.46	0.61
Cystine %	0.38	0.38	0.38	0.57	0.32	0.51

*See Table 5 for the composition of the premix.

Attempts to use FFSB to formulate a ration containing 23% crude protein in the absence of maize, resulted in low dietary ME. In the absence of maize, attempt to formulate rations containing ME of 3000 kcal/kg resulted in higher protein diets.

One thousand five hundred (1,500) birds were used in this trial. They were alloted to similar groups of 50 birds per group. Three replicates of 50 birds each were alloted to each dietary treatment.

Results and Discussion

The results obtained in this trial are summarized in Table 14. The results indicated that fish meal was a better supplement to soybean meal than methionine alone. The results obtained confirmed earlier findings in that cooking of FFSB improved its nutritive value at least in terms of weight gain and feed efficiency (Groups 5 and 6 vs Groups 3 and 4). The use of FFSB in place of commercial SBM resulted in similar weight gain and feed efficiency (Groups 5 and 6 vs 1 and 2). These results thus confirmed earlier results in this investigation which showed that properly processed FFSB can be used as a source of supplementary protein in poultry diets replacing all of the plant protein supplement in the diet.

Diet 8 containing no maize and a higher level of cooked FFSB (73.60%) improved growth rate significantly more than group 7 with only 30.30% cooked FFSB and containing no maize, probably because diet 8 had an optimal ME value of 3000 kcal/kg diet as compared to 1835 kcal/kg diet in diet 7. However, feed intake and efficiency of feed utilization were similar. Diet 8 had a protein level as high as 32.60% and although the ME was similar to the control ration,

Table 14: Effect of elimination of maize in fullfat soybean diet on the performance of broiler chickens 0-5 weeks of age.

Diet Number	Dietary Treatment				Met.Energy	% Protein	Wt.Gain (g)	Feed intake g/Bird	Feed Efficiency Feed/g Gain	Feed cost per kg gain (₦)
	% Maize	% SBM	% FFSB	% FM						
1	53.00	28.50	-	7.50	3000	23.2	806^{a}	1461^{bc}	1.81^{a}	0.59^{cd}
2	49.05	43.35	-	-	3000	23.2	737^{b}	1545^{cd}	2.09^{bc}	0.66^{c}
3	43.60	-	*28.70	7.50	3000	23.1	595^{c}	1609^{f}	2.69^{de}	0.78^{b}
4	33.10	-	*43.50	-	3000	23.2	841^{a}	1657^{e}	1.97^{ab}	0.57^{d}
5	43.60	-	+28.70	7.50	3000	23.1	505^{d}	1530^{cd}	3.02^{e}	0.75^{b}
6	33.10	-	+43.50	-	3000	23.1	750^{b}	1565^{d}	2.08^{ab}	0.52^{de}
7	-	-	+30.30	-	1835	23.2	505^{d}	1414^{ab}	2.80^{de}	0.45^{e}
8	-	-	+73.60	-	3000	32.6	565^{c}	1379^{ab}	2.44^{cd}	0.61^{c}
9	-	-	*30.30	-	1835	23.2	340^{e}	1346^{a}	3.95^{f}	0.63^{c}
10	-	-	*73.60	-	3000	32.6	320^{e}	1359^{a}	4.24^{g}	1.06^{a}
	SEM						34.7	75.6	0.20	0.045

Column values bearing the same superscript or no superscript are not significantly different ($P>0.05$).
* Raw FFSB
+ Cooked FFSB.

the abnormally high protein level must have created an imbalance effect such that performance characteristics were affected. On the other hand, diet 7 was similar in protein content to the control ration but low in ME. The energy in the diet proved inadequate to meet growth requirements and this resulted in growth depression as compared to the control diet (Diet 1). Diet 9 and 10 were similar to 7 and 8 in all respects except that diets 9 and 10 contained raw FFSB whereas diets 7 and 8 contained cooked FFSB. In the two diets (Groups 9 and 10) the raw soybean factor also appeared to depress the performances of the birds fed on these diets. On the whole, the generally poor performance of the birds fed on these 4 diets in which maize was eliminated i.e. 7, 8, 9 and 10 appeared in a large measure to be due to the effect of protein-energy imbalance. FFSB diets without maize resulted in diets which were either too high in protein or too low in ME. Neither of these conditions was conducive in supporting satisfactory growth performance. Attempts to formulate rations with cooked FFSB (in the absence of maize) containing the same levels of protein and energy as the control ration were not successful with the ingredients used in ration formulation.

The enhancement of efficiency resulting from addition of FM in diet 1 resulted in lower feed cost per kg gain compared to diet 2 with only SBM + added methionine. In diets 3 and 5, which were similar except for the fact that diet 3 contained raw FFSB while diet 5 contained cooked FFSB, cooked FFSB in diet 5 resulted in greatly improved efficiency which resulted in lower feed cost per kg gain compared to diet 3. Similarly feed cost per kg gain was lower in group 6 compared to group 4. Also in similar diets in which maize was eliminated (7 vs 9 and 8 vs 10), cooking of FFSB tended to improve efficiency and resulted in lower feed cost per kg gain.

TRIAL 5

Objective

Although result in trial 4 indicated that complete elimination of maize in fullfat soybean diets resulted in growth depression for broiler chickens from day old to 5 weeks of age, it was considered necessary to test similar treatments on broiler finishers (6-9 weeks of age).

Experimental

There were 9 treatments in this trial. The composition of the diets used is outlined in Table 15. The control diet (Diet 1) contained SBM as the main supplementary protein source. Diet 2 was similar to diet 3 but diet 2 contained raw FFSB while diet 3 contained 30 minutes cooked FFSB at the same level of inclusion. Diets 4 to 9 were formulated to contain no maize as energy source. Rather, raw or 30 minutes cooked FFSB was used in the attempt to replace maize completely as energy source in the diets.

The high level of FFSB required to raise the ME level to 3000 kcal/kg diet in the rations which contained no maize, raised the crude protein to abnormally high level. Rations containing the least FFSB level resulted in suboptimal ME values.

One thousand, three hundred and fifty (1,350) birds were used in the trial. Equal number of male and female birds were randomly alloted into similar weight groups of 50 birds per group. Three such groups were alloted to each dietary treatment. The dietary treatments employed are outlined in Table 16.

Table 15: Composition of diets used in trial 5.

Ingredients	Control	FFSB Diets				
	1	2&3	4&6	5&7	8	9
Maize	56.35	44.10	-	-	-	-
Soybean meal	33.10	-	-	-	-	-
Fullfat soybean	-	33.45	15.80	73.60	35.80	55.80
Wheat offals	3.80	18.75	80.50	22.70	60.50	40.50
Palm oil	3.05	-	-	-	-	-
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Common salt	0.30	0.30	0.30	0.30	0.30	0.30
Premix*	0.20	0.20	0.20	0.20	0.20	0.20
DL-Methionine	0.20	0.20	0.20	0.20	0.20	0.20
Calculated Composition						
Metabolizable Energy (kcal/kg)	3000	3000	1445	3000	1983.2	2521.4
Protein (%)	20.00	20.00	20.00	32.6	24.6	28.73
ME/P ratio	150	150	72.2	92.0	81.3	87.7
Fat (%)	7.06	8.94	7.13	15.14	9.9	12.68
Fibre (%)	3.68	4.57	9.24	6.13	8.32	7.16
Calcium (%)	1.17	1.17	1.18	1.27	1.21	1.24
Total phosphorus (%)	0.93	1.07	1.59	1.25	1.47	1.35
Available phosphorus (%)	0.67	0.72	0.89	0.78	0.84	0.81
Lysine (%)	1.42	1.08	1.02	1.94	1.34	1.65
Methionine (%)	0.46	0.48	0.42	0.61	0.48	0.55
Cystine (%)	0.33	0.33	0.26	0.51	0.34	0.43

* See Table 5 for the composition of the premix.

Results and Discussion

Results of this trial are summarized in Table 16. In combination with maize, cooked FFSB (Group 3) significantly improved growth rate more than raw FFSB at the same level (Group 2). Feed intake values for raw FFSB (Group 2) and the cooked FFSB (Group 3) were, however, similar to the control.

When maize was completely eliminated, growth rate was significantly depressed (Groups 4 and 5 vs 1).

The higher level of 73.60% cooked FFSB significantly improved growth rate as compared to 15.80% cooked FFSB (Group 5 vs 4); 73.60% raw FFSB also significantly improved growth as compared to 15.80% raw FFSB (Group 7 vs 6) and 55.80% cooked FFSB significantly improved growth rate as compared to 35.80% cooked FFSB (Group 9 vs 8). Improvement in growth performance in these pairs of treatments was probably related to those diets in which the ME was optimal or approached the optimal as in the case of group 9. In these results optimal ME level appeared to be more beneficial than protein level because where ME levels were optimal growth performance was better (Group 5 vs 4, Group 7 vs 6) although these values were all significantly less than the control (Group 1) or the cooked or even the raw FFSB in combination with maize. On the other hand, where ME was sub-optimal, growth was depressed irrespective of optimum protein level (Group 4 vs 5, Group 6 vs 7).

Although protein levels were also higher in Groups 5, 7 and 9 than in Groups 4, 6 and 8 respectively, the higher protein levels did not appear to be responsible for the improvement in performances in those treatments. Olomu and Offiong (1980) observed that there was no beneficial improvement in performance of broiler chickens fed

Table 16. Effect of eliminating maize in fullfat soybean diet on the performance of broiler chickens 6-9 weeks of age.

Diet Number	Dietary Treatment	Met. Energy	% Protein	Wt.Grain (g)	Feed Intake g/bird	Feed Efficiency g feed/g gain	% Mortility	Feed cost per kg gain (₦)
	% Maize % FFSB							
1	56.35 + - (Control)	3000	20.00	973^{a}	2528^{ab}	2.59^{a}	0.67^{ab}	0.77^{e}
2	44.10 + 33.45 Raw	3000	20.00	666^{b}	2627^{a}	3.94^{a}	0.67^{ab}	0.98^{de}
3	44.10 + 33.45 Cooked	3000	20.00	779^{a}	2574^{a}	3.27^{a}	0.33^{c}	0.82^{e}
4	- + 15.80 Cooked	1445	20.00	330^{e}	2291^{c}	6.94^{cd}	2.00^{ab}	0.97^{e}
5	- + 73.60 Cooked	3000	32.6	452^{d}	2496^{b}	5.52^{b}	0.33^{c}	1.38^{bc}
6	- + 15.80 Raw	1445	20.00	234^{f}	2300^{c}	$9,82^{e}$	2.3^{a}	1.27^{bc}
7	- + 73.60 Raw	3000	32.6	322^{e}	2594^{a}	8.05^{d}	1.00^{ab}	2.01^{a}
8	- + 35.80 Cooked	1983.2	24.4	322^{e}	2393^{bc}	7.43^{d}	0.67^{ab}	1.33^{bc}
9	- + 55.80 Cooked	2521.4	28.73	433^{d}	2504^{b}	5.77^{bc}	0.67^{ab}	1.21^{d}
	SEM	38	97.9	1.47		1.018		0.156

Column values bearing the same superscript or no superscript are not significantly different ($P \geq 0.05$).

on rations containing more than 23% crude protein, at least in terms of growth rate, feed efficiency and feed cost per kilogram of gain. Rather, efficiency deteriorated significantly at 26% crude protein. Similarly, protein levels above 20% did not exert any additional advantage to broiler finisher chickens (6-9 weeks) of age.

Diets containing higher levels of raw or cooked FFSB to replace maize and were optimal in ME or nearly so, had the effect of improving feed intake (Group 5 vs 4; Group 7 vs 6; Group 9 vs 8). In each of these pairs, except in group 9 vs 8, feed intake was significantly depressed in those diets in which the ME was sub-optimal.

Although this seems to follow the pattern of performance in weight gain, it departed from the concept that the higher the energy content per unit of the diet, the lower its consumption. The groups with the poor feed intake values in these pairs were on diets containing high levels of fibre which must have decreased nutrient density. Efficiency of feed utilization was similar for raw and cooked FFSB when in combination with maize and the values were similar to that of the control (Groups 2, 3 and 1). Efficiency of feed utilization for each of the other treatments was significantly lower than the value for groups 2, 3 and 1. Mortality was generally low and did not appear to be affected by treatment.

As in trial 4, the use of large amounts of FFSB in the diets to obtain similar ME to the control diet but in the absence of maize resulted in diets that were too high in protein resulting in an imbalance effect. Similarly, broiler finisher diets designed to obtain 20% protein and based on FFSB as sole protein source and in the absence of maize resulted in diets too low in ME and also resulted in creating

a protein-energy imbalance. In either case the result was a marked depression in performance by those FFSB diets in which maize was eliminated. As in the starter (0-5 weeks) period, optimum ME appeared to be more beneficial than protein level in FFSB diets in which maize had been eliminated. It appeared that FFSB could not fully replace maize in diets for broiler chickens. Where this has been attempted performance characteristics were depressed significantly. However, in combination with maize, cooked FFSB diets could be as good as conventional maize - SBM diet for broiler chickens (Group 3 vs 1) provided ME values of the diets are optimal. The results also confirm earlier findings in the present studies that cooking of FFSB improved its feeding value. Feed cost per kg gain was lowest in the control diet (Group 1) and highest in Group 7 which was raw FFSB diet without maize and containing abnormally high protein level of 32.6%. Feed cost was also significantly higher in Groups 5, 6, 8 and 9 than the control (Group 1). These rations which were without maize, were either sub-optimal in ME or contained higher than the required level of 20% protein. These factors probably impaired efficiency and resulted in higher feed cost per kg gain. Feed cost per kg gain on Groups 2, 3 and 4 did not differ significantly from the control (Group 1).

TRIAL 6

Objective

The previous trials (Trials 4 and 5) had underlined the importance of an optimal energy level in FFSB diets for broiler chickens.

Performance was greatly depressed in groups in which maize was eliminated and replaced by FFSB. Trial 6 was undertaken to further assess the effect of combination of FFSB with maize at two different levels.

Experimental

FFSB was tested in combination with 2 levels of maize. Raw and cooked FFSB were tested at 43.50% in combination with 33.10% maize (Treatments 2 and 3 - Table 17). Then 50% of the maize level was tested in combination with 36.80% or 42.18% cooked FFSB. (Treatments 4 and 5). These were compared to a control SBM-Maize ration and another cooked FFSB ration in which maize was absent to serve as a negative control. It was not possible to adjust the variable components of the rations to make rations 4 and 6 isocaloric with the other rations without altering the protein level. In the case of ration 5, oil was used to make it isocaloric with the other rations without altering the protein level and this resulted in a high fat diet. The composition of the diets used in the trial is shown in Table 17. The treatments employed are shown in Table 18.

Nine hundred (900) chicks were used in the trial. The birds were divided into similar weight groups of 50 birds per group. Three such groups were randomly alloted to each dietary treatments. Other aspects of management of the birds were as outlined in the general experimental procedure.

Table 17: Composition of diets used in trial 6

Ingredients	Control	Raw & Cooked		Cooked FFSB Diets	
	1 %	2 & 3 (%)	4(%)	5 %	6 %
Maize	49.05	33.10	16.55	16.55	-
Fullfat soybean	-	43.50	36.30	42.18	35.00
Soybean meal	43.35	-	-	-	-
Wheat offals	-	19.70	42.95	31.31	57.10
Palm oil	3.90	-	-	6.26	4.20
Bone meal	2.50	2.50	2.50	2.50	2.50
Periwinkle shell	0.50	0.50	0.50	0.50	0.50
Common salt	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.20	0.20	0.20	0.20	0.20
Calculated composition					
Metabolizable Energy (kcal/kg)	3000	3001	2415	3000.7	2253
Protein %	23.3	23.3	23.3	23.3	23.3
Fat %	7.9	10.49	9.80	16.58	8.42
Fibre %	3.79	4.96	4.39	4.04	4.68
Calcium %	1.22	1.22	1.22	1.25	1.23
Total phosphorus %	0.85	1.03	1.22	1.12	1.33
Available phosphorus %	0.59	0.64	0.70	0.65	0.74
Lysine %	1.75	1.30	1.27	1.31	1.29
Methionine %	0.49	0.51	0.49	0.49	0.47
Cystine %	0.37	0.37	0.35	0.36	0.34

*See Table 5 for the composition of the premix.

Results and Discussion

The results obtained in this trial are summarized in Table 18. The analysis of variance results showed a significant influence of dietary treatment on weight gain, feed intake and efficiency of feed utilization.

Results of the previous trials (Trial 4 and 5) had shown that growth improved when dietary ME was optimal. Those results tended to show that optimal ME was more beneficial than protein level.

In this trial, although only two levels of maize were used, results showed that reducing the maize level from 33.10% to 16.50% affected performance characteristics. With such reduction and or elimination of maize, the ME of diets 4 and 6 became sub-optimal and growth was significantly less than that of the control (Group 1) and Group 3 birds which were fed on ration containing 33.10% maize and having optimal ME level. Reduction of maize level in diet 5 reduced growth rate below the level of group 3 and the control, although the ME of the diet was optimal. Maize had been eliminated in diet 6 to serve as negative control and this resulted in sub-optimal ME level. The performance of diet 6 was similar to that of diet 2 which contained raw FFSB and was expected to depress performance as in all previous trials.

In efficiency of feed utilization all the treatments were poorer than the control group. Treatments 2, 4 and 6 were not significantly different and 3 and 5 were not significantly different.

Feed intake of treatments 4, 5 and 6 were not significantly different while feed intake of groups 2 and 3 were not significantly different

Table 18: Effect of maize level in fullfat soybean diets on the performance of broiler chickens 0-5 weeks.

Diet Number	Dietary Treatment		ME Kcal/kg	% Protein	Wt. Gain (g)	Feed Intake g/Bird	Feed Efficiency g feed/ g gain	Mortality	Feed cost /kg gain (₦)
	% Maize	% Soybean							
1	Maize +	SBM(Control)	3000	23.3	635^{d}	1483^{c}	2.34^{a}	3.3^{c}	0.75^{c}
2	33.10 +	43.50 Raw FFSB	3001	23.3	373^{ab}	1353^{abc}	3.63^{cd}	5.7^{c}	1.08^{a}
3	33.10 +	43.50 Cooked FFSB	3001	23.3	510^{c}	1456^{bc}	2.85^{b}	12.7^{a}	0.90^{ab}
4	16.55 +	36.80 Cooked FFSB	2425	23.3	357^{a}	1264^{a}	3.54^{cd}	8.0^{b}	0.743^{bc}
5	16,55 +	42,18 Cooked FFSB	3000.7	23.2	410^{b}	1331^{ab}	3.24^{bc}	8.0^{b}	0.64^{c}
6	- -	35.0 Cooked FFSB	2253	23.3	330^{a}	1282^{a}	3.87^{d}	11.8^{a}	1.00^{a}
	SEM				28	78	0.22	6.39	0.105

Column values bearing the same superscript or no superscript are not significantly different ($P>0.05$).

from the control (Group 1). Lowering the level of maize as in treatments 4 and 5, or eliminating maize as in treatment 6, had the same effect on feed intake.

The birds on treatments 3 and 6 recorded the highest mortality, but there was no difference between treatment 2 and the control (Group 1). Also treatments 4 and 5 were similar inspite of the difference in their ME values.

Groups 4 and 6 were similar in weight gain, feed intake and efficiency of feed utilization, although maize was eliminated in diet 6 and vegetable oil used to raise the ME level. In both 4 and 6 ME was sub-optimal. Diet 5 which had optimal ME, produced better growth response than diet 4 probably because of its optimal ME value.

Results showed that group 3 with cooked FFSB was significantly better than group 2 with raw FFSB in weight gain and efficiency of feed utilization. This confirms findings reported in earlier trials in these studies that cooking of FFSB improved its nutritional value. However, group 2 consumed less feed although the difference was not significant. This seemed to be a direct effect of treatment which improved utilization of cooked FFSB in diet 3.

Although generally performance was below expectation, performance was better at optimal ME level except in group 2 in which raw FFSB impaired growth rate even though the ME of the diet was optimal.

Feed cost per kg gain was highest for Groups 2 and 6 (raw FFSB ration containing maize and cooked FFSB ration containing no maize). These were not significantly different from Group 3. Groups 1, 4 and 5 were not significantly different in feed cost per kg gain although diet 4 contained 2415 kcal/kg diet as compared to

about 3000 kcal/kg in diets 1 and 5. The feeding of cooked FFSB tended to lower feed cost per kg gain compared to the feeding of raw FFSB (Treatment 3 vs Treatment 2) although the difference was not significant. Elimination of maize and therefore lowering the ME value of the diet also increased feed cost per kg gain (Treatment 6 vs Treatment 5).

TRIAL 7

Objective

Studies with broiler starter (0-5 weeks) in trial 6 indicated that efficiency of FFSB rations was governed by energy level of the diet. The maize level in FFSB diet was important in meeting optimum energy level. Varying maize level affected ME value and this depressed performance. Trial 7 was designed to test similar treatment on broiler finishers (6-9 weeks of age).

Experimental

Since the trial was designed to test similar treatments as were applied to broiler starters (0-5 weeks) in Trial 6, the basic experimental design of Trial 6 was not altered. Five diets were used in this trial. Diet 1 was a maize - SBM diet to serve as the control ration. Diets 2 and 3 contained 42.10% maize and 35.25% raw or cooked FFSB respectively. Fifty percent of the maize level in rations 2 and 3, i.e. 21.05% was incorporated into another cooked FFSB ration to constitute treatment 4 while treatment 5 which was made up without maize as energy source served as negative

control (Table 19). Elimination of maize in diet 5 affected the energy value and resulted in the ME value of this diet becoming sub-optimal.

Seven hundred and fifty (750) chickens were used in the trial. They were divided into similar weight groups made up of equal number of males and females per group. Three such groups were randomly alloted to each dietary treatment. There were thus three replicates per treatment. The birds were managed as outlined in the general experimental procedure.

Results and Discussion

The treatments used and the results are summarized in Table 20. In these results, apart from group 2 in which the raw FFSB factor may have depressed growth, the important factor which influenced performance characteristics in the FFSB diets appeared to be optimal ME. In Treatment 5 where there was no maize, the diet did not meet optimal ME value and this resulted in growth rate significantly lower than all the other treatments. Feed intake and efficiency of feed utilization of this group (Group 5) was however, similar to group 2 which was raw FFSB treatment. When maize level was dropped from 42.01% (on which performance was similar to the control) to 21.05% in group 4, it depressed growth rate slightly below that of the 42.10% maize level (Group 3) although there were no differences in feed intake or efficiency of feed utilization. The results thus underlined the importance of optimal ME value in a FFSB diet and the role of maize in meeting optimal ME. However, it is pertinent to observe that other feed ingredients such as oils could be used to raise the ME level in the feed, but such practice might affect cost considerably.

Table 19. Composition of diets used in Trial 7

Ingredients	Control diet	Raw & Cooked FFSB Diets	Cooked FFSB Diets	
	1 %	2 & 3 %	4 %	5 %
Maize	56.35	42.10	21.05	-
Soybean meal	33.10	-	-	-
Fullfat soybean	-	35.25	32.10	21.00
Wheat offals	3.80	18.95	34.45	70.05
Palm oil	3.05	-	8.70	5.25
Bone meal	3.00	3.00	3.00	3.00
Common salt	0.30	0.30	0.30	0.30
Premix*	0.20	0.20	0.20	0.20
DL-Methionine	0.20	0.20	0.20	0.20
Calculated Composition				
Metabolizable energy kcal/kg	3000	3000.2	3000.7	1949.0
Protein %	20.0	20.5	20.3	20.2
Fat %	5.06	8.33	17.33	12.84
Fibre %	3.39	3.64	5.75	8.61
Calcium %	1.18	1.18	1.18	1.19
Total phosphorus %	0.93	1.08	1.19	1.50
Available phosphorus %	0.66	0.72	0.76	0.86
Lysine %	1.41	1.12	1.07	1.00
Methionine %	0.50	0.50	0.46	0.43
Cystine %	0.33	0.34	0.31	0.27

*See Table 5 for the composition of the premix.

Feed cost per kg gain in this trial was lower for cooked FFSB diet at the higher level of maize inclusion i.e. 42.10%, when compared to the raw FFSB diet at the same level of inclusion (diet 3 vs diet 2). Feed cost per kg gain for raw FFSB diet containing maize (Group 2) was, however, similar to that of the control diet (Group 1) and Group 4 which was cooked FFSB diet with 50% of the maize level in treatments 2 and 3. The feeding of diet 5 in which maize was eliminated seemed to result in higher feed cost per kg gain. Although these observed values showed some variabilities the differences were not significant.

Results of these experiments confirmed previous observations with broiler chicks in these studies in which lowering the maize level in the rations significantly reduced the performances of the birds. It seems therefore that lowering of maize level in FFSB rations or eliminating it completely, in attempt to use FFSB as major energy source may invariably result in suboptimal ME value of the rations. Feeding of such rations will probably result in reduced growth and efficiency of feed utilization because of reduced available utilizable energy for maximum growth.

Table 20: Effect of maize level in fullfat soybean diets on the performance of broiler chickens 6-9 weeks trial 7.

	% Maize	% SBM	%FFSB	ME Kcal/ kg	Weight Gain (g)	Feed Intake g/Bird	Feed Efficiency g feed/ g gain	% Mortality	Feed cost/ kg gain (₦)
1.	56.35	33.10	-	3000	1108^{c}	2558	2.30^{a}	-	0.68
2.	42.10	-	*35.25	3000	923^{b}	2564	2.77^{ab}	-	0.69
3	42.10	-	+35.25	3000	1094^{c}	1613	2.39^{a}	-	0.59
4	21.05	-	+32.10	3000	995^{b}	2475	2.48	-	0.66
5	-	-	+21.00	1947	688^{a}	2297	3.32^{b}	-	0.713
	SEM				46	379	0.40	-	0.147

Column values bearing the same superscript or no superscript are not significantly different ($P>0.05$).

* Raw FFSB

+ Cooked FFSB

SECTION 3

PULLET EXPERIMENT

Objective

The purpose of this trial was to test the effect of fullfat soybean as a protein source and an energy source for pullet development from 8-20 weeks of age.

Experimental

The pullets used in this trial were Shaver Starcross egg type pullets. They were reared to 8 weeks of age on deep litter on a common diet devoid of soybean meal. At 8 weeks of age, the birds were randomised into similar weight groups of 40 birds each. Three such groups were placed on each treatment. There were thus three replicates per treatment. The average initial weight per bird was 390 grams. They were innoculated against Newcastle and infectious bursal diseases.

Five dietary treatments were employed in the trial. There was a control diet (Diet 1) in which commercial SBM served as the main source of supplementary protein for comparison with the 4 experimental diets in which FFSB was the main source of supplementary protein. Of the 4 experimental diets, 2 were raw and cooked FFSB diets, each of which contained 18.75% FFSB and 55.25% maize on the one hand and the other 2, raw and cooked FFSB diets each containing 37% FFSB and no maize. These two diets without maize were not isocaloric or

isonitrogenous with the other diets. These were one raw and one cooked FFSB diets in which 37.00% FFSB was the main source of supplementary protein. This resulted in a dietary crude protein value of 24.82% and ME of 2027.14 kcal/kg diet respectively. The composition of these diets is presented in Table 21. There were only 2 variable components in these two rations, namely FFSB and wheat offals. It was difficult to adjust these variable components further without either further lowering the ME or raising the crude protein beyond the value in the table. Feed and water were supplied ad libitum and the experiment lasted from 8 to 20 weeks of age.

Record of weight gain, feed consumption and mortality were kept. Weights of the birds and feed consumption were determined every 28 days throughout the duration of the experiment.

At the end of 20 weeks, the birds were weighed and distributed into 36 cm^2 laying cages, two birds per cage, and fed layers rations in order to study the effect of the rearing rations on their laying performance. No artificial light was provided during the laying period. The ages at first egg, 5% production were recorded and taken to be the day on which the respective percentages were attained and maintained for 3 consecutive days.

Results and Discussion

The result of this trial is summarized in Table 22. Diets 2 and 3 can be compared directly with the control group because in terms of protein level and ME level they were similar. In terms of body weight

Table 21. Composition of diets - pullet trial

Ingredients	Control	FFSB Diets	
	1 %	2 & 3 Raw & Cooked FFSB Diets %	4 & 5 Raw & Cooked FFSB Diets %
Maize	66.80	55.25	-
Soybean meal	18.90	-	-
Fullfat soybean	-	18.75	37.00
Wheat offal	11.70	23.40	60.40
Bone meal	2.15	2.15	2.15
Common salt	0.25	0.25	0.25
Premix*	0.20	0.20	0.20
Calculated Composition			
Metabolizable energy (kcal/kg)	2890	2890	2027.14
Protein %	16.00	16.03	24.82
Fat %	4.06	6.80	10.13
Fibre %	3.82	4.56	8.37
Calcium %	0.84	0.84	0.91
Total phosphorus %	0.81	0.91	1.33
Available phosphorus %	0.52	0.56	0.70
Lysine %	0.98	0.80	1.37
Methionine %	0.43	0.43	0.49
Cystine %	0.27	0.26	0.35

*See Table 5 for the composition of the premix.

performance, the cooked FFSB diet (Group 3) was significantly better than the raw FFSB diet (Group 2) and similar to the control diet (Group 1). Body weight of the birds fed raw FFSB was not significantly different from that of birds fed the control diet. Raw FFSB (Group 2) tended to depress feed intake although not significantly below cooked FFSB (Group 3). Feed conversion was similar for the control (Group 1), raw FFSB (Group 2) and cooked FFSB (Group 3). However, this parameter, namely feed conversion, may not be of particular significance in pullet growth studies, except in so far as it highlights the quantitative utilization of the different rations used in the experiment.

Elimination of maize from the diets containing raw or cooked FFSB resulted in diets that were lower in ME but with protein level of 24.82% as compared to 16%. Feeding of these diets (Groups 4 and 5) resulted in body weight and weight gain which were significantly less on the raw FFSB diet than on the cooked FFSB. Both of these (Groups 4 and 5) were significantly less in body weight and weight gain than the control (Group 1). Feed intake of birds fed FFSB diets without maize were slightly higher, but not significantly so, than that of birds fed cooked FFSB with 55.25% maize (Group 3) and also not significantly different from the control (Group 1). In efficiency of feed conversion, raw and cooked FFSB containing no maize were significantly different and were significantly less than that on the control diet (Group 1). Thus the high protein and sub-optimal ME level tended to result in poor efficiency of feed utilization inspite of increased feed consumption.

Table 22: Effect of fullfat soybean and eliminating maize in FFSB diets on the development of egg type pullet 8-20 weeks of age.

Diet No.	Dietary Treatment			% Protein	ME Kcal/ kg	Body wt. (g)	Weight gain (g)	Feed intake g/bird	Efficiency of feed utilization	Feed cost to 20 weeks (₦)	Age at first egg (days)	Age at 5% production (days)	Age at 50% Production (days)
	%FFSB	%SBM	Maize										
1.Control	-	18.90	66.90	16.00	2890	1343^{cd}	952^{cd}	6673^{b}	7.00^{a}	1.73	142.60^{a}	150.20^{a}	184.60^{b}
2.Raw	18.75	-	55.25	16.03	2890	1286^{c}	891^{c}	6257^{a}	7.02^{a}	1.50	147.60^{b}	155.60^{b}	179.40^{a}
3.Cooked	18.75	-	55.25	16.03	2890	1383^{d}	988^{cd}	6378^{ab}	6.45^{a}	1.53	145.40^{ab}	150.40^{a}	177.60^{a}
4.Raw	37.00	-	-	24.82	2027.14	1095^{a}	700^{ab}	6522^{ab}	9.32^{c}	1.10	165.80^{c}	171.40^{c}	194.80^{c}
5.Cooked	37.00	-	-	24.82	2027.14	1177^{b}	782^{b}	6504^{ab}	8.32^{b}	1.10	167.80^{c}	170.60^{c}	189.40^{b}
SEM						44.2	41.3	215.5	0.44	0.0514	2.28	1.99	2.33

Column values bearing same superscripts or no superscripts are not significantly different (P > 0.05)

Judged by the similarities in weight gain of groups 1, 2 and 3, it can be surmised that raw or cooked FFSB could be used in pullet diets to raise egg type pullets from 8 to 20 weeks of age without adversely affecting body weight, feed consumption or efficiency of feed utilization. However, where these diets are without maize the ME may become sub-optimal. This may create an imbalance in the nutritive ratio due to high protein level. This will result in reduction in body weight which may increase the age at first egg. In this trial age at first egg was similar for cooked FFSB and control (Groups 3 and 1). Raw FFSB significantly increased age at first egg by 5 days as compared to that of the control (Group 2 vs 1). There was no significant difference between raw FFSB and cooked FFSB in the age to first egg. (Group 2 vs Group 3). Eliminating maize completely in raw and cooked FFSB diets, significantly increased age at first egg by between 23 - 25 days. This productive characteristic namely, age at first egg, is a function of dietary treatment during the growing period and is in some large measure influenced by the quality of the diet. Quality of pullet ration is also important up to age at 5% production. Age at 5% production was similar for cooked FFSB and the control group (Groups 3 and 1), but was significantly increased by raw FFSB by about 5 days. The raw and cooked FFSB diets in which maize was eliminated significantly increased age at 5% production by between 20 and 21 days. However, feed cost to 20 weeks of age was lowest on those diets (Treatments 4 and 5) in which maize had been eliminated. Maize elimination from these diets necessitated the use of larger proportions of wheat offal in the diets in order to raise the ME value. This resulted in relatively cheaper rations compared to the rations containing

maize which is a more expensive feed ingredient. The lower feed cost (Table 22) in this case does not, therefore, reflect better biological efficiency as does feed conversion ratio, which was poorer on those rations in which maize had been eliminated.

From the result of the pullet experiment, feeding of egg type pullets on rations containing raw FFSB does not appear to pose serious problems other than slight delay in onset of production. However, feeding of raw or cooked FFSB diets in which maize has been eliminated appears to significantly raise age both at first egg and at 5% production.

SECTION 4

EXPERIMENT WITH LAYING BIRDS

Objective

Experiments with broiler chickens had shown that this category of chickens were not able to efficiently use raw fullfat soybean. Results showed that proper heat treatment was necessary to achieve maximum growth when FFSB was fed. Pullet chickens seem more able to tolerate the presence of raw FFSB in the diet than was the case with broiler chickens. It was then considered necessary to study the utilization of raw and cooked FFSB in the diets of laying birds. The objective of the present trial was to determine the relationship between heat treatment and the utilization of raw and cooked FFSB by laying hens, in the presence or absence of maize in the diet.

Experimental

The birds used in this trial were Shaver Starcross egg type pullets. These birds were raised on the floor on conventional starter and grower diets until 21 weeks of age when they were weighed and randomly distributed into similar weight groups of 24 birds each and placed in laying cages at the rate of 2 birds per 36 cm^2 cage. These birds were housed in open sided poultry house having 0.9 meter high dwarf walls. The group initial weights of the birds were determined.

The composition of the main diets is shown in Table 23. There were 5 diets in the experiment. The control diet was a maize - SBM diet while the experimental diets contained FFSB in either raw or cooked form. The control diet contained 16% protein level and energy of 2400 kcal/kg diet in accordance with the recommendation of Olomu and Offiong (1983). Treatments 2 (raw FFSB diet), and 3 (cooked FFSB diet) also had ME value of about 2400 kcal/kg. Diets 4 and 5, raw and cooked FFSB diets respectively, had ME value of 1120 kcal/kg. These 2 diets contained no maize but had FFSB and wheat offal serving as the main sources of energy. All the diets were supplemented with 0.2% DL-Methionine. Calcium level was maintained at about 3.7%. The levels of available phosphorus in the five treatments were almost similar (1.4 - 1.6%). The calculated contents of total sulphur amino acids (methionine and cystine) are also shown. The calculated methionine + cystine level (0.58 - 0.68) was above the 0.53% recommended for layers by the NRC (1971) and 0.5 - 0.6% recommended by Olomu (1978).

Each experimental diet was fed to 5 groups of 24 birds for a total of 336 days. These 336 days were divided equally into twelve 28 day periods. Data collected were summarized on the basis of these 28 days periods. Feed and water were supplied ad libitum. No artificial lights were provided.

Records were kept of feed consumption, daily group egg production and mortality. One day in each week, average weight of eggs laid by each group was determined. At the end of the 336 days, final body weight was taken before the experiment was terminated. Data collected, based on 28 day intervals, were subjected to analysis of variance.

Table 23: Composition of main diets used in experiment with laying birds.

Ingredients	Control 1 %	Raw and Cooked FFSB 2&3 %	Raw and Cooked FFSB 4&5 %
Maize	50.40	36.65	-
Soybean meal	18.10	-	-
Fullfat soybean	-	20.40	6.10
Wheat offal	21.60	33.05	84.00
Periwinkle shell	7.00	7.00	7.00
Bone meal	2.25	2.25	2.25
Common salt	0.25	0.25	0.25
Premix *	0.20	0.20	0.20
DL-Methionine	0.20	0.20	0.20
Calculated Composition			
Metabolizable Energy kcal/kg	2401	2401	1120
Protein %	16.0	16.8	16.8
Fat %	3.92	6.91	5.47
Calcium %	3.67	3.67	3.68
Total phosphorus %	1.76	1.86	2.30
Available phosphorus %	1.42	1.46	1.60
Lysine %	0.99	1.66	0.81
Methionine %	0.44	0.42	0.37
Cystine %	0.25	0.26	0.21

*See Table 5 for composition of the premix.

Significance of difference between means was determined by applying Duncan's Multiple Range Test (Steel and Torrie, 1960) at the 5% level of probability.

Results and Discussion

The results obtained in the trial are summarized in Table 24. Analyses of variance of these data showed that there were no significant differences in egg production between the control, raw and cooked FFSB where maize was a component of the diet (Groups 1, 2 and 3). Treatments 4 and 5 containing no maize depressed egg production significantly below the level of the other three treatments. Cooking FFSB did not improve egg production in diets where maize was absent (Groups 4 and 5), whereas in those diets containing maize (Groups 2 and 3) egg production of the raw and cooked FFSB groups were similar to that of the control (Group 1).

Although there were variations, feed consumption showed no significant difference between groups 2 and 3 which were raw and cooked FFSB diets with maize, nor were these treatments different from the control diet (Group 1) in terms of feed intake. It would appear that there was no difference in the utilization of raw or cooked FFSB by layers. Eliminating maize completely from the diet resulted in diets which, although isonitrogenous with the other experimental diets, was sub-optimal in ME. This resulted in increased feed consumption (Treatments 4 and 5). This was in agreement with the concept that the lower the dietary energy the greater the consumption of such feed. The consumption of raw and cooked FFSB diets which had no maize (Treatments 4 and 5) was statistically

Table 24: Effect of raw and cooked FFSB and replacement of maize with FFSB on the performance of layers.

	1 Control	2 Raw FFSB Diet with maize	3 Cooked FFSB Diet with maize	4 Raw FFSB Diet without maize	5 Cooked FFSB Diet without maize	S.E.M
Hen Day Production (%)	56.20^{a}	54.68^{a}	53.70^{a}	35.05^{b}	39.47^{b}	1.83
Hen housed production (%)	54.76^{a}	50.34^{a}	50.43^{a}	34.07^{b}	38.30^{b}	1.82
Feed/bird/day (g)	132.88^{a}	138.77^{ab}	140.77^{abc}	157.17^{bc}	160.91^{c}	2.63
Feed/doz. eggs (kg)	2.94^{a}	3.25^{a}	3.27^{a}	7.15^{b}	6.06^{b}	0.34
Feed cost/doz egg (kg)	0.73	0.75	0.75	0.92	0.78	0.03
Initial body weight (kg)	1.24	1.24	1.24	1.24	1.24	-
Final body weight (kg)	2.05	1.89	1.94	1.78	1.78	0.0
Egg weight (g)	59.56^{a}	59.30^{ab}	59.68^{a}	55.42^{c}	57.74^{b}	0.37
Age at 50% Production (days)	184.60^{b}	179.40^{a}	177.60^{a}	194.80^{c}	189.40^{b}	2.33
Age of Peak production (days)	236.20^{a}	254.8^{ab}	276.00^{bc}	335.00^{d}	300.40^{cd}	17.58
Mortality (%)	0.55	1.80	1.00	0.29	0.36	1.084

Column values bearing the same superscript or no superscript are not significantly different ($P>0.05$)

similar and significantly higher than the control. The consumption of these 2 diets was more probably because of their reduced ME value.

The dietary methionine and the total sulphur amino acid levels in the diets were between 0.42 - 0.44 and 0.68% respectively for diets 1, 2 and 3. Diets 4 and 5 contained dietary methionine and total sulphur amino acid 0.37 and 0.58% respectively. These were higher than NRC (1971) recommendation. The significantly poorer productive performance of groups 4 and 5 did not appear to be attributed to sulphur amino acid being limiting. Rather, sub-optimal ME value appeared to be incriminated and this was directly related to the diets being devoid of maize or any other high energy ingredient to raise the ME value while maintaining an optimum protein level.

Efficiency of feed utilization, expressed as feed/dozen eggs, was similar for both raw and cooked FFSB (both containing maize). It would appear that cooking added no beneficial improvement to group 3 birds that were fed cooked FFSB diets in this respect. The control group consumed less feed per dozen eggs although statistically the FFSB diets (Groups 2 and 3) were similar in efficiency to the control group. Efficiency was poorer in treatments 4 and 5 from which maize was absent and this raised feed cost per dozen eggs especially in the case of cooked FFSB (Diet 5). Although the protein value of treatments 4 and 5 were similar to that of 1, 2 and 3, their performance characteristics in this respect was significantly poorer than that of the control and the other 2 experimental groups (i.e. Groups 2 and 3) in which maize contributed to make the ME optimal. In those diets without maize, namely treatments 4 and 5, efficiency of feed utilization was depressed even though the diets

were adequate in methionine. The best feed conversion was obtained from the groups in which the ME was optimum (2400 kcal/kg) and poorest in groups fed on diets in which the ME was sub-optimal (1120 kcal/kg).

Dietary treatment did not have any significant effects on final body weight of the birds after 336 days of the experiment, although birds on treatments 4 and 5 (raw and cooked FFSB diet without maize) tended to be lighter. These same treatments depressed egg weight. Treatments 2, 3 and the control group were similar in this respect and were significantly better than treatments 4 and 5. This result tended to show that reduced egg size could probably be affected by factors other than protein level.

Age at 50% production is a useful production parameter. Analysis of the data on this showed that the complete replacement of maize in the ration and the presence of raw FFSB (Treatment 4) significantly increased age at 50% production as compared to the control group. However, replacing maize completely and in the presence of cooked FFSB (Treatment 5) resulted in age at 50% production similar to that of the control group (Treatment 1). The treatments containing raw and cooked FFSB with maize (Treatments 2 and 3) respectively, attained age at 50% production 5-7 days earlier and were significantly better than the control group (Treatment 1) in this respect. Age at peak production was lowest for the control whereas FFSB diet without maize depressed it significantly. Surprisingly, age at peak production was significantly higher on the diet containing cooked FFSB with maize (Treatment 3) as compared to the control diet (Treatment 1); but age at peak production on raw FFSB diet containing maize (Treatment 2) was not significantly

different from the control. Both raw and cooked FFSB diets without maize increased the age at peak production significantly above those of the control and the other treatment groups (Groups 4 and 5 vs Groups 1, 2 and 3).

Throughout the trial, mortality was extremely low and was not affected by treatment. Although the observed values showed higher mortality percentage levels for groups 2 and 3 (Table 24) than the other treatments, these values were not significantly different.

Apart from slight differences in the ages at 50% production and at peak production, there were no significant differences in any of the other parameters evaluated on the control, raw and cooked FFSB treatments containing maize (Groups 1, 2 and 3). These similarities in the results appeared to indicate the ability of the laying bird to utilize raw FFSB as efficiently as it utilizes cooked FFSB. The marked depression in performance when raw or cooked FFSB was fed in diets in which maize had been eliminated, would be associated with the reduced ME level of those diets which probably did not meet the energy requirement of laying birds.

GENERAL DISCUSSION

One of the important considerations of a feedstuff that is to serve as a protein source for poultry is its balance of amino acids. In the protein of plant origin, the amino acid lysine and the sulphur amino acids, methionine and cystine, may be limiting for growth and other productive function;. Although soybean protein is somewhat deficient in methionine, (Lepley, 1983) argues that soybean has an excellent amino acid balance and can be used as the only source of supplementary protein, but not in its raw form. The relative lysine level does not appear to be limiting. However, the level of sulphur amino acids per 100 of crude protein is low and this suggests that methionine should be added to soybean containing diets.

From the beginning of research on soybean (Osborne and Mendel 1917), it had become obvious that raw soybean was not a satisfactory source of supplementary protein for monogastric species of animals. Proper heat treatment was shown to be an effective way to inactivate components which interfere with protein digestion. The major toxic factor is the trypsin inhibitor. This substance which interferes with protein digestion and absorption, decreases systemic protein utilization either by increasing tissue catabolism or by disrupting protein synthesis and it increases pancreatic enzyme and the pancreas weight in rats and chickens (Myer et al., 1983). Attempt to inactivate the toxic protein in raw soybean to improve its nutritional quality for chickens has been a continuous process, and has been the basis for the present study.

Broiler Experiments

Effects of heat treatment

The first trial was conducted to study the effects of 3 methods of treatment namely roasting, autoclaving and cooking on the nutritive value of fullfat soybean for broiler chickens. Results indicated that during the starting stages (0-5 weeks), the use of raw and roasted FFSB in diets resulted in lower weight gain, decreased feed consumption and a poor efficiency of feed utilization compared to the control and the groups fed cooked and autoclaved soybean diets.

The relatively poor performance of the raw and roasted FFSB groups as compared to the control group and the groups fed on diets containing cooked and autoclaved FFSB seemed to indicate the beneficial effect of cooking and autoclaving in destroying most of the anit-nutritional factors and improving the protein utilization.

The poor performance of the birds fed on diets containing raw soybean appeared to be related to the presence of the inhibitor factor which resulted in poor utilization of raw soybean protein. This was in agreement with the results of Carew and Nesheim (1962) who reported very poor growth rate when chicks received diets containing unheated soybean protein.

There seems to be some controversy as to whether the utilization of unheated soybean by chicks is dependent on the physiological development of the proteolytic enzyme system with age as proposed by Alumot and Nitsan (1961) or whether unheated soybean is inferior to properly heated soybean because of poor availability of amino acids as proposed by Smith and Scott(1965). However, Salman and McGinnis (1968) found no improvement in digestibility of unheated soybean

by chicks up to 6 weeks of age, although the digestibility coefficient for unheated soybean meal was always lower than those of the heated meal. In addition to poor protein utilization, the action of the inhibitor stimulates the pancreas to produce more enzyme to offset the effect of the inhibitor as first reported by Lyman (1957) and Lyman and Lepkovsky (1957), although the increased enzyme production does not appear to improve protein ligestion. This stimulation causes increased protein requirement and probably results in poor performance of birds when raw soybean is fed. In the present investigation, such increased protein requirement could probably explain the poor performance of the birds fed raw FFSB diets.

Ewing (1963) reported that the digestibility of raw soybean protein was equivalent to that of heated soybean protein and that the difference in value was in the different availabilities. The nature of the difference between raw and heated soybean protein involved the availability of sulphur bearing amino acids. He explained that in the raw soybean, methionine was present in moderate quantities analytically,and appeared to be combined as to be only poorly available. Heating released the methionine from an unavailable combination of an unknown nature. Diets containing raw soybean protein were defficient in available cystine and supplied a sub-optimal level of available methionine.

From the result of the experiments with chicks appetite, protein digestibility and nitrogen utilization with its associated pancreatic hypertrophy were probably responsible for the poor performance of the birds on diets containing raw FFSB. In the present trials, feed intake was depressed by raw FFSB diets. Liener (1953) estimated that one half of the growth depression associated with the ingestion

of raw soybean was due to the anti-nutritional factor soyin, which interferes with normal appetite, at least in rats. Liener (1953) also implicated hemmaglutnin, another anti-nutritional factor as a possible feed intake reducer in soybean. The presence of these anti-nutritional factors could explain the lowered feed intake and poor performance of raw FFSB fed birds reported in these studies with chickens. These observations are in agreement with those of Wood et al., (1971) who observed that in young chicks receiving diets containing raw soybean, both appetite depression and antitrypic factors were at work. They associated increased sensitivity (weight loss) to suppression of appetite.

The improvement in performance on diets containing cooked FFSB suggests that the heat treatment during cooking destroyed or sufficiently reduced the anti-tryptic factor to an innocuous level, so that proteolytic activity and nitrogen utilization progressed un-impaired.

Roasting in this study did not appear to be a satisfactory treatment method to enhance the nutritive value of fullfat soybean protein. Other researchers have shown that roasting was not an effective method of enhancing the nutritional value of soybean. Featherstone and Rogler (1966) and White et al., (1967) showed that soybean roasted in an infrared cooker did not promote chick growth as rapidly as soybean meal and added oil. These authors reported that pelleting, however, eliminated the growth depression due to the roasted soybean. Mitchell et.al.,(1972) subjected roasted soybean to further processing and reported that grinding of the roasted soybean through screens smaller than 160 milimeters had no significant effect

on weight gain whether the feed was fed in mash or pellet form. The poor performance characteristics of the group fed on diets containing roasted FFSB indicated the inadequacy of this method in improving the nutritional value of FFSB. It could be that the dry heat employed in roasting rendered other factors unavailable. Evidence of the destructive effect of roasting to legume protein could be advanced in support of this consideration. Methionine has been cited in most literature as the most limiting amino acid in most legume protein followed by lysine. But McOsker (1962) found lysine the most limiting in roasted legumes. He explained that the change in the sequence of limiting amino acid upon roasting might be caused by actual alteration or a decreased availability of lysine. Data in his experiment showed a decrease of about 15 percent of lysine content while methionine was decreased by 10 percent. McOsker (1962) concluded that destruction of lysine, as well as a probable lowering of biological availability was responsible for lysine being limiting following roasting. Other hypotheses can be advanced for the poor performance of the birds fed on diets containing roasted FFSB. Scott, Nesheim and Young (1969) pointed out that most plant proteins contain reducing carbohydrates which readily react with the free amino group of proteins. This carbohydrate-amino acid reaction results in the formation of linkages that are resistant to hydrolysis by digestive enzymes. Lysine is particularly subject to this reaction. Dry heat (as in roasting) accelerates this reaction. Lea and Hannan (1950) reported that even mild heating of protein-carbohydrate mixture can lead to the reaction of the amino group of lysine with the carbonyl group of reducing sugars, producing a bound form of lysine which is unavailable. Evans and Butts (1948) observed that dry heat

treatment of proteins appears to bind lysine in such a manner that it cannot be utilized by the animal. Acid hydrolysis, but not digestion in vivo, can free the lysine that is so bound. Two types of reactions take place when soybean is subjected to dry heat treatment: one is the destruction of lysine and the other a binding of the lysine so that digestive enzymes are unable to effect its liberation. Evans and Butts (1948) observed that lysine is thus made biologically inactive when a complex material such as soybean is subjected to drastic heat treatment, such as roasting. The possibility of reactions of the type in the roasted FFSB used in the trial could not be ruled out as a possible explanation for the poor growth performance of the birds fed rations containing roasted FFSB as a protein supplement.

Chemical availability of lysine has been used to determine soybean quality under experimental conditions and reported availability values have ranged from 76 to 110% (Hill et al., 1966; Kelly and Scott, 1966; Combs et al., 1965; Gupta et al., 1958).

In the present trial, cooking in boiling water significantly improved weight gain, feed intake and feed conversion ratio, indicating satisfactory processing by this method. These findings agree with those of earlier workers (Lepley 1983). Cooking of soybean in water is probably the oldest method of treatment (Lepley 1983). It has been shown that moisture and heat tend to destroy the anti-nutritional factors much faster than dry heat alone (Mustakas et al., 1964; Rackis 1974; Rackis et al., 1975). Soybean subjected to steam heat at 100°C improved the protein efficiency ratio much better than dry heat even over extended period of time (Lepley 1983). It was also

shown by the same author that protein in steam-heated soybean meal did not deteriorate until after 90 minutes of heating.

Autoclaving of fullfat soybean significantly improved performance in the present trial and resulted in performance similar to the control in terms of growth rate and efficiency of feed utilization.

This observation did not differ from that of White et al., (1967), who reported that diets containing raw unextracted soybean produced significantly lower body weight of chicks fed from 7-28 days than did similar diets containing soybean that had been autoclaved. White et al.,(1967) used autoclaved unextracted soybean and extruded soybean meal diets and found that they did not differ significantly from the control diet in supporting body weight and feed utilization, but autoclaving improved the feeding value of unextracted soybean and the quality approached the nutritional value of extracted soybean meal and oil in isocaloric-isonitrogenous diets. However in the present studies birds on the autoclaved FFSB consumed more at 39% level of inclusion of fullfat soybean and less than the controlat the 11% level and showed significant differences at both levels.

The laboratory autoclaved is not considered a practical processing method for soybean for use in livestock feeding because large quantities of the product would be required. However the result of the experiment showed that it was a method of effectively removing some of the anti-nutritional factors in raw soybean. Heat processing, such as autoclaving has been shown to decrease the detrimental effect of many anti-nutritional factors in legume seeds (Ayer et al., 1983). On the basis of the foregoing observations it may be concluded that the combined poor utilization of nitrogen and the depressing effect on appetite

shown when raw and roasted FFSB were fed, does not justify recommending the inclusion of raw FFSB or roasting as a method of treating if for use in the diet of broiler chicks in the starter period 0-5 weeks of age. Cooking in boiling water for 30 minutes is the most practical method of choice. Autoclaving is also effective although laboratory autoclaving is not practical.

During the finishing period raw FFSB depressed performance at 39% level of inclusion while roasted FFSB was similar to the control diet in all the parameters studied. Raw FFSB and the control group were not significantly different at lower inclusion level of 12.5%. At both levels cooked FFSB was superior to all other treatments including the control group.

Although raw FFSB caused a depression in performance at the 35% level, the apparent lack of difference in performance among the control, raw and roasted FFSB at the 12.5% level seemed to indicate that during the finishing period (6-9 weeks of age) broiler chickens might not be so sensitive to soybean trypsin inhibitor (SBTI) and perhaps to other anti-nutritional factors in soybean. This result is in agreement with the observation of Alumot and Nitsan (1961) that chickens from 4 weeks of age could use raw soybean and that intestinal proteolysis progressed and approached normal by the age of 6 weeks. Similarly, Nesheim et al., (1961) indicated that most of the effect on digestibility caused by raw soybean meal disappeared by the time chickens were 4 weeks of age. Saxena et al., (1963) also reported that chickens that were older than 6 weeks or more did not appear to be affected by the toxic factor in raw soybean. Contrary to these observations, Bornstein and Lipstein (1963) reported that age had no

effect on the degree of sensitivity of chicks to the inhibitory properties of raw soybean meal.

In the present trials, the optimum cooking time in boiling water for processing whole soybeans, was found to be 30 minutes of the three durations of cooking employed (15, 30 and 45 minutes). The duration of cooking can either improve or impair the nutritive value of soybean depending on whether it is optimal or excessive. Under-cooking on the other hand, can render SBTI and other anti-nutritional factors still potent in the beans. The increase in the nutritional value of FFSB with 30 minutes cooking time in these trials was probably due to increased digestibility of its protein as a result of inactivation of toxic factors present in soybean. While roasting and 15 minutes cooking were not significantly different during 6-9 weeks of age in any respect, they differed during the starter period with roasted FFSB being significantly better than 15 minutes cooking in weight gain and feed conversion ratio. Infact 15 minutes cooking appeared inferior to raw FFSB in weight gain and feed efficiency, which was not easy to explain. Forty-five minutes cooking also appeared inferior to 30 minutes cooked FFSB during the starter period whereas during the period 6-9 weeks they were similar.

Cooking time of 30 and 45 minutes proved superior to the control group in weight gain during the 6-9 weeks period. The finding of Simovic et al, (1972) may help to explain this observation. Simovic et al, (1972) noted that heat treatment increased the availability of the oil in soybean which resulted in enhanced feed utilization. Thus, the 30 and 45 minutes cooked FFSB soybean diets in the present trials might have been higher in energy than calculated and were

perhaps also higher than the control. This suggests that more utilizable calories were probably available to the chickens fed on the 30 and 45 minutes cooked FFSB diets than were available from the other diets. This is in addition to improved protein utilization as a result of adequate heat application.

Arnold et al, (1971) pointed out that in this type of study feed: gain ratio was probably a better criterion for evaluating optimum time and temperature treatment than weight gain alone. The improvement in performance and the similarity in the results for 30 and 45 minutes cooking time periods both in weight gain and feed gain ratio and even feed intake indicates that the optimum cooking time lies between 30 and 45 minutes. Using feed gain ratio of the control as a criterion for measuring optimum performance, the best cooking time appeared to be 45m minutes but 30 minutes seemed attractive because it is shorter and would mean savings in labour and other inputs.

When Simovic et al, (1972) investigated time temperature relationship using temperatures of 288 - 357°C and times from 30 seconds to 3 minutes, an optimum time was found at each temperature, indicating that shorter treatment time could be used provided the total heat input was similar. This is similar to the high temperature - short time or low temperature - long time heat treatment used in milk pasteurization.

Effects on organ weights

One of the most sensitive tests to measure the effectiveness of processing in destroying the trypsin inhibitor in legume seeds is the

effect of feeding the treated seeds on certain organs particularly the pancreas of the test animals. In the current trial, raw FFSB diet produced relative pancreas weight which was significantly higher than that of the other treatments. Pancreas size of the birds fed the cooked FFSB were not significantly different from the control group. More reduction was observed in the pancreas weight of the 45 minutes cooked FFSB group below the level of the 15 and 30 minutes cooked FFSB group which seemed expected in view of the fact that there was greater heat input in 45 minutes cooking than in 15 minutes cooking to destroy more of the TI in the FFSB. The decrease in relative pancreas weight when cooked FFSB was used in place of raw FFSB agrees with the findings of earlier workers. For example, Featherstone and Rogler (1966), Salman and McGinnis (1968) and Simovic et al., (1972) showed that in addition to improving protein utilization and the performance of the birds, heat treatment of soybean prevented hypertrophy of the pancreas. The increase in pancreas size first reported by Chernick et al.,(1948) was thought to be a compensatory action. Alumot and Nitsan (1961) associated hypertrophy of the pancreas in raw soybean fed birds with increased enzyme production as the pancreas reacts in the presence of TI in the intestines and secretes more enzyme to compensate for the effect of the inhibitor. This increased stimulation of the pancreas results in hypertrophy.

Liver and spleen weights were not affected by treatment. All 3 durations of cooking produced similar spleen weights. Small and insignificant differences were observed in the relative liver weights of the different treatments. Treatment did not seem to have any

effect on relative thyroid weight.

Use of FFSB in rations without maize

Attempt was made to take advantage of FFSB and eliminate maize. When FFSB was used in diets from which maize was absent, the dietary ME were either optimal or sub-optimal depending on the amount of FFSB in the diet. Diets containing higher levels of FFSB were optimal in ME but resulted in protein values above the optimal. Diets containing lower levels of FFSB and were optimal in protein resulted in sub-optimal ME values. Irrespective of whether FFSB was cooked or raw in the diet, optimal ME and sub-optimal protein level or sub-optimal ME and optimal protein resulted in growth depression and poor efficiency of feed utilization. Infact in those diets in which maize and cooked FFSB were both components, performance characteristics were improved and were similar to the control although such combinations in the case of raw FFSB showed a depression in body weight.

Apart from the imbalance effect created by optimal ME with exceedingly high protein levels or sub-optimal ME with optimum protein levels, feeding of the diets with sub-optimal ME resulted in reduced intake of utilizable calories available to the chickens fed on such diets. This might have been the case in those diets containing sub-optimal ME.

In the case of raw FFSB diets in which maize was eliminated other factors might have contributed to the poorer performance as

compared to the cooked FFSB treatment. One is the SBTI and the other, as some reports have indicated, is that raw soybean possesses a heat - labile factor which depresses fat absorption in young chickens (Brambila et al (1961). In addition, the effects of other anti-nutritional factors such as soyin and hemaglutinins probably contributed to the poor performance of the raw FFSB fed birds.

These results thus indicate that advantage may be taken of the higher ME of FFSB, as compared to SBM, in reducing the maize content of broiler diets. However, the results also show that within the limitations imposed by the dietary ingredients used in these trials, it is not possible to eliminate all the maize in broiler diets without detrimental effects. The reason is probably because the restriction in the number of ingredients used does not allow for the formulation of broiler diets of the right C/P ratio using FFSB and in the absence of maize. More research efforts are required in this direction to maximally explore the potential of FFSB in providing most of the energy in broiler diets.

Experiment with Pullets

The use of raw or cooked FFSB in raising egg type pullets from 8 to 20 weeks of age on isocaloric 16% protein diets was investigated. The results showed that raw FFSB fed pullets did not differ from the cooked FFSB fed birds and the control in weight gain, feed intake or efficiency of feed utilization. However, raw FFSB depressed age to 5% egg production by 5.2 - 5.4 days as compared to the control and cooked FFSB treatment.

The relatively little difference in performance between raw FFSB and cooked FFSB groups is probably an evidence of the ability of birds older than 4 weeks to utilize unheated FFSB diets as postulated by Alumot and Nitsan (1961), Nesheim et al, (1961) and Saxena et al (1963). Also the apparent similarity in feed intake, efficiency of feed utilization between raw and cooked FFSB groups supports the observation by Alumot and Nitsan (1961) that proteolytic activity and protein utilization was not affected after 6 weeks of age. On the whole, the use of raw FFSB did not seem to result in any deleterious effect other than delaying age at first egg, by about 5 days, a fact which might even be an advantage considering the fact that poultrymen sometimes favour delaying the onset of production in pullets to prevent the production of many small eggs.

When raw and cooked FFSB were fed in diets without maize but with higher proportions of wheat offal, reduced body weights, depressed efficiency of feed conversion and delay in age to 5% production by about 21 days were observed. However, the feed cost for rearing these pullets to 5% production was considerably reduced when compared to the control diets and those raw cooked FFSB diets with maize.

These observations were probably as a result of the sub-optimal ME and very high protein levels in these maize less diets. These resulted in a disproportion of the calorie protein ratio and a reduction in intake of essential nutrients required for optimum performance. The reduction in the cost of production of pullet is due to the relative cost of wheat offal compared to maize. The results however show that in the absence of maize, healthy pullets can be produced with FFSB serving as one of the main feed ingredients. The

only apparent adverse effect to some producers is the delay in coming to lay which may be an advantage to those producers who want to prevent their birds from coming to lay too early.

Experiment with laying hens

The effect of feeding cooked and raw FFSB on egg production was examined over a 12 month production period in diets which were adequately supplemented with methionine. Productive performance was similar on the control, raw and cooked FFSB diets in terms of hen day or hen housed production. There was also similarity in feed intake, efficiency of feed utilization, final body weight and average egg weight.

Surprisingly, however, the raw and cooked FFSB improved age at 50% production significantly better than the control group, but at peak production the raw was similar to the control and was not poorer than the cooked beans group. These similarities in performance following the use of raw and cooked FFSB by the laying hen was in agreement with Ewing (1963) who observed that chickens would not be adversely affected when some raw soybean meal was incorporated into practical laying rations. Ewing (1963) observed that raw soybean meal when fed at 15% protein level and properly supplemented with methionine and Vitamin B_{12}, would support good egg production as properly heated meal under the same condition. Ewing (1963) contended that the major difference in the utilization of raw soybean meal between laying hens and growing chickens was in the insensitivity of the former to soybean inhibitors. Similarly, Summers et al (1966) found that there were no differences in egg production and egg

quality measurements when the dietary protein was supplied by raw soybean meal, as compared to when it was supplied by heated SBM. This similarity between raw and cooked FFSB for the laying hen is also supported by the work of Fisher et al, (1957) and Saxena et al, (1957) who reported that unextracted unheated soybean flakes supported egg production when the diet was adequate in methionine. Lathshaw (1973) noted that when the diets were adequate in the sulphur amino acids the form of soybean meal whether raw flakes, heated or roasted soybean had no significant effect on egg production, feed intake or mortality although it lowered egg weight and affected body weight.

More recently, Scott (1973) has reported on feeding trials which showed that substituting commercially processed and ground whole soybean for soybean meal in laying hens rations was an attractive alternative to the vagaries of today's protein markets. Scott (1973) reported that egg production and efficiency of feed utilization in hens receiving diets in which the protein and the fat supplements were supplied in the form of processed ground whole soybean were approximately equivalent to the values obtained when commercial dehulled soybean meal and feed fat were used in isocaloric equi-protein diets. This worker found no danger in using processed ground whole soybean in the laying hens rations. The method of processing FFSB in the present study namely cooking for 30 minutes, had satisfactorily improved the nutritive value of soybean for chickens. The inexpensive procedure involved and the recent trend in the price of soybean meal, should make commercial processing of FFSB an attractive alternative.

When maize was completely eliminated from the diets and raw or cooked FFSB used as the main energy source, the ME of the diets became sub-optimal although the diets were still isonitrogenous with the other diets in the experiment. Productive performance in terms of hen day and hen housed production were depressed. Because of the low energy level, feed intake was higher on these diets resulting in poor feed efficiency. Egg weight on the raw FFSB diet without maize was depressed more than that of the cooked FFSB treatment without maize. Age at 50% production and at peak production were substantially increased.

The relatively poorer performance in the absence of maize seemed to indicate that FFSB could not probably be used as the main source of dietary energy. However, in combination with maize FFSB diets had proved to be similar to the control in isocaloric equi-protein diets.

However, it would appear that research has not established a definite consensus as to whether or not raw FFSB can be fed to laying hens without adversely affecting production. Hill and Renner (1963) reported that neither ground raw soybean nor unheated extracted soybean flakes maintained maximum egg production in laying hens. This view had been supported by Rogler and Carrick (1964). Even Ewing (1963) reported that in another experiment when the effects of protein levels, vitamin B_{12}, methionine and crude soybean inhibitor were studied, that raw soybean meal was poorly utilized at 12.21% protein level but this level supported good egg production with the heated meal. From the overall results of the layer feeding trial, it is concluded that raw or cooked FFSB may be included in the rations of laying birds without any adverse effect on the performance of the birds provided the ME and methionine levels are adequate. FFSB rations formulated to

exclude maize or other energy sources may result in sub-optimal ME value and may adversely affect the birds performance.

Pullfat soybean - Its potential as an energy source

The potential which FFSB has as an energy source in diets for chickens rests on the fact that soybean is rich in oil. The oil content ranges between 18 and 20% (Ewing 1963; Oyenuga 1968). However, for the oil to serve as energy source its availability and absorbability when fed in the diet are to be considered. Renner and Hill (1960) observed that the ME of soybean was lower than expected because of the poor absorbability of its oil. Working with flaked soybeans, Carew et al,(1961) reported that the compression of the product during flaking seemed to cause disruption of the cellular structure and make the oil more available to the digestive enzymes. This improvement in availability and absorbability brings about improvement on the ME of soybean. When Nesheim et al, (1961) investigated the effect of raw soybean on fat digestibility and discovered that 2 week old chicks absorbed only 49% of dietary soybean oil while 3 week old chicks could absorb 73%, they thought that the TI in raw soybean oil meal might be involved in poor digestibility of the oil. Diets containing completely heated soybean meal was over 94% absorbed by the chicks. But subsequent research findings (Brambila et al, 1961, Sambath et al, 1967; Garlich and Nesheim 1965) have shown that there is a heat-labile factor in raw soybean which depresses fat absorption in young chickens. Even in laying hens, Hill and Renner (1963) reported that unheated soybean interfered with fat utilization. The utilization of oil in ground soybean is reported to be markedly poorer than if it had been

added to the diet as such.

In the light of the foregoing observations, it would seem that the relatively poor performance of the broilers on diets containing raw FFSB in the present experiments was due not only to the presence of the inhibitor factors in soybean, but also to low level of available utilizable calories because of poor level of oil absorption. Although cooking FFSB destroyed or considerably reduced the TI level and resulted in diets that gave performances that were similar to or even sometimes better than the control in some respects in these experiments, FFSB was only ground and not subjected to any other treatment to further improve the availability and absorbability of the oil so that more utilizable calories could become available to the birds. Carew and Nesheim (1962) had observed that maximum value from heat treated soybean as a poultry feed ingredient can be obtained only if a processing method is used that will allow maximum availability of the oil present in the beans. They reported that poor availability of soybean oil in ground soybean limited its usefulness as an energy source for the chickens. Carew et al, (1961) reported that ground soybean had an ME value that was only 86% of that which would be anticipated on the basis of its composition. Availability of the oil can be improved by flaking before including in the diet and this would improve performance. Earlier Carew et al, (1959) investigated the use of heat treated ground soybeans as a source of soybean oil for improving growth on practical diets but without success and explained that the ME of heated ground soybean was substantially less than that expected from the prior knowledge of the value of soybean oil meal and soybean oil due to poor digestibility.

It seems probably that the improvement in performance resulting from cooking FFSB in the present study could be further enhanced had the beans been subjected to further processing to improve oil availability and absorbability. When White et al (1967) experimented with extruded soybean meal and observed a slightly lower weight gain in chicks receiving the extruded soybean versus the control diet, they found that pelleting extruded soybean resulted in improved live performance which they attributed to reduction in bulkiness. However, Wood et al,(1971) contended that the extra response was not necessarily due to increased diet density per se but more likely a consequence of further heat involved in the pelleting process. But studies on the availability of the oil in extracted soybean by Featherstone and Rogler (1966) showed that grinding alone was not sufficient to make the oil more available. These workers reported that further treatment such as flaking or pelleting resulted in an increase in oil availability. From these observations it would seem that the full energy potential of FFSB would be derived if ground beans are subjected to further treatment.

SUMMARY OF FINDINGS AND CONCLUSIONS

Nine feeding experiments (seven with broiler chickens and one each with pullets and laying hens) were carried out to evaluate the nutritive value of fullfat soybean for chickens. The observations made from the study are summarized hereunder:

Broiler feeding trials

1. Inclusion of 39% or 11% fullfat ground soybean in the diets in the raw or roasted form depressed growth rate of broiler starter chicks (0-5 weeks). Cooking and autoclaving of the fullfat soybean improved performance significantly at both levels of inclusion. At 39% level, autoclaving was much superior to cooking in weight gain, but not in the other parameters studied. Broiler chickens fed the diets containing cooked or autclaved fullfat ground soybean compared favourably with the birds fed the control diet in weight gain and efficiency of feed utilization.

2. Although raw FFSB at 35% level of inclusion depressed growth rate during 6-9 weeks of age, the depression was not as severe at 12.5% level of inclusion. At this level (i.e. 12.5%) the birds fed raw fullfat ground soybean diet were similar to those fed the control diet. At both 35% and 12.5% levels, birds fed the roasted FFSB diet were similar to the birds in the control group in all the parameters tested. Cooked fullfat ground soybean dietary groups were superior to the control group in weight gain but not in feed intake and feed efficiency.

3. Sensitivity to the feeding of raw or roasted FFSB seemed to diminish during the 6-9 weeks of age.

4. Effect of cooking for 15, 30, and 45 minutes showed that the best cooking time ranged between 30-45 minutes. Differences between raw, roasted and 15 minutes cooking on the one hand and 30 and 45 minutes cooking were very precise during 6-9 weeks of age. Raw, roasted and 15 minutes cooking depressed growth rate but 30 and 45 minutes cooked FFSB were similar and improved growth significantly more than the control group. Birds fed the raw, roasted and 15 minutes cooked fullfat ground soybean diets weighed significantly less than 30 minutes and 45 minutes cooked ground soybean diet groups. This fact might be associated with appetite depression which could be associated with under heating.

5. Raw ground soybean dietary treatment significantly increased pancreas weight. Roasted and fullfat soybean cooked for 15, 30 and 45 minutes had no hypertrophic effect on the pancreas. Autoclaving also decreased relative pancreas weight.

6. Addition of 7.5% Fish meal to raw fullfat ground soybean diet with maize, improved growth rate and feed efficiency. Fish meal addition proved more beneficial than addition of 0.2% methionine.

7. Complete absence of maize in the presence of FFSB to serve as main energy source resulted in diets which were too high in protein or too low in metabolizable energy. Each of these conditions resulted in growth depression presumably from effect of imbalance.

It would seem that FFSB could not fully replace maize as an energy source in broiler diets without adversely effecting performance.

8. In combination with maize, cooked FFSB meal could be as good as conventional soybean meal for broiler chickens if the MW value of of the diet is made optimal.

9. The level of maize inclusion tended to influence the ME value in fullfat ground soybean diets. Low maize levels tended to depress ME in the diets and resulted in less utilizable calories available to the birds for growth.

10. In pullet raising, raw or cooked fullfat ground soybean could be used in the diets of egg type birds without adverse effect. When maize was eliminated from the diet the ME value became sub-optimal and resulted in reduced body weight. This increased the age at first egg. Eliminating maize completely in raw or cooked fullfat ground soybean diets in the present experiment significantly increased age at first egg by 22-25 days.

Layers feeding trial

11 The performance of birds that were fed either raw or cooked fullfat ground soybean diets with maize, was similar to that of the birds fed the control diet in all the parameters studied.

12. The birds that were fed either raw or cooked FFSB without maize did not perform as well as those fed on fullfat ground soybean diets with maize as dietary component. Hen day and hen housed production were significantly depressed. Those birds fed on the diets without maize had a poor efficiency of feed utilization as compared to the other dietary treatment groups and the control groups. Feed intake was high probably because of low energy level in the diets. Elimination of maize in the layers diets tended to depress egg weight, age at 50% production and age at peak production.

13. Although all the diets had the same level of methionine supplementation, this did not alleviate the effect of low energy in the diets in which maize had been eliminated.

14. Judging from the overall results of the layer feeding trial, it is concluded that FFSB in the raw or cooked form can serve as a suitable protein supplement without adversely affecting productive performance. However, it does not appear to be able to replace maize completely as the main energy source. In the present study, in combination with maize, raw or cooked fullfat ground soybean diets had given results which were comparable to that of the isocaloric equi-protein control diet.

REFERENCES

REFERENCES

Almquist, H.J., Mecchi, E., Kratzer, F.H. and Grau, C.R. (1942) Soybean protein as a source of amino acids for the chick. J. Nutr. 24: 385-392.

Alumot, E. and Nitsan, Z. (1961). The influence of soybean anti-trypsin on the intestinal proteolysis of the chick. J. Nutr. 73: 71-77.

Anderson, D.L., Hill, F.W. and Renner, R. (1958). Studies of the metabolic and productive energy of glucose for the young chick. J. Nutr. 65: 561.

Applegarth, A. Furuta, F. and Lepkovsky, S. (1964). Morphologic response, growth and microscopy of the pancreas of chickens on raw and heated soybean diets. Poultry Sc. 43: 733-739.

Arnold, J.B., Summers, J.D. and Bilanski, W.K. (1971). Nutritional value of heat treated whole soybean. Can. J. Anim. Sc. 51: 57-65.

Armby, H.P. and Fries, J.A. (1918). Metabolizable energy values for alfalfa hay and starch. J. Agric. Res. 15: 269-289.

Association of Official Agricultural Chemists (1975). Official Methods of Analysis of AOAC, 10th Ed. Washington D.C.

Bajjalieh, N., Orf, J.H., Hymowitz, T. and Jensen, A.H. (1978). Response of young chicks to raw, defatted Kunitz Trypsin inhibitor variant soybean as sources of dietary protein. Poultry Sc. 59: 328-332.

Barnes, R.H. and Kwong, E. (1965). Effect of soybean Trypsin inhibitor and penicillin on cystine biosynthesis in the pancreas and its transport as exocrine protein secretion in the intestinal tract of the rat. J. Nutr. 86: 245-252.

Bird, H.R., Boucher, R.V., Caskey, C.D. Jr.; Hayward, J.W. and Hunter, J.E. (1947). Urease activity and other chemical criteria as indicator of inadequate heating of soybean oil meal. In Methods of Analysis: Association of Official Agricultural Chemists Journal. Vol.30: 355-365.

Booth, A.N., Robbins, D.J., Ribelin, W.E. and De Eds, F. (1960). Effect of raw soybean and amino acids on pancreatic hypertrophy in rats. Proc. Soc. Exp. Biol. Med. 104: 681-683.

Borchers, R., Ackerson, C.W., Sandstedt, R.M. and Kimmett, L. (1947). Trypsin inhibitor: Determination and heat destruction of the trypsin inhibitor of soybean. Arch. Biochem. 12: 367-374.

Bornstein, S. and Lipstein, B. (1963). The influence of age of chicks on their sensitivity to raw soybean oil meal. Poultry Sc. 42: 61-69.

Brambila, S., Nesheim, M.C., and Hill, F.W. (1961). Effect of trypsin supplementation on the utilization by the chick of diets containing raw soybean oil meal. J. Nutr. 75: 13.

Carew, L.B.Jr., Renner, R. and Hill, F.W. (1959). Growth stimulating effect of soybean oil and unextracted soybean flakes in chick rations. Poultry Sc. 38: 1183-1184.

Carew, L.B. Jr., and Nesheim, M.C. (1962). Effect of pelleting on the nutritional value of ground soybeans for the chick. Poultry Sc. 41: 161-168.

Carew, L.B. Jr., Hill, F.W., and Nesheim, M.C. (1961). The comparative value of heated ground unextracted soybean and heated dehulled soybean flakes as a source of soybean oil and energy for the chick. J. Amer. Oil Chem. Sc. 38: 249-253.

Carver, J.S., McGinnis, J.M., McClary, C.F. and Evans, J.R. (1946). The utilization of raw and heat treated soybean oil meal for egg production and hatchability. Poultry Sc. 49: 1373.

Carrol, R.W., Hensley, G.W. and Graham, W.R. (1952). The site of nitrogen absorption in the rat fed raw and heat treated soybean meals. Science. 115: 36-59.

Chernick, S.S., Lepkovsky, S. and Chaikeff, I.L. (1948). A dietary factor regulating the enzyme content of the pancreas. Changes induced in size and proteolytic activity of the chick pancreas by the ingestion of raw soybean meal. Amer. J. Phys. 55: 33-41.

Clandinin, D.R., Gravens, W.W., Elvehjem, C.A. and Halpin, J.C. (1947). Deficiencies in overheated soybean oil meal. Poultry Sc. 26: 150-156.

Combs, G.F., Bossard, E.H. and Childs, G.R. (1965). Importance of considering quantitative consumption in chicks bioassay for available methionine and lysine. Poultry Sc. 44: 1360.

Clandinin, D.R., Bayly, L. and Caballero, A. (1966). Rapeseed meal studies. Effects of 5-vinyl-2 oxazolidinethione, a goitrogen in rapeseed meal, on the rate of growth and

thyroid function of chicks. Poultry Sc. 45: 833-838.

Evans, R.J. and Butts, H.A.(1948). Studies on the heat inactivation of lysine in soybean oil meal. J. Biol. Chem. 175: 15-20.

Evans, R.J., McGinnis, J.M. and St. John, J.L. (1947). The influence of autoclaving soybean oil meal on the digestibility of the protein. J. Nutri. 33: 661.

Ewing, W. Ray (1963). Poultry Nutrition. 5th Ed. Publisher. The Ray Ewing Co. Div. of Hoffman La Roche Inc. California.

Featherstone, W.R. and Rogler, J.G. (1966). A comparison of processing conditions of unextracted soybean for utilization by the chick. Poultry Sc. 45: 330-336.

Fisher,H. and Griminger, P. (1961). Further studies on unextracted raw soybeans for laying hens. Feedstuffs Vol. 33: No. 51: 38.

Fisher, H.D., Johnson, D.Jr. and Ferdo, S. (1957). Utilization of raw soybean meal protein for egg production in the chicken. 61: 611-621.

Fisher, H. and Johnson, D. (1958). The effectiveness of essential amino acid supplementation in overcoming growth depression of unheated soybean meal. Arch. Biochem. Biophys. 77: 124.

Garlich, J.D. and Nesheim, M.C. (1965). The effect of Sodium taurocholate on fat malabsorption induced by feeding unheated soybean proteins. Aroc. Soc. Exp. Biol. Med. 118: 1022.

Griminger, P. and Fisher, H. (1960). Unextracted raw soybean for laying hens. Feestuffs Vol.32 No.12: 18.

Goatcher, W.D. and McGinnis, J.M. (1972). Effect of autoclaving Field Beans (Phaseolus Vulgaris) and of supplementing diets containing beans with amino acids or antibiotics on performance of young chicks. Poultry Sc. 51: 1976-1983.

Gupta, J.D., Dakroury, A.M., Harper, A.E., and Elvehjem, C.A. (1958). Biological availability of lysine. J. Nutr. 64: 259.

Gohl, B.O. (1975). Tropical Feeds: A feed information Summaries and nutritive values. Published by F.A.O. Rome.

Hayward, J.W. (1967). Heat processing of soybean meal for maximum protein quality. Soybean Digest May 1967.

Hayward, J.W. and Hafner, F.H. (1941). The supplementary effect of cystine and methionine upon the protein of raw and cooked soybeans as determined with chicks and rats. Poultry Sc. 20: 139-148.

Hayward, J.W., Steenbock, H. and Bohstedt, G.J. (1936). The effect of heat as used in the extraction of soybean oil upon the value of the protein of soybean oil meal. J. Nutr. 11: 219-234.

Hill, C.H., Borchers, R., Ackerson, C.W. and Mussehl, F.E. (1953). Lack of effect of amino acids on the prowth retardation due to unheated soybeans. Arch. Biochem. Biophys. 43: 286-289.

Hill, F.W. and Renner, R. (1963). Effects of heat treatment on the metabolizable energy value of soybean and extracted soybean flakes for the hen. J. Nutr. 80: 375-380.

Hill, F.W. and Renner, R. (1958). Studies of the metabolizable energy of soybean and soybean products for the chick. Poultry Sc. 32: 1212.

Hill, D. C., Singh, J. and Ashton, G.C. (1966). A chick bioassay of lysine in intact protein as measured by growth assay. Poultry Sc. 45: 1096.

Hill, F.W. and Anderson, D.L. (1958). Comparison of metabolizable energy and productive energy determinations with growing chicks. J. Nutr. 64: 587.

Josefsson, E. (1972). Nutritional value and use of rapeseed meal. In: Rapeseed, cultivation, composition, processing and utilization. Elsevier Publishing Co. Amsterdam, London; New York.

Kelly, M. and Scott, H.M. (1966). Availability of lysine in intact protein as measured by growth assay. Poultry Sc. 45: 1096.

Khayambashi, H. and Lyman, R.L. (1966). Growth depression and pancreatic intestinal changes in rats force-fed amino acid diets containing soybean trypsin inhibitor. J. Nutr. 89: 455.

Kornberg, H.L. and Davies, R.E. (1955). Gastric Urease. Physiol. Rev. 35: 169-177.

Korte, R. (1973). Heat resistance of phytohemapplutinins in weaning food mixtures containing beans (Phaseolus vulgaris). Ecol. Food Nutr. 1: 303.

Kunitz, M. (1945). Crystalization of a trypsin inhibitor from soybeans. Science 101: 668.

Kwong, E. and Barnes, R.H. (1963). Effect of soybean trypsin inhibitor on methionine and cystine utilization. J. Nutr. 81: 392.

Latshaw, J.D. (1973). Soybean processing and its effect on the laying hen. Poultry Sci. Vol. 53: 4. 1342-1347.

Lea, C.H.and Hannan, R.S. (1950). Studies of the reaction between proteins and reducing sugars in the dry state: Nature of the protein groups reacting. Biochem. Biophy. Octa. 5: 433-454.

Lesson, S., Boorman, K.N., Lewis, D. and Shrimpton, D.H. (1974). Metabolizable energy studies with turkeys; Metabolizable energy of dietary ingredients. Br. Poultry Sc. 15: 183-189.

Lepley, K. C. (1983). Fullfat soybean meal for Swine. Animal Nutr. Highlights. July, 1983. Publisher: American Soybean Association. U.S.A.

Liener, I. E. (1953). Soybean processing and its effect on the laying hen. Poultry Sc. 53: 4. 1342-1347.

Liener, I. E. (1977). Protease inhibitor and hemaglutinins in legumes. Published symp. of Food technologists 1975. The AVI Publishing Co. Westport. pp. 284-303.

Lyman, R. L. (1957). The effect of raw soybeam meal and trypsin inhibitor diets on the intestinal and pancreatic nitrogen in the rat. J. Nutr. 62: 285-294.

Lyman, R.L.and Lepkovsky, S. (1957). The effect of raw soybean meal and trypsin inhibitor diets on pancreatic enzyme secretion in the rat. J. Nutr. 62: 269.

McOsker, D.E. (1962). The limiting amino acid sequence of raw and roasted peanut protein. J. Nutr. 76: 453-459.

Melnick, D., Oser, B.L. and Weiss, S. (1946). Rate of enzymic digestion of proteins as a factor in nutrition. Science 103: 326-329,

Mitchell, R.J., P. W. Waldroup, C.M. Hillard and Hazen, K.R. (1972). The effects of pelleting and particle size on utilization of roasted soybeans by broilers. Poultry Sc. 51: 506-510.

Mustakas, G.C., Griffin Jr. E.L., Allen, L.E. and Smith, O.B. (1964). Production and nutritional evaluation of extruded cooked fullfat soybean flour. J. Amer. Oil Chem. Soc. 41: 607-614.

Myer, R.O., Coon, C.N. and Proseth, J.A. (1983). The nutritional value of extruded beans (Phaseolus vulgaris) and extruded mixtures of soybeans in chick diets. Anim. Nutr. Highlights March 1983. Published by Amer. Soybean Association.

Nesheim, M.C. and Garlich, J.D. (1964). Digestibility of unheated soybean meal for laying hens. J. Nutr. 88: 187-192.

Nesheim, M.C., Brambila, S. and Hopkins, D.T. (1961). The effect of raw soybean on fat digestibility in the young chick. Fed. Proc. 20: 368.

Nesheim, M.C., Garlich, J.D.and Hopkins, D.T. (1962). Studies of the effect of raw soybean meal on fat absorption in young chicks. J. Nutr. 78: 89.

Niam, M., Gertler, A. and Birk, Y. (1982). The effect of dietary raw and autoclaved soybean protein fraction on growth, pancreatic enlargement and pancreatic enzymes in rats. British J. Nutr. 47: 281.

Nutrient Requirements of Poultry (1977). National Academic of Science, Washington D.C.

Ogundipe, S.O. and Adams, A.W. (1974). Practical raw unextracted soybean meal diets for egg type pullets. Poultry Sc. 53: 2095-2100.

Ogundipe, S.O. (1980). Effects of boiling and boiling/roasting on subsequent utilization of soybean by chickens. Ph.D. Dissertation, Michigan State University. East Lansing, Mich. U.S.A.

Olomu, J.M. (1978). Protein and energy nutrition of Poultry in Nigeria. In Breeds and Nutrition of Poultry in Nigeria. World's Poultry Sc. Assoc. Nigeria Branch.

Olomu, J.M. (1974). Rapeseed and Rapeseed meals as energy and Protein sources for chickens. Ph.D. Dissertation. Univ. of Alberta, Edmonton, Canada.

Olomu, J.M. and Offiong, S.A. (1983). Performance of Brown egg type layers fed different protein and energy levels in the tropics. Poultry Sc. 62: 345-352.

Olomu, J.M. and Offiong, S.A. (1980). Effects of different protein and energy levels and time of change from starter to finisher rations on the performance of broiler chickens in the tropics. Poultry Sc. 59: 4. 828-835.

Osborne, T.B., and Mendel, L.B. (1917). The use of soybean as a food. J. Biol. Chem. 32: 369-375.

Oyenuga, V.A. (1968). Nigerian foods and feeding stuffs. Their chemistry and nutritive value. 3rd Ed. Ibadan Univ. Press.

Patton, A.R., Wilgus, H.S.Jr. and Harshfield, G.S. (1939). The production of goitre in chickens. Science 89: 162.

Rackis, J.J. (1966). Soybean trypsin inhibitors. Their inactivation during meal processing. Food Technology 20: 102-104.

Rackis, J.J. (1974). Conversion of raw soybean into high quality protein products. Nutrition and Food Science. 2: 299-323.

Rackis, J.J., McGhee, J.E. and Booth, A.N. (1975). Biological threshold levels of soybean trypsin inhibitors by rats bioassay. Cereal Chem. 52: 85-92.

Renner, R. and Hill, F.W. (1960). Studies of the effect of heat treatmento on the metabolizable energy value of soybeans and extracted soybean flakes for the chick. J. Nutr. 70: 219-225.

Renner, R., Clandinin, D.R., Robblee, A.R. (1953). Action of moisture on damage done during overheating of soybean oil meal. Poultry Sc. 32: 582-585.

Riesen, W.H., Clandinin, D.R., Elvehjem, C.A. and Gravens, W.W. (1947). Liberation of essential amino acids from raw properly heated and overheated soybean oil meal. J. Biol. Chem. 167: 143-150.

Ropler, J.C. and Carrick, C.W. (1961). Studies with unextracted soybean for chickens and turkeys. Feedstuffs Vol.33, No.4 26.

Ropler, J.C. and Carrick, C.W. (1964). Studies on raw and heated unextracted soybeans for layers. Poultry Sc. 43: 605-611.

Salman, A.J. and McGinnis, J. (1968). Effect of supplementing raw soybean meal with methionine on performance of layers. Poultry Sc. 47.

Sambath, W., Nesheim, M.C.and Serafin, J.A. (1967). Separation of soybean whey into fractions with different biological activities for chicks and rats. J. Nutr. 92: 479.

Saxena, H.C., Jensen, L.S., Spencer, J.V. and McGinnis, J. (1963) Production, interior egg quality and some physiological aspects of feeding raw soybean meal to laying hens. Poultry Sc. 43: 291-293.

Saxena, H.C., Jensen, L.S. and McGinnis, J. (1963). Influence of age on utilization of raw soybean meal by chickens. J. Nutr. 80: 391-396.

Scott, M.L. (1973). Processed whole soybean in commercial layer diets. Feedstuffs, March 1973.

Scott, M.L., Nesheim, M.C. and Young, R.J. (1969). Nutrition of the chicken. Published by M.L. Scott and Associates, Ithaca, New York.

Serafin, J.A. and Nesheim, M.C. (1970). Influence of dietary heat-labile factors in soybean meal on amino acid pools and turnover in the chick. J. Nutr. 100: 786.

Sharpless, G.R., Pearsons, J. and Prato, G. (1939). Production of goitre in rats with raw and with treated soybean flour. J. Nutr. 17: 545-555.

Sibbald, I.R., Slinger, S.J. and Ashton, G.C. (1962). Factors affecting the metabolizable energy content of poultry feeds. The level of protein and the test material in the diet. Poultry Sc. 41: 107-115.

Sibbald, I.R. and Slinger, S.J. (1963). Factors affecting the metabolizable energy content of poultry feeds. Protein quality. Poultry Sc. 42: 707-710.

Simovic, R., Summers, J.D. and Bilanski, W.K. (1972). Heat treatment of fullfat soybeans. Can. J. Anim. Sc. 52: 183-188.

Sklan, D., Budowski, P., Ascarelli, I. and Hurwitz, S. (1973). Lipid absorption and secretion in the chick. Effect of raw soybean meal. J. Nutr. 103: 1299-1305.

Smith, R.E. and Scott, H.M. (1965). Use of free amino acid concentration in blood plasma in evaluating the amino acid adequacy of intact proteins for chick growth. II. Free amino acid pattern of blood plasma of chicks fed sesame and raw, heated and overheated soybean meals. J. Nutr. 86: 45-50.

Steel, R.G.D. and Torrie, J.A. (1960). The principles and procedures of statistics. McGraw Hill Book Co. Inc. New York, N.Y.

Summers, J.D., McConachie, J.D., Slinger, S.J. and Pepper, W.F. (1966). The value of raw unextracted soybeans for laying hens. Poultry Sc. 45: 165-169.

White, C.L., Greene, Waldroup, P.W. and Stephensen, E.L. (1967) The use of unextracted soybeans for chicks. Comparison of infra-red cooked, autoclaved and extruded soybeans. Poultry Sc. 46: 1180-1185.

Wilgus, Jr. H. S., Gassner, F.X., Patton, A.R. and Gustafson, R.G. (1941). The goitrogenicity of soybeans. J. Nutr. 22: 43-52.

Wood, A.S., Summers, J.D., Moran, E.T. and Pepper, W.F. (1971) The utilization of unextracted soybean for chicks. I. Composition of infra-red cooked, autoclaved and extruded soybeans. Poultry Sc. 46: 1180-1185.

Woodly, A., Summers, J.D. and Bilanski, W.K. (1972). Effects of heat treatment on the nutritive value of whole rapeseed for poultry. Can. J. Anim. Sc. 52: 189-194.

Yates, J.D. (1963). The feeding of unextracted soybeans to poultry. Ph.D. Dissertation. Michigan State University, East Lansag, Michigan, U.S.A.

Yen, J.T., Jensen, A.H., Hymowitz, T. and Baker D.H. (1973). Utilization of different varieties of raw soybeans by male and female chicks. Poultry Sc. 52: 1875-1882.

APPENDICES

Appendix 1: Analysis of Variance of 4-week body weight gain of broiler chickens (Experiment 1)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F. Value
Treatment	4	133359.6	33339.9	76.744**
Residual	20	3394.2	3394.2	7.813
Total	29	11595.2	2898.8	6.673
Grand Total	29	8688.6	434.4	
Grand Mean	310.8	157037.5	5415.1	
Total number of observations	30	157037.5	100.0	

S.E.M. 20.84

** Indicates significant differences due to treatment.

Appendix 2: Analysis of Variance of 9-week body weight gain of broiler chickens (Experiments 2).

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F. Value
		103752	51876	25.434**
Treatment	2	19200	19200	9.413
Residual	6	16060	8030	3.937
Total	11	151251	13750	
Grand Total	11			
Grand mean	786			
Total number of observations	12			

S.E.M. 42.2

** Indicates significant differences due to treatment

Appendix 3: Analysis of Variance of 5-week body weight of broiler chickens (Experiment 3).

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F. Value
Treatment	5	551050.0	110210.0	156.117**
Residual	12	8471.3	705.9	
Total	17	559521.3	32913 .0	
Grand Total	17			
Grand Mean	478.3			
Total number of observations	18			

SEM 26.57

** Indicates significant differences due to treatment.

Appendix 4. Analysis of variance of 9-week body weight gain of broiler chickens (Experiment 3).

Source of variation	Degrees of Freedom	Sum of Squares	Mean Square	F. Value
Treatment	5	66341	13268	2.955**
Residual	12	53871	4489	
Total	17	120212	7071	
Grand Total	17	120212		
Grand Mean	2403			
Total number of observations	18			

SEM 67.0

**Indicates significant differences due to treatment.

Appendix 5. Analysis of variance of effect of treatment on relative organ weights of broiler chickens 0-6 weeks of age.

Source of variation	Degrees of Freedom	Sum of Squares	Mean Square	F. Value
Treatment	6	0.771417	0.128570	20.385**
Sex	1	0.003707	0.003707	0.589
Diet Sex	6	0.007123	0.001187	0.189
Residual	68	0.428863	0.006307	
Total	81	1.211109	0.014952	
Grand Total	83	1.236904		
Grand Mean	0.4156			
Total number of observations	84			

SEM = 0.07942

**Indicates significant differences due to treatment.

Appendix 6. Analysis of Variance of 5-week body weight gain of broiler chickens (Experiment 4).

Source of Variations	Degrees of Freedom	Sum of Squares	Mean Square	F. Value
Treatment	9	921000	102333	97.63**
Residual	20	23355	1168	
Total	29	944355	32564	
Grand Total	29			
Grand Mean	596.5			
Total number of observations	30			

SEM 34.7

** Indicates significant differences due to treatment

Appendix 7. Analysis of Variance of 9-week body weight gain of broilers chickens (Experiment 5).

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F. Value
Treatment	8	1497014	187127	126.552**
Residual	18	26595	1477	
Total	26	1523609	58500	
Grand Total	26	1523609		
Grand Mean	501.1			
Total number of observations	27			
SEM	38.4			

** Indicates significant differences due to treatment

Appendix 8. Analysis of Variance of 5-week body weight gain of broiler chickens (Experiment 6).

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F. Value
Treatment	5	201242.7	40248.5	51.553**
Residual	12	9535.1	794.6	
Total	17	210777.8	12398.7	
Grand Total	17	210777.8		
Grand mean		436.1		
Total number of observations		18		

SEM 28.19

** Indicates significant differences between diets due to treatment

Appendix 9. Analysis of Variance of 9-week body weight gain of broiler chickens (Experiment 7).

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F. Value
Treatment	4	349284	97321	41.790**
Residual	10	20895	2090	
Total	14	370179	26441	
Grand Total	14	370179		
Grand Mean	952			
Total number of observations	15			

SEM 45.7

** Indicates significant differences due to diet.

Appendix 10. Analysis of Variance of age (days) to 5% Production.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F. Value
Treatment	4	2246.160	561.540	90.864**
Residual	20	123.500	6.180	
Total	24	2369.760	98.740	
Grand Total	24			
Grand Mean	159.64			
Total number of observations	25			

SEM	2.486
**	Indicates significant differences due to treatment

Appendix11. Analysis of Variance of age (days) to 50% Production.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F. Value
Treatment	4	1007.76	251.94	2.563*
Residual	20	1965.60	90.28	
Total	24	2973.36	123.89	
Grand Total	24			
Grand Mean	185.2			
Total number of observations	25			

SEM 9.91

* Indicates significant differences due to treatment.

Appendix 12. Analysis of Variance of percentage Hen Day Production (Layers Experiment)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F. Ratio
Treatment	4	4454.12	1113.53	14.630*
Residual	44	3348.95	76.11	
Total	48	7803.07	152.56	
Grand Total	59	11636.06		
Grand Mean	47.7			
Total number of observations	10			

SEM 1.83

* Indicates significant differences due to diets.

Appendix 13. Monthly egg production of layers fed on diets containing raw and cooked FFSB diets and cooked FFSB diets in which maize had been eliminated.

28 Day Periods	Dietary Treatment				
	1	2	3	4	5
1	12.7	13.2	11.6	11.5	13.0
2	17.2	17.8	14.9	10.3	14.8
3	17.0	18.1	16.9	4.9	12.2
4	19.8	17.9	16.7	12.7	12.4
5	13.5	10.5	7.3	4.8	6.1
6	19.1	18.3	18.8	10.7	8.6
7	17.8	17.2	17.7	11.9	7.5
8	17.9	13.8	15.3	4.7	4.5
9	14.4	11.8	13.4	3.5	10.5
10	15.3	13.6	11.7	15.2	13.6
11	11.9	12.9	12.2	13.9	14.4
12	8.3	8.8	9.6	4.6	4.5
Total Eggs	184.9	173.9	166.1	98.7	122.1
Average for each 28 day period	15.4	14.5	13.8	8.2	10.2