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NUTRIENT COMPOSITION, PEST AND MICROBIAL STATUS AND EFFECTS OF DISCARDED BISCUITS ON THE GROWTH PERFORMANCE, CARCASS CHARACTERISTICS AND ECONOMIC PROFILES OF GROWING-FINISHING PIGS

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ABSTRACT

A ten-week experiment was conducted to evaluate discarded biscuits (DB) as an alternative to maize in pig diets. Proximate composition, pest and microbial status of the DB and its effects on growth performance, economics of production and carcass characteristics of growing-finishing pigs were determined. Twenty Large White starter pigs aged 9-10 weeks with an average initial weight of 16.6kg were allotted to 4 dietary treatments with 5 replicates in a Randomized Complete Block Design (RCBD) based on their weight and sex. They were fed *ad libitum* with isonitrogenous diets containing 0%, 10%, 20% and 30% levels of DB replacing similar amounts of maize and labelled 0%DB (Control), 10%DB, 20%DB and 30%DB, respectively. Prior to the feeding trial, samples of the DB were studied for their proximate composition, pest and microbial status. The DB contained 17.0% moisture, 9.90% crude protein (CP), 0.63% crude fibre (CF), 11.0% ether extract (EE), 0.50% ash and 60.97% nitrogen-free extract (NFE). *Tribolium* species was the main insect pest identified in the samples; both live and dead forms were observed. The microbial analysis uncovered three (3) fungi species, namely *Penicillium sp*., *Aspergillus niger* and *Aspergillus versicolor* with *Penicillium sp*. being the most dominant. There were no significant (P>0.05) differences in the values for the average daily feed intake (ADFI), total feed intake (ATFI), daily weight gain (ADWG), total weight gain (ATWG) and feed conversion ratio (FCR) for the four dietary treatments. There was a linear decrease in feed cost as the level of DB increased in the diet, and the cost of gain followed a similar trend. Carcass characteristics were similar (P>0.05). It was concluded that DB could constitute as much as 30% of the diet and replace about 60% of the maize in the diet of growing pig without any adverse effect on growth performance and carcass characteristics.

Key words: Back fat, discarded biscuit, carcass, insect pests, microbial status, pigs

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INTRODUCTION

Maize has for a long time been a traditional and indispensable cereal grain in the commercial diets of monogastric farm animals in Ghana [1]. Maize typically forms anywhere from 50-60% of such diets [1]. However, the competition between humans, livestock and industries has brought about a high demand for maize resulting in the escalating price of maize and consequently the cost of feeding pigs and poultry [2]. The solution to this problem of escalation in prices of maize and animal products may be in the use of alternative feed ingredients that are cheaper and not competed for with man. In an effort to find alternate sources of feedstuffs, several studies have been conducted to determine the suitability of some agro-industrial by-products (AIBP) as feed ingredients in the diets of pigs and poultry. Ghana abounds in a wide variety of AIBP and crop residues that can be used as alternative feed resources for pigs to help reduce the competition between humans and some livestock species and poultry for the same ingredients such as maize and fish [3]. Even though no accurate figures are yet available, the few biscuit factories in Ghana produce substantial quantities of by-products, which are usually discarded [4]. These discarded biscuits are not used as human food on aesthetic and health grounds. There is a dearth of information on the physical characteristics of DB. Of particular concern to animal nutritionists and all current and potential users of DB should be the pests and microbial profile of DB since these affect the nutritive value. Furthermore the few studies done earlier in Ghana including the report [5] have been short-term in nature and have not provided the necessary details to ensure optimum utilisation of the DB currently available in some parts of the country. The objective of the current study is to address the above-mentioned concerns and to provide further information on the usefulness of the locally available DB in swine feeding operations.

MATERIALS AND METHODS

Source of the DB and other feed ingredients

The DB was obtained from the Britannia Biscuit factory, Spintex Road, Accra through a sales agent in Kumasi. The other ingredients used in the experiment were obtained from the open market in the Kumasi metropolis.

Processing of DB

Before the DB was used, all foreign materials like polyethylene materials, pieces of sticks and biscuit wrappers were removed and discarded. The DB was then milled in a hammer mill to obtain a particle size of 2mm.

Location of the study

Pest and microbial identification of the DB samples were done at the entomology and pathology laboratories respectively of the Department of Crop and Soil Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. Proximate composition of the DB and the diets used in experiment, and the feeding trial on the other hand, were done in the Animal Nutrition laboratory and the livestock section, respectively, of the Department of Animal Science, KNUST, Kumasi. The average maximum and minimum temperature for the experimental area during the feeding trial

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was 33.5ºC and 22.3ºC respectively while the mean relative humidity was between 66.5% and 88.5%. The feeding trial spanned a period of ten (10) weeks.

Pest, microbial and chemical analysis of DB

Live and dead pests were identified by physical examination of a known quantity of the DB with a hand lens [6]. Microbial analysis was done by a fivefold-six step serial dilution of DB. A 0.1ml of the diluent was then used to inoculate potato dextrose agar (PDA) which was subsequently incubated at a temperature of 27± 2ºC for 5 days. Fungal cultures formed were identified under a light microscope [7] using their morphological and cultural characteristics [8]. The proximate composition of the DB and the experimental diets were determined using the procedure outlined by the Association of Official Agricultural Chemists [9]. The proximate components determined included: moisture, CP, EE, CF, ash and NFE.

Experimental animals, design of the experiment

Twenty (20) Large White starter pigs (12 females and 8 males) with an average initial weight of 16.6 kg were randomly allotted to four iso-nitrogenous dietary treatments in a Randomized Complete Block Design (RCBD) based on their sex and weight. Each treatment consisted of 2 males and 3 females. The treatments were designated 0%DB (Control-no inclusion of DB), 10%DB (each 100kg diet contained 10kg of DB), 20%DB (each 100kg diet contained 20kg of DB) and 30%DB (each 100kg diet contained 30kg of DB) (Table 1). The level of inclusion of maize was reduced with the addition of DB. Each treatment was replicated five times.

Housing, management and feeding of pigs

Pigs were housed in a 160 × 66 × 103 cm^3 welded wire mesh, individual concrete-floored cages which have been constructed within roofed pens measuring 3.6 × 3.1m^2. Each pen had four individual cages and each cage was provided with a concrete water and wooden feed trough. Pens and water troughs were washed daily. Pigs were given *ad libitum* access to feed and water during the entire experimental period.

Parameters measured

The body weight of each animal was taken prior to the commencement of the experiment and subsequently on weekly basis. The difference between initial weight and the final weight of each pig was considered as total weight gain. The total weight gain was divided by the number of days spent by each animal on the experiment to obtain the daily weight gain. Amount of feed consumed by each pig per week was measured and the total feed consumed by each animal was obtained by adding the individual weekly feed intakes. Daily feed intake was determined by dividing the total feed intake by the duration. Feed conversion ratio (FCR) was calculated as the ratio of feed consumed to the weight gain. Feed cost was calculated using the prevailing market prices of the various feed ingredients whilst feed cost per kg weight gain was obtained by multiplying the feed cost by the FCR.

Carcass evaluation

After each pig has attained the target weight of 65±2.5kg it was slaughtered for subsequent carcass analysis. The weights of lungs, heart, liver, spleen, kidneys, full and

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empty GIT, empty stomach, head and trotters were taken. The eviscerated carcasses were then chilled for 24hrs at a temperature of 4^{o}C after which the chilled dressed carcass weight, carcass length, back fat thickness, P2 and some primal cuts were measured.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) using the Genstat Statistical Package [10] and the least significant difference (LSD) was used to separate the treatment means where differences were deemed significant. Significant differences between means were set at P < 0.05.

RESULTS

Pest and microbial status of DB

Physical examination of the samples indicated that there was the presence of both live and dead forms of the flour beetle (*Tribolium sp.*) in the DB. *Penicillium sp*., *Aspergillus niger* and *Aspergillus versicolor* were the main fungi species found in the DB with *Penicillium sp.* being the most common.

Chemical composition of DB

Proximate analysis of the samples indicated that DB used in this experiment contained 17, 9.9, 0.63, 11, 0.5 and 60.97% moisture, crude protein (CP), crude fibre (CF), ether extract (EE), ash and nitrogen-free extract (NFE) respectively on as-fed basis (Table 2).

Growth performance and economics of production

Feed intake

Table 3 indicates that pigs on the 10%DB and 20%DB consumed more feed daily than those on the Control (0%DB) and 30%DB. Again, more feed was consumed by pigs on treatments 10%DB and 20%DB during the entire experiment compared to those on the Control who also consumed more feed than pigs on treatment 30%DB. It is noteworthy that all these differences were not significant (P > 0.05).

Weight gain, live weight changes and duration

All pigs on the DB-supplemented diets gained more weight than their contemporaries on the Control diet (0%DB) at the end of the experiment. On daily bases however, pigs on the Control diet gained more weight than those on diet 10%DB but not as much as those on treatments 20%DB and 30%DB. Hence, pigs on treatment 10%DB required more days to reach the targeted slaughter weight. All these differences however were statistically similar (P > 0.05) (Table 3).

Feed conversion ratio (FCR) and economics of production

The addition of varying levels of DB to the diets of pigs did not influence (P > 0.05) the FCR. The cost of feed decreased upon the inclusion of DB. A similar scenario was observed with regards to the feed cost per kg live weight gain as can be observed from Table 3. These differences were not significant (P > 0.05).

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Carcass characteristics

As shown in Table 4, no significant (P > 0.05) differences were recorded between the various means of the carcass components measured from the pigs after they were slaughtered.

DISCUSSION

Pest and microbial status of DB

Tribolium sp. are known pests of flour and are noted to be responsible for the production of substances like benzoquinone which is a potent carcinogen [11]. Infestation and or contamination of feed with these insects, their larva and body parts have been noted to reduce palatability and the chemical composition of the food substance [11, 12]. Furthermore, consumption of insect infested feed may lead to dermatitis and other allergic reactions in humans and animals [11, 12]. It has been documented [13, 14], that insects may disseminate moulds and other pathogenic microbes when they infest and feed on some of these feed ingredients meant for animal consumption. It will, therefore, be advisable for farmers to store DB well to ensure decreased insect infestation.

Fungi of the *Aspergillus* and *Penicillium* genera grow best and produce aflatoxins at environmental temperatures above 21ºC which is characteristic of the tropics [15, 16]. Also, decrease in the water activity as a result of poor storage is said to be one of the reasons for the occurrence of species of *Aspergillus* and *Penicillium* in feedstuff [15]. It has been stated that aflatoxins produced by these fungi are potent toxins to both humans and animals [17, 18]. These toxins may bind with nucleic acids and impair protein formation in the body [17, 18]. The authors [17, 18] further indicated that aflatoxins in the feed of animals can cause loss of appetite, retarded growth, haemorrhage, diarrhoea and death in extreme cases. Furthermore, prolonged intake of feed or foodstuff loaded with aflatoxins has been observed to cause organ damage and cancer [19]. Thus caution must be taken when adding ingredients like DB to the feed of farm animals. Toxin binders can also be added to animal feeds when such an ingredient is to be used.

Chemical composition of DB

The proximate composition of the DB used in this experiment was different from those reported earlier [4, 20, 21]. The differences in nutrient composition can be attributed to the differences in storage, biscuit products or formula used in the manufacture of the various biscuits. Also post manufacturing management of biscuit may influence the nutrient composition of the DB. The differences between the DB used in this experiment and other experiments [4, 20, 21] suggests that proper analysis should be done to ascertain the actual nutrient composition of DB if it is to be used as an ingredient in the feeding of farm animals. This notwithstanding, the composition of DB used in the current study suggests that it can be used as an alternative to maize and other energy sources which are relatively expensive [22] and thus resulting in a decrease in the cost of feeding farm animals.

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Growth performance and economics of production

Feed intake and live weight changes

Feed intake values similar to those recorded in this study have been reported earlier when pigs were fed diets containing DB [5, 20]. On the other hand, significant ($P < 0.05$) decreases in feed intake were recorded when maize in the diet of rams was completely replaced with biscuit waste [21]. It has been stated that animals eat to satisfy their energy requirement [23] and the fact that there were no significant differences in the quantity of feed consumed by pigs indicated that DB has similar energy content as maize. Furthermore, feeding bakery waste to sheep has been reported [24] to result in better ($P < 0.05$) weight gains compared to those on a control diet. Similar increases ($P > 0.05$) in weight gains were recorded when pigs were fed DB-based diets [5]. This can be attributed to the fact that DB has a similar nutrient composition as the maize which it is substituting. However, this contradicts reports by Davidson in 1966 as cited [5] that feeding bakery waste to pigs may affect nutrient utilization and growth rate by forming a ball and becoming soggy in the stomach. Thus significant ($P < 0.05$) reduction [21] in weight gain was recorded when the levels of DB in the diet of the rams were increased. Contrary to these, this study recorded similar ($P > 0.05$) feed intakes and weight gains.

Feed conversion ratio (FCR) and economics of production

It has been explained that decreases in feed cost and feed cost per kg live weight gain may be obtained when feeding a by-product like DB since it is far cheaper than maize and some other conventional feedstuffs and again for the fact that the demand for DB, other bakery wastes and AIBP's are generally low [5].

Carcass characteristics

Earlier research [5] had indicated that feeding pigs with DB-based diets does not influence the weight of carcass and its components. Also, feeding biscuit waste to broilers was observed not to result in any significant differences in the weight of organs and other primal cuts [25, 26]. Conversely, significantly ($P < 0.05$) higher offal weights were recorded when Yankasa rams were fed diets containing biscuit waste [27]. The fact that pigs on maize based diets and those on the DB-based diets recorded similar organ and primal cut weights indicates that DB has no detrimental effects of the individual organs and also on the meat of the pigs.

CONCLUSION

The results of the study showed that discarded biscuit is similar in nutrient composition to maize. Its high energy and CP content are comparable to maize. The results of pests and microbial analysis showed that the level of infestation of the discarded biscuit was not severe and that it could be fed to pigs. The discarded biscuit could constitute as much as 30% of the diet and replace nearly 70% of the maize in the diet of growing-finishing pigs without any adverse effect on growth performance, carcass characteristics, haematological and serum biochemical characteristics.

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RECOMMENDATIONS

Based on the results of the study, a 30% inclusion level of discarded biscuits is recommended for pig farmers. It is also recommended that higher inclusion levels of discarded biscuits should be investigated.

Table 1: Percentage composition of the experimental diets

	DIETARY TREATMENTS			
INGREDIENT	0 % DB	10 % DB	20 % DB	30 % DB
Maize	60	50	40	30
Discarded Biscuits	0	10	20	30
Fishmeal	8	8	8	8
Soyabean Meal	6	6	6	6
Wheat bran	24.5	24.5	24.5	24.5
Oyster shell	1	1	1	1
Common Salt	0.25	0.25	0.25	0.25
Vitamin-Trace Mineral Premix	0.25	0.25	0.25	0.25
Total	100	100	100	100
Analysed composition (%)				
	As Fed			
Crude protein	17.2	18.5	17.9	18
Ether extract	3	4	5.5	7
Crude fibre	2.27	2.27	1.73	1.31
Moisture	9.5	10	9	8
Ash	5	5	5	5
Nitrogen Free Extract	63.03	60.23	60.87	60.69
Dry matter	90.50	90.00	91.00	92.00

Provided the following/kg diet: Vitamin A–8,000 IU, Vitamins D_3 –3,000 IU, Vitamins E–8 IU, Vitamin K –2mg, Vitamin B_1– 1 mg, Vitamin B_2–0.2 mg, Vitamin B_{12}–5 mg, Nicotinamide –10 mg, Selenium– 0.1 mg, Ca Pantothenate – 5 mg, Folic acid –0.5 mg, Choline Chloride –150 mg, Iron –20 mg, Manganese –80 mg, Copper –8 mg, Zinc –50 mg, Cobalt –0.225mg, Iodine –2 mg Antioxidant – 0.1ppm

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Table 2: Proximate composition of DB

Proximate Parameters	As fed (%)	Dry matter (%)
Moisture	17.00	-
Crude protein	9.90	11.93
Crude fibre	0.63	0.76
Ether extract	11.00	13.25
Ash	0.50	0.60
Nitrogen-free extract	60.97	73.46
TOTAL	100.00	100.00

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Table 3: Growth performance and economics of production of pigs fed DB

	Dietary treatments				LSD	Sig.
	0%DB	10%DB	20%DB	30%DB		
Number of pigs	5	5	5	5		
Parameter						
Mean initial weight, kg	16.60	16.70	16.70	16.70	2.308	NS
Mean final weight, kg	63.40	64.50	64.40	63.90	1.869	NS
Mean total weight gain, kg	46.80	47.80	47.80	47.20	2.061	NS
Mean daily weight gain, kg	0.718	0.700	0.746	0.736	0.081	NS
Mean total feed intake, kg	125.00	132.60	131.90	121.80	17.09	NS
Mean daily feed intake, kg	1.90	1.94	2.05	1.90	0.189	NS
Mean FCR (feed/gain)	2.67	2.78	2.76	2.58	0.325	NS
Mean duration to slaughter (days)	65.80	68.60	64.40	64.40	7.230	NS
Feed cost/kg, GH¢	0.87	0.81	0.76	0.71	-	-
Feed cost/kg live weight gain, GH¢	2.32	2.25	2.10	1.83	0.248	NS

LSD-Least significant differences, Sig-Significance, NS-Not significant

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Table 4: Carcass characteristics of pigs fed diets containing varying levels of DB

	Dietary treatments				LSD	Sig.
	0%DB	10%DB	20%DB	30%DB		
Number of pigs	5	5	5	5		
Absolute						
Live weight at slaughter, kg	63.40	64.50	64.40	64.00	-	-
Dressed weight, kg	48.24	48.95	48.99	48.91	2.516	NS
Dressing percentage (%)	76.08	75.88	76.06	76.53	2.665	NS
Chilled carcass weight, kg	41.50	42.20	42.21	41.70	2.462	NS
Carcass length, cm	70.42	71.80	71.36	70.58	1.365	NS
Shoulder, kg	3.46	3.71	3.68	3.72	0.432	NS
Loin, kg	6.10	6.37	6.22	6.12	0.535	NS
Belly, kg	4.09	4.39	4.36	3.76	0.522	NS
Thigh, kg	6.03	6.10	5.93	6.37	0.426	NS
Back fat thickness, cm	2.95	2.75	3.08	3.03	0.712	NS
Leaf fat, kg	0.59	0.54	0.60	0.54	0.280	NS
Head, kg	4.28	4.40	4.36	4.48	0.304	NS
Trotters, kg	0.96	1.05	0.95	1.03	0.132	NS
Fillet, kg	0.45	0.45	0.40	0.44	0.060	NS
Viscera, kg	9.20	8.94	9.68	9.08	0.981	NS
GIT (full), kg	6.37	5.93	6.49	5.86	1.086	NS
GIT (empty), kg	2.68	2.75	2.77	2.67	0.333	NS
Empty stomach, kg	0.28	0.30	0.30	0.30	0.051	NS
Heart, kg	0.18	0.19	0.18	0.19	0.140	NS
Kidney, kg	0.21	0.22	0.23	0.26	0.053	NS
Liver, kg	1.27	1.29	1.01	1.43	0.359S	NS
Lungs, kg	1.04	1.12	1.12	1.13	0.211	NS
Spleen	0.10	0.11	0.11	0.12	0.028	NS
P2, cm	2.03	1.98	2.08	2.09	0.731	NS

LSD – Least significant difference, Sig – Significance, NS – Not significant

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