

Influence of processing temperature on chemical composition of solar-dried blood meal and on performance of broiler chickens

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ABSTRACT

An experiment was conducted to ascertain the optimum temperature for cooking (pre-heating) raw blood before solar drying. Raw blood was subjected to three cooking temperatures (50°, 70° and 90°C) for 30 min before solar drying at a temperature range from 45° to 56°C. In a feeding trial, four hundred and eighty 14-day-old broiler chickens were randomly allocated to four groups. The dietary treatments consisted of the control diet, which contained fish meal and soyabean meal as the main protein sources, and three isoenergetic and isoprotein diets each of which contained 75 g of one of the three types of solar dried blood meals (SDBM) kg⁻¹. Feed and water were provided *ad libitum* for a period of 6 weeks.

There was no significant effect of the cooking temperature on the chemical composition of the solar-dried blood meals. The dietary treatments did not have significant ($P>0.05$) impact on feed intake, body weight gain, feed conversion efficiency or carcass yields. There were no health-related problems nor mortality attributable to the addition of SDBM to the diet.

KEY WORDS: processing temperature, blood meal, chemical composition, broiler chickens, growth performance

INTRODUCTION

Fish meal is an important constituent of broiler chickens diets because of its high protein content and good amino acid profile. However, its use is constrained by its high cost with consequent high prices of eggs, poultry meat and products. There is, therefore, the need for continuous search for new dietary protein ingre-

dients. The slaughter of animals for meat purposes generates considerable amount of blood (Ayangbile et al., 1993). Blood meal contains about 800 g protein kg⁻¹ dry matter (DM), 90 g lysine kg⁻¹ DM and small amounts of ash and lipids. However, a notable feature of raw blood is its high moisture content. This makes it particularly sensitive to deterioration by endogenous enzymes and to microbial putrefaction. It must necessarily be processed before incorporation into animal diets.

Various industrial procedures have been employed in preparing blood meal. However, in some areas, where conventional protein feedstuffs such as fish meal are either scarce or expensive, blood from slaughterhouses is discharged into drains, streams and rivers, thus polluting the environment because facilities for drying may not be available. This points to the need for simple procedures for preparing blood meal to be used in poultry feeds. In the tropics, where there is abundance of sunlight, solar drying has been advocated as a simpler and cheaper method for drying than other industrial methods. Donkoh et al. (1999) described a solar-drying method in which the raw blood from the slaughterhouse was pre-heated in an open pan for 30 min at a temperature of 60°C to facilitate evaporation of water and coagulation. The coagulated blood, together with the small amount of the liquid fraction which remained, was transferred to a solar dryer for drying at 35°-50°C to a moisture content of about 100 g kg⁻¹DM. However, evidence indicates that processing may, if not carried with careful control, reduce the nutritive value of the product. Overheating during the preparation of blood meal can seriously lower digestibility and the availability of specific amino acids, particularly lysine (Hamm and Searcy, 1976; Moughan and Donkoh, 1991; Crawshaw, 1994; NRC, 1994). Since blood is susceptible to damage from processing, an optimum temperature for cooking (pre-heating) raw blood efficiently without damaging the nutritive quality would be desirable for the solar-drying technique.

The objective of this study was to determine the optimum temperature for cooking raw blood before solar drying and further ascertain the growth performance of broiler chickens fed diets containing the variously processed meals.

MATERIAL AND METHODS

The blood used in the study was obtained from the Meat Science Unit of the Department of Animal Science, Kwame Nkrumah University of Science and Technology, Kumasi (Ghana). The raw material comprised mainly of blood obtained as a result of pig slaughterings but included small amount of that of cattle. The raw blood was divided into four portions and subjected to the following heating regimens: Treatment 1: raw clotted blood was placed in the solar dryer without pre-heating, Treatment 2: raw blood was heated in an open pan for 30 min at a temperature of 50°C,

Treatment 3: raw blood was heated for 30 min at a temperature of 70°C,
 Treatment 4: raw blood was heated for 30 min at a temperature of 90°C.

The coagulated blood from Treatments 2, 3 and 4 were transferred to a solar dryer. The dryer consisted of a four-panel solar collector, which contained a black-painted absorber. The collector was covered by a transparent, ultra-violet stabilised polythene sheet. Three axial flow fans of 40-watt output each are positioned under the collector, and one end of the tunnel was sealed. The fans, powered by a photovoltaic solar panel mounted above the collector, forced the hot air through the tunnel into a drying chamber. Access to the drying chamber was through a wooden gate at the top of the chamber. The wooden gate was covered with a fly-proof net, which allowed the dehydrating air to escape. Incoming air had to pass the fans at the end of the collector, although measures were taken to prevent dirt from entering the chamber. The aim of the process was to encourage the evaporation of moisture from the surface of the blood and the migration of moisture from inside the coagulated blood to its surface. Crucial factors in this process included ensuring a steady flow of warm air. The temperature, air speed and relative humidity were measured during the drying process using Almemo 2290-8 data logger (Table 1). The recording of data took place between 08.00 and 18.00 h GMT. The rate of dehydration was measured by weighing the blood at 2-h intervals. The raw blood, which was not cooked before being placed in the solar dryer, deteriorated in condition (i.e. got rotten) and was therefore discarded.

TABLE 1
 Drying conditions recorded in the solar tunnel and outside between 08.00 and 18.00 GMT

Parameters	Solar tunnel		Ambient	
	minimum	maximum	minimum	maximum
Temperature, °C	45	56	26	31
Relative humidity, %	19	30	56	76
Air speed, ms ⁻¹	0.28	0.52	0.12	0.30
Dehydration rate, gH ₂ O min ⁻¹	12.8		8.6	

Proximate analyses (dry matter, crude protein, ether extract, ash and crude fibre) of the variously processed solar-dried blood meals (SDBM) were carried out using the standard procedures of the AOAC (1990) while water activity was measured using a Durotherm aw Wert-Messer meter. Available lysine contents of the SDBMs were determined by the Ousterhout and Wood (1970) modification of the method of Kakade and Licner (1969). The metabolizable energy (ME) contents of the different types of SDBM were estimated using the formula indicated by Pauzenga (1985):

ME (kcal/kg) = (37 x % protein) + (81.8 x % fat) + (35.5 x % nitrogen-free extractives).

The chemical composition of the SDBMs is presented in Table 2.

Total surface viable microbial counts and isolation (Table 3) were determined on the fresh blood and each of the three types of SDBM by the method outlined by Bainbridge et al. (1996), while identification of microbes, which involved the examination of colonial characteristics, morphology, motility, staining and biochemical properties, was carried out using the guidelines of the International Commission on Microbiological Specifications for Food (1978).

TABLE 2
Dry matter content, g kg⁻¹ and chemical composition¹ of the three types of processed blood meal (in g kg⁻¹DM, except water activity and ME)

Component	Type of blood meal		
	SDBM1	SDBM2	SDBM3
Dry matter	950.0	960.0	950.0
Water activity, a _w	0.22	0.20	0.22
Crude protein	819.0	825.0	836.0
Crude fibre	30.0	36.0	31.0
Ether extract	13.2	13.7	14.7
Ash	42.0	40.0	41.0
Nitrogen-free extractives	45.8	45.3	34.0
Available lysine	72.8	73.5	73.0
Metabolizable energy, MJ kg ⁻¹	13.81	13.92	13.84

¹each value is the mean of triplicate determinations

TABLE 3
Mean viable counts (x 10²) g⁻¹, kinds and numbers (x 10²) g⁻¹ of microflora isolated from fresh and processed blood¹

Item	Fresh sample	SDBM1	SDBM2	SDBM3
Mean viable count	20.9 ± 0.60	2.6 ± 0.15	2.4 ± 0.18	2.7 ± 0.17
Species				
Coliforms	1.8 ± 0.25	0.4 ± 0.09	0.3 ± 0.05	0.5 ± 0.07
<i>Escherichia coli</i>	2.7 ± 0.26	0.1 ± 0.01	0.2 ± 0.03	0.1 ± 0.02
<i>Mucor</i> spp.	6.5 ± 0.38	0.7 ± 0.10	0.8 ± 0.09	0.8 ± 0.10
<i>Proteus</i> spp.	3.3 ± 0.41	0.5 ± 0.11	0.4 ± 0.08	0.6 ± 0.10
<i>Staphylococcus</i> spp.	3.6 ± 0.32	0.6 ± 0.15	0.8 ± 0.19	0.9 ± 0.18

¹each value is the mean of triplicate determinations

Four experimental diets (Table 4) were formulated: a control diet which contained no SDBM and diets 1, 2 and 3 which contained 75 g SDBM 1 (preheated at

50°C), SDBM 2 (preheated at 70°C) and SDBM 3 (preheated at 90°C) per kg diet, respectively. The diets were formulated to be isoprotein and isoenergetic.

TABLE 4

Composition of experimental broiler diets

	Experimental diets			
	Control	1	2	3
Ingredients, g kg ⁻¹				
maize	580	580	580	580
solar-dried blood meal	0	75	75	75
fish meal	190	100	100	100
soyabean meal	60	35	35	35
wheat bran	140	180	180	180
oyster shell, ground	10	10	10	10
dicalcium phosphate	10	10	10	10
vitamin/mineral premix	5	5	5	5
NaCl	5	5	5	5
Chemical analysis, g kg ⁻¹ DM				
crude protein	223.1	221.3	221.8	222.1
crude fibre	34.4	38.4	38.8	38.5
crude fat	36.2	33.7	33.8	33.8
lysine	11.8	13.6	13.6	13.6
methionine	5.1	4.4	4.4	4.4
isoleucine	8.9	7.3	7.3	7.3
ME, MJ kg ⁻¹ ^b	11.50	11.55	11.56	11.55

^a vitamin-mineral premix supplied (kg⁻¹ diet): vit. A, 7500 IU; vit. D₃, 2200 IU; vit. E, 9.5 IU; (mg): vit. K, 1.7; riboflavin, 2.5; cobalamin, 0.05; pantothenic acid, 6; niacin, 20; choline, 240; folic acid, 0.5; Mg, 2.3; Fe, 45; Cu, 5.5; Mn, 55; Zn, 50; I, 0.8; Co, 0.2 mg

^b calculated according to National Research Council data (1994)

Four hundred and eighty unsexed 14-day-old commercial broiler chickens (Afabro strain) were individually weighed. Three replicates were allotted randomly to the four dietary treatments. Forty birds were placed in deep litter pens each measuring 9.6 m². The study was conducted for 42 days. Birds had free access to feed and water throughout the experimental period. Chickens were vaccinated against Gumboro and Newcastle diseases. They were also protectively medicated for *Coccidiosis* at 3 days of age and again during the third week using sulphadimidine sodium 33% *via* the drinking water.

The parameters studied included: feed intake, body weight gain and feed conversion efficiency (feed:gain ratio). Records of mortality were also kept. At 56 days of age, all birds were weighed and four broilers from each of the 12 replicates were selected at random, starved of feed for 18 h, killed by cutting the jugu-

lar vein, exsanguinated, defeathered and eviscerated. Carcass yield was calculated from eviscerated weight and liveweight.

Statistical analysis was accomplished by the one-way analysis of variance (Steel et al., 1997).

RESULTS AND DISCUSSION

The data on the drying conditions recorded between 08.00 and 18.00 GMT are presented in Table 1. The maximum temperature attained in the solar drying chamber was 56°C, which was 25°C higher than the ambient temperature. A high and constant wind speed increased the rate of drying. Using the solar tunnel, the times for the drying of the blood cooked at 50°, 70° and 90°C were 48, 36 and 24 h, respectively, compared to 84, 72 and 60 h for the traditional open air method. The longer time taken by the blood sample cooked at 50°C to dry might be attributed to the high moisture content after cooking compared with that cooked at 90°C. As indicated earlier, the uncooked (raw) blood got rotten when it was placed in the solar dryer and was therefore discarded. The spoilage of the uncooked blood sample might be attributed to its high moisture content and temperature, which made it susceptible to rapid deterioration by endogenous enzymes and to microbial putrefaction. Thus, raw blood must be preheated or cooked before solar drying to facilitate evaporation and coagulation and therefore enhance the keeping quality during solar drying. However, in cooking, care should be taken to avoid prolonged heating since this can result in considerable damage to the protein with the loss of digestibility and protein quality (Miller and De-Boer, 1988).

The results of the chemical analysis (Table 2) of the three types of processed blood meals show the products to be good sources of high quality nutrients. The fact that the SDBM contained high amounts of total protein (819-830 g kg⁻¹) and available lysine (72.8-73.5 g kg⁻¹) indicates that the processing conditions used did not adversely affect the nutritional quality of the resultant products. Crude protein and available lysine content in meals are similar to values reported by Donkoh et al. (1999) for SDBM preheated at 60°C before solar drying.

A moisture content of 5% and water activity of 0.22 a_w will inhibit the growth and development of microorganisms, while yeast or mould cannot grow at water activity level of below 0.62 a_w . The water activity level of 0.22 a_w obtained in the meals falls below the guidelines of the Food and Agriculture Organization (1990) for dried products (0.5 a_w to 0.75 a_w). Consequently, the SDBMs will have long shelf life.

There was no impact of processing condition on the mean total viable microflora count of the processed blood meals. In all it was lower than in the fresh blood sample (Table 3). Microflora isolated from the fresh blood samples included

Staphylococcus spp., coliforms, *Escherichia coli*, *Proteus* spp. and *Mucor* spp. The samples were, however, free from pathogenic bacteria such as faecal coliform bacteria and *Salmonella*. Similarly, *Staphylococcus* spp., coliforms, *Escherichia coli*, *Proteus* spp. and *Mucor* spp. were recovered from the solar-dried blood meals, though at relatively lower numbers. Tests for the microbiological counts of the various blood meals indicate that dehydration alone may not be sufficient to eliminate microorganisms, demonstrating the need for strict hygiene before and after the drying process.

The general performance of the experimental chickens is shown in Table 5. Average feed consumption per bird for the 6-week period ranged from 3.39 to 3.51 kg. Feed intake by broiler chickens was not significantly ($P>0.05$) influenced by the inclusion of the various SDBM in diets.

TABLE 5
Effect of processed blood meal on the performance of broiler chickens^a over the period from 14 to 56 days of age

Indices	Dietary treatments				SEM
	Control	1	2	3	
Feed intake, kg	3.45	3.39	3.40	3.51	0.09
Protein intake, kg	0.77	0.75	0.75	0.78	0.013
Initial body weight, kg	0.226	0.231	0.228	0.220	—
Body weight gain, kg	1.74	1.62	1.69	1.73	0.03
Feed conversion ratio, kg feed/kg body weight gain	1.98	2.09	2.01	2.03	0.002
Mortality, %	0.83	0.83	1.67	1.67	0.33
Carcass yield, % LBW	70.5	70.3	70.3	71.1	0.004

SEM – standard error of mean

^a n = 120 birds for each dietary treatment, with 3 replicates per treatment

LBW – live body weight

Similarly, there were no substantial differences in mean body weight gains between birds fed the SDBM-free (control) diet and those which contained the different types of SDBM. The efficiency with which feed was converted to weight gain (feed:gain ratio) was also unaffected by dietary treatments.

The carcass yields of broiler chickens fed diets with or without SDBM were similar, indicating the inclusion of the SDBM preheated to various temperatures before solar drying, exerted no significant impact on this parameter.

A total of seven mortality cases were recorded during the experimental period (Table 5). Post-mortem autopsies indicated no specific causes for deaths attributable to inclusion of the SDBM.

It seems that raw blood may be cooked between the temperatures of 50° and 90°C before solar drying to facilitate evaporation of water and coagulation without adverse effect on the chemical composition and nutritional value of the SDBM. The lowest cooking temperature effectively prevented deterioration of the blood meal as the higher cooking temperatures and thus its use might be more economical. Processed blood meals may be included in broiler diets at a level of 75 g kg⁻¹ in place of fish meal and other protein sources without detrimental effects on growth performance.

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STRESZCZENIE

Wpływ temperatury na skład chemiczny suszonej na słońcu mączki z krwi i wyniki produkcyjne kurcząt brojlerów

Celem doświadczenia było określenie optymalnej temperatury podczas wstępnego ogrzewania surowej krwi przed jej suszeniem na słońcu.

Surową krew ogrzewano w temperaturze 50°, 70° lub 90°C przez 30 min przed suszeniem jej na słońcu, w temperaturze wahającej się od 45° do 56°C. W 6-cio tygodniowym doświadczeniu żywieniowym, 408 14-to dniowych kurcząt brojlerów podzielono losowo do 4 grup i żywiono następującymi dietami: kontrolną, w której głównym źródłem białka była mączka rybna i śruta sojowa oraz 3 izoenergetycznymi izobiałkowymi dietami, zawierającymi po 75 g jednej z trzech rodzajów mączki z krwi (SDBM) kg⁻¹. Pasze i woda podawane były do woli.

Nie stwierdzono istotnego wpływu temperatury ogrzewania na skład chemiczny suszonej na słońcu mączki z krwi. Podobnie nie stwierdzono istotnych różnic ($P > 0,05$) w pobraniu paszy, przyrostach, wykorzystaniu paszy oraz wydajności rzeźnej, a także w stanie zdrowia i upadkach kurcząt pomiędzy grupami.