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Assessment of the Effectiveness of Cocoa Pod-Husk Ash Extract as Alkaline in Reducing the Crude Fiber Levels in Sorghum Spent Grain (Pito Mash)

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Abstract
A ratio of 1:8.1 alkali strength of NaoH to cocoa pod husk ash extract was determined, based on the concentration of 25g of cocoa pod husk ash/200ml of water. This was established after titrating aqueous solutions of NaOH and cocoa pod husk ash in turns against 1MHcl.In the second category, four different solutions with concentrations of 62.5g/0.5L, 125g/1L, 187.5g/1.5L and 250g/2.0L were prepared. Each solution was divided into three equal parts, and used to treat 50g of milled pito mash. These were allowed to digest for 24, 48 and 72 hours. The 48 digestion duration, was found to be the most effective in reducing crude fiber content of the pito mash from 10.22 – 6.74%. The CP, EE. NDF, ADF and hemicelluloses were also reduced from 30.80 – 28.80, 9.50 – 2.50, 73.00 – 53.00, 30.00 – 26.00 and 43.00 – 27.00 % respectively, whilst ash and moisture contents increased from 3.50 – 12.00 and 3.00 – 11.50%, respectively, in alkali concentration of 1.5L in the treatment duration of 48hour.
Key words: Crude fiber, Acid detergent fiber, Neutral detergent fiber, hemicelluloses

INTRODUCTION

Most Agricultural-by products are classified as low - nutrient value and had high fiber content and/or anti-nutritional factors which influence the utilization of other nutrients in feed through changes in the gut transit time, digestion, absorption and therefore feed intake (Gonzalles-Alvarado et al.,2007; Mourao et al.,2008). Dried pito mash (DPM), a by – product of locally brewed pito drink, might provide a suitable substitutes for maize. It is currently available in large quantities in wet form especially in pito brewing communities, where at times its disposal in the wet form creates environmental pollution. Chickens are monogastrics and the digestion period is short, therefore, carbohydrate substances in their feed have to be easily digestible. The inclusion of dry pito mash (sorghum spent grain) in animal feed is essentially due to its nutritional content and availability. However, the high crude fiber content limits its inclusion levels in chicken diets, The use of chemicals for treatment of Agricultural by-products to improve the nutritive value of high fiber feedstuff has been documented, among which sodium hydroxide (NaOH) treatment is prominent (Sobamwa and Longe, 1992; Chestworth, 1992). Though, a sigh of relief to poultry farmers, this will add to the existing high cost of poultry production. It thus becomes imperative to find local Agricultural by- products that could provide an alternative but equal in alkaline strength to replace the NaOH. Cocoa pod- ash extract could provide a suitable alternative for NaOH chemical. The study therefore seeks to assess the effectiveness of reducing the total crude fiber content of the sorghum spent grain (pito mash) with the cocoa pod husk extract.

MATERIALS AND METHODS

The study was conducted at the Poultry Unit of the Animal Science Department Teaching and Research Farm of Kwame Nkrumah University of Science and Technology, Kumasi
The study was in two categories:
1. Preparation of alkali extract of cocoa pod husk
2. Treatment of the dried pito mash with alkali extract of cocoa pod husk

Test for alkalinity

Fresh cocoa pod husks were collected from a cocoa farm in Agona - Ashanti in the Sekyere East District of the Ashanti Region. The cocoa pod husks were rinsed in water to remove sand and any other foreign materials and then spread out thinly on polythene sheet to sundry for two weeks. Cocoa pod ash was obtained by burning the dried husks. The ash extracts were prepared by suspending 10, 15, 20 and 25g of the ash in four different conical flasks each containing 200ml of water. The mixtures were thoroughly mixed by stirring with a rod at regular intervals of 5 minutes for 40 minutes and allowed to stay undisturbed for 1hour. The mixture in each flask was then filtered through clean 'calico' cloth and then whatman filter paper to obtain the ash extract. The pH of the four different extract were determined by using the pH indicator device and the results shown in (table 1). The ash extract with a concentration of 25g/200ml was selected for optimization and subsequent treatment of the pito mash, since it recorded the highest pH value (table1).

Determination of alkali strength of cocoa pod extracts comparing it with NaoH solution

Titration of 50 ml of cocoa pod ash extract against 1M Hcl.

Fifty millimeters of the cocoa – pod ash extract used as the alkaline, at a concentration of 25g/200ml was pipette into a conical flask and titrated against 1MHcl using two drops of phenolphthalein as indicator. Two sets of the titration were done to determine the average titer volume of 22.90ml. 1MHcl (Tab. 2a)

Titration of 50ml. NaOH solution against 1MHcl

Sodium Hydroxide (NaOH) aqueous solution of varying alkali strength were prepared as follows

1. 1.0g NaOH granules were dissolved in 200ml of distilled water in a conical flask to give a solution with a concentration of 1g/200ml
2. 2.0g NaOH granules were dissolved in 200ml of distilled water in a conical flask to yield a solution with concentration of 2g/200ml
3. 3.0g NaOH granules were dissolved in 200ml of distilled water in a conical flask to yield a solution with concentration of 3g/200ml
4. 4.0g NaOH granules were dissolved in 200ml of distilled water in a conical flask to yield a solution with concentration of 4g/200ml

The solutions in each flask were stirred in turn at regular intervals to ensure total dissolution of the granules. Similarly, two sets of titration were performed to determine the average titer volume for each of the NaOH solutions. (Table 2b).The results obtained from the two titrations: cocoa pod ash extract on one side and the NaOH solutions were used to determine the alkali strength of the extract. This was done as follows. Since 3g NaOH aqueous solution yielded an average titer volume of 22.20ml HCl came closer to that of 25g of cocoa pod ash, (22.90ml Hcl table2a/2b), this was then used as the basis for comparison to determine the alkali strength of the cocoa pod ash extract as explained below.

If 22.20ml Hcl neutralizes 3g/200ml aqueous solution of NaOH Therefore 22.90ml Hcl would neutralized $\frac{22.90}{22.20} \times 3g = 3.09g$, approximately 3.1g. It could be inferred that 3.1g NaOH is equivalent to 25g cocoa pod ash in alkali strength, which is translated into a ratio of 1:8.1

Treatment of pito mash with cocoa pod ash extracts (alkali)

Upon determination of alkali strength of the ash extract, four different solutions with concentrations of 62.5g/ 0.5 L, 125g/1 L, 187.5g/ 1.5 L and 250g/ 2.0 L were prepared. The same procedure as described previously was used. This was done based on the selected 25g/200ml ash extract. Each of the four solutions was sub divided into three equal parts and poured into twelve plastic containers.Wet pito mash was sun-dried for two weeks and milled with electric blender. The milled pito mash was soaked in the alkali solution by pouring 50g into each of the twelve plastic containing the solution of varying concentrations. These were allowed to digest for 24, 48 or 72 hours in the Nutritional laboratory of the Animal Science Department, KNUST. This was first to find out the best alkali treatment that would pre-digest fibrous materials in the pito mash and whether or not the extent of degradation is time dependent. At the end of each of the allotted period, the soaked materials were gently squeezed through clean 'calico' cloth, then spread on polythene sheet, allowed to dry for two days and reground for chemical analysis.

Chemical analysis of treated pito mash

Dried samples, weighing 40g, each were taken from pito mash treated with the four different alkali solutions. These samples were analyzed for proximate components according to Association of Official Analytical Chemists(AOAC,1990) to provide information on crude protein, crude fiber, ether extract, ash content and moisture content, while acid detergent fiber, neutral detergent fiber and hemicellulose content were determined using the method of Van Soest et al (1991).The mineral components of interest, i.e. magnesium, iron, calcium, copper, sodium, potassium and phosphorus contents of the treated and untreated pito mash were also determined according to the procedures described by Motsara and Roy (2008). The results from the proximate analysis showed that 1.5l of the ash extract to 50g of dried pito mash yielded the best mixing rate to effectively digest the high fiber content of the pito mash. It was finally decided to treat 1.5l of the alkali solution of cocoa pod ash to every 50g of the dried pito mash. This forms the bases for the preparation of large quantities of the test ingredient for use in the subsequent feeding

RESULTS

The table below shows the cocoa - pod husk extract of different concentrations with their corresponding pH values. The results indicate an increasing alkalinity as the quantity of the cocoa - pod husk ash was increased.

Table 1 **Test for alkalinity**

flask label	**ph**	**weight of cocoa- pod ash (g)**	**concentration of the extract**
207	9.55	10	10g/200ml
209	9.65	15	15g/200ml
213	9.69	20	20g/200ml
216	9.72	25	25g/200ml

Table 2a Titration of 50ml of cocoa- pod ash extract (25g/200ml) against 1MHcl. Indicator used: Phenolphthalein

TITRATION	**INITIAL READING**	**FINAL READING**	**AVERAGE TITRE VALUE**
1	0.00	23.80	23.80
2	23.00	45.80	22.00
Volume of 1MHCl	-	-	22.90ml

Table 2b Titration of 50 ml NaOH solution against 1M Hcl

Concentration	**Titration**	**Initial Reading**	**Final Reading**	**Act. Volume**	**Ave. Titer Volume**
1g NaOH	1 2	0.00 20.40	10.50 20.40	10.50 9.90	10.20
2g NaOH	1 2	0.00 16.50	16.50 34.50	16.50 18.00	17.25
3g NaOH	1 2	0.00 22.60	22.60 44.40	22.60 21.80	22.20
g NaOH	1 2	0.00 0.00	29.50 31.70	29.50 31.70	30.6

Table 3.

Effect of alkali treatment on proximate and chemical compositions of pito mash

DURATION OF TREATMENT

		24hours				**48hours**				**72hours**			
		Alkali treated Pito mash				Alkali treated Pito mash				Alkali treated Pito mash			
Constituents	**untreate Pito mash**	**0.5L**	**1.0L**	**1.5L**	**2.0L**	**0.5L**	**1.0L**	**1.5L**	**2.0L**	**0.5L**	**1.0L**	**1.5L**	**2.0L**
Crude Protein	30.8	27.0	25.90	23.50	25.50	27.50	29.20	28.80	28.30	30.80	29.00	30.00	28.90
Crude Fiber	10.82	8.09	7.65	7.69	8.05	7.89	8.52	6.74	6.81	9.09	9.64	10.20	I0.65
Ether extract	9.50	2.50	4.00	3.50	3.00	2.50	1.50	2.50	1.00	0.50	1.50	3.00	1.00
Ash content	3.50	16.5	17.00	16.50	18.50	10.50	10.00	12.00	12.00	16.50	17.00	15.50	12.00
Moisture Content	3.00	7.00	5.50	4.50	6.50	11.50	13.00	11.50	13.00	13.50	12.50	12.00	12.00
NDF	73.00	47.00	70.00	48.00	49.00	55.50	53.00	53.00	51.00	53.00	52.00	56.00	61.00
ADF	30.00	16.00	25.00	24.00	19.00	24.00	27.00	26.00	22.00	32.00	32.00	30.00	31.00
Hemi-cellulose	43.00	31.00	45.00	24.00	30.00	31.50	26.00	27.00	29.00	21.00	20.00	26.00	30.00

Table 3 shows the application and the effect of the various concentrations of the cocoa – pod husk ash extract on proximate and chemical composition of the pito mash. Crude fiber degradation ranged between 7.60 – 8.09%, 6.70 – 8.52% and 9.00 – 10.65% for alkali reaction time of 24, 48, and 72hours duration respectively. Alkali reaction time of 48hours duration was most effective in degrading the crude fiber content of the pito mash, suggesting that the digestion process was complete within the 48hours, as the 72 hour treatment period recorded crude fiber values similar to the untreated pito mash. The crude protein of the alkali – treated pito mash showed a considerable decline as compared to the untreated pito mash. This varied between 25.0 – 27.0%, 27.0 – 29.20% and 28.0 – 30.8% for treatment duration of 24, 48 and 72hours respectively. Ether extract show a considerable decrease accompanied by excessive deposition of ash following alkali treatment. The moisture content of the pito mash varied with treatment period. The percentage moisture content were consistently lower in the untreated pito mash than the treated ones. Among the treatment duration, alkali reaction time of 48hours exhibited the lowest crude fiber values of 670. – 8.52%.

Table 4 Mineral composition of the alkali treated and untreated pito mash

Components	Untreated pito mash(%)	Treated pito mash(%)
K	1.59	5.62
Na	2.57	4.18
Ca	1.72	0.82
Mg	2.95	5.63
P	0.43	0.51
Cu	1.75	8.50
Fe	2.25	10.44

The results on the mineral composition of the test ingredient (Table 4), above shows a general increase in the amount of the major inorganic elements in the treated alkali pito mash. This may be due to the residual mineral components of the

DISCUSSION

Feed is by far the greatest expense item in the production of commercial eggs. It therefore becomes necessary to explore efficient and effective feeding program that is cost effective and maximizes profit margins. The use of non-conventional feed stuffs like agricultural by-products such as dried pito mash in poultry feeding, aimed at reducing this high cost of production, thereby providing an alternative feed energy source for cereals and grains such as maize, millet, etc becomes imperative. Agricultural by-products being good potential substitute for conventional feed stuffs could be relied upon, provided appropriate measure is adopted to improve digestibility and utilization in poultry nutrition. The goal behind the pre-digesting of dried pito mash with cocoa- pod husk ash extract (alkali) was to enhance digestibility and nutritive value for monogastrics such as poultry and pigs. The proximate composition of the alkali-treated and untreated dried pito mash (table 3) indicates that alkali reaction time of 48 hours yielded a significant reduction in crude fiber content (6.7% with 1.5 l of the alkali extract). These results seemed to agree with Adomako et al. (2004) who found that treatment of crop residues; cassava peel, plantain peel and cocoa pod husk with maize stalk ash extract (alkali) with a Ph. of 10.7 for 48 hours resulted in a significant reduction in tannin content, with the cocoa pod husk recording the highest detannification effect of 84%. They added further that, treatment of the three crop residues with the ash extract for 24 hours gave a less pronounced effects. Similarly, an improved rate of degradation by cellulose was noticed by these scientists, after treating the crop residues with the corn stalk ash extract for the same duration of 48 hours: cocoa pod husk – 71.1%, cassava peel – 116.1% and plantain peel – 133.3%.

They therefore suggested that the effectiveness of the extract in the solubilization process and the subsequent increase in the digestibility of the crop residues could be time dependent. The results obtained in this study however could not fully agree with findings of Adamafio et al. (2004) since beyond the 48 hours, that is 72 hour digestion period yielded higher crude fiber values for all the four volumes of the extract: 0.5, 1.0, 1.5, 2.0 liters, than that of 24 and 48 hours and even values tend to be similar to that of the untreated dried pito mash (table 3). The mechanism for this trend could not be exactly understood, but is most likely that the action though, could be time-bound in the rate of degradation of the fiber content and that beyond 48 hours, because the digestion process was not terminated, some reversible reactions could have taken place to restore the original structural arrangements. This is evident in the findings of Sobamiwa and Longe (1992) who after treating cocoa pod husk meal with cocoa pod husk ash extract for 24 and 48 hours, observed that alkali reaction time of 48 hours yielded similar results as the 24 hours duration. This suggests that the degradation processes were completed within the first 24 hours.

Cocoa-pod husk ash extract (alkali) treatment was employed in this study with the aim of improving dried pito mash utilization in the layers, with regards to the levels of untreated dried pito mash which had been widely reported as high in crude fiber and moderate in protein (Fombad and Mafeni, 1989). The neutral detergent fiber (NDF) and the acid detergent fiber (ADF) representing the cell wall and cell contents of the pito mash are mainly cellulose, hemicellulose and lignin. In plant material cellulose chains are formed in an order manner to produce a compact aggregate known as micro-fibrils. These structures are held firmly to each other by the inter-and - intra-molecular hydrogen bonding thereby making it very stable and that this configuration makes cellulose essentially insoluble and extremely resistant to enzyme degradation though can be hydrolyzed to glucose by strong acid or alkali (McDonald et al., 2002). Hemicellulose is a molecule which is linked covalently by a hydrogen bonding to the cellulose micro-fibrils, thus adding significant strength to the cells, though much resistant to chemical degradation than cellulose it can be hydrolyzed by a relatively mild acid or alkali treatment (McDonald et al., 2002).

A noticeable reduction in crude fiber content of the alkali-treated pito mash for 48 hours from 10.82 - 6.74 % in 1.5L of the extract as compared to the corresponding values of 24 hours from 10.82 – 7.69 % and 72 hours from 10.82 – 10.20% in equal volume of alkali extract. This could mean that the 48 hour digestion period was adequate enough to improve carbohydrate and other nutrient availability for utilization. These results were in agreement with those obtained by Barreveld (1993), who found that the mechanism involved in the degradation process might be due to the replacement of intra and inter-fibril hydrogen linkage of much larger Na-ions, and therefore leading to the breakage of bonds between lignin and cellulose. The present study revealed one major factor that might have contributed wholly or partially to the significant reduction in the crude fiber content, is the replacement of intra - and inter-fibril hydrogen linkage of much larger Na-ions as reported earlier. This phenomenon might have been facilitated by the presence of not only Na-ions of higher molecular weight than the hydrogen, but another element, potassium which is equally a mineral of higher molecular weight, as the mineral composition of the untreated and alkali-treated pito mash showed an appreciable increase of potassium from 1.59 - 5.62% and sodium from 2.57 - 4.18% respectively (Table 4). The combined effect of these two minerals might have contributed immensely in reducing the crude fiber content of the alkali treated pito mash. One another significant thing that was detected was the heat produced after 48 - hour treatment of the dried pito mash with the alkali which could have facilitated the softening processes of the crude fiber. According to Brendan (2013), fermentation is an exothermic reaction, meaning heat is given off as a by-product from converting the sugar to alcohol and carbon dioxide. Since the alkali-treated pito mash was covered and left for the digestion period of 48 hours, fermentation might have taken place. The microorganism in the treated material might have respired anaerobically to produce alcohol and carbon dioxide with heat released as by-product. This might have supported the weakening of the cell wall to pave way for the cellulose swearing. In this regard, the present study which recorded an alteration in the chemical composition of the dried pito mash treated with the extract in crude protein, ester extract, NDF, ADF and Hemicellulose with a corresponding increase in the ash content for all the treatment durations of 24, 48 and 72 hours compared favourably with literature (Table3). For instance, Abiola et al. (2002) noted that alkali treatment with melon husk resulted in increased ash content from 15.70 to 16.88% and reduced the crude fiber from 29.0 to 14.0%. In addition, Oladunjoye et al. (2010) indicated th the proximate composition of lye alkali - treated cassava peel meal showed a reduction in crude protein from 5.24 - 5.20% and crude fiber from12.38 - 12.20%.

One noticeable evidence of the effectiveness of the cocoa pod husk ash extract (alkali) in reducing the crude fiber content of the pito mash, thereby improving its utilization in the subsequent inclusion in the experimental diets, for which this study sought to know was the reduction in NDF, ADF and Hemicellulose content of the test ingredient in all the four different concentrations of 0.5 L, 1.0 L, 1.5 L and 2.0 L of the alkali extract for the three treatment duration of 24, 48 and 72hours (Table 3). In this study, the predetermined results of titration of cocoa pod husk ash extract (alkali) with1M HCL solution with phenomenon as indicator indicated that 8.3g cocoa pod husk ash was equivalent to 1g NaOH in alkali strength. This translates to a ratio of 1 : 8 (NaOH : Cocoa pod husk ash). This ratio, from literature falls within the range of 1 : 4 and 1 : 9 from two varieties of cocoa and the ratio of 1 : 6 reported

CONCLUSION

The alkali – treated pito mash inclusion in the experimental diets has justified the need to employ alkali treatment to reduce the dietary fiber of Agricultural by - products and their subsequent inclusion in monogastric nutrition, as the study has shown improvement in all the parameters measured. The following conclusions can be drawn from the results of this study.

- Alkali – reaction time duration of 48hours resulted in a significant reduction of crude fiber content of pito mash from 10.82 – 6.74 percent and that digestion was fully completed within the 48hours. This suggests that digestion of crop residues could be time dependent and that treatment beyond 48hours could not earn desirable results.
- 8.1g Cocoa pod husk ash was equivalent to 1g NaOH in alkali strength.

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