PHYSICO-CHEMICAL CHARACTERISTICS OF CO-FERMENTATION PRODUCT OF SOYMILK PROCESSING BY-PRODUCT (OKARA) AND PALM KERNEL CAKE FOR POULTRY FEED IMPROVEMENT

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ABSTRACT
The production of soymilk generates large quantities of a byproduct 'okara' which are often improperly disposed in a manner that constitutes an environmental hazard. This experiment was designed to evaluate the feasibility of producing a nutritionally enhanced poultry feedstuff by co-fermenting a mixture of okara and palm kernel cake. About 300 g of okara was mixed with 100 g of PKC and then subjected to solid state fermentation for 0, 3, 6 and 9 days and thereafter sundried. This was replicated four times for each period of fermentation. The products were analyzed for physicochemical characteristics such as bulk density (BD), specific gravity (SG), water holding capacity (WHC) and particle size distribution (PSD), pH, trypsin inhibitor (TI) level and proximate composition (PC). The results showed that the physical characteristics and proximate composition of the product did not vary with period of fermentation, however the trypsin inhibitor levels decreased significantly ($P<0.001$) from 206.11 mg/kg on day 0 of fermentation to 36.38 mg/kg after 6 days of fermentation.
Keywords: soybean, okara, palm kernel cake, solid state fermentation.

INTRODUCTION
The processing of soybeans into milk yields a white or yellowish wet residue as by-product known as *okara* which is often treated as an industrial waste with little market value because it is not shelf stable (Vander Riet *et al*, 1989). In addition, the antinutritional factors such as protease inhibitors and phytate content of the raw okara is high because the amount of heat applied before separating the okara from the milk is low. The growing appreciation of the health benefits of soy foods such as soymilk, tofu and soy yoghurts has increased the global output of okara and hence its disposal has become a significant problem in recent years (O'Toole, 1999). Drying of okara is expensive and thus an ineffective means of processing okara (Puechkamut & Panyathitipong, 2012). Evidence exist suggesting that the use of solid state fermentation (SSF) to reduce antinutritional factors in okara is feasible, but its use is limited by the physicochemical characteristics okara (Matsuo, 1997; Kasai, *et al* 2004). Such limitation could be overcome by blending with materials such as palm kernel cake (PKC) (Aladi *et al.*, 2013) and thereafter subjecting the blended mass to SSF in order to remove the anti nutritional factors and improve nutritive value (Aladi, 2016). Enzymes released during SSF process are expected to improve digestibility of PKC in the blend. This work was therefore designed to evaluate the effect of solid SSF on mixtures of okara and PKC on the physicochemical characteristics and nutrient digestibility for poultry.

MATERIAL AND METHODS
Production of Okara and solid state fermentation of the mixture
The okara used for this work was produced following the conventional domestic method of producing soymilk described by Ali (2010). About 305 ± 5 g okara (produced from processing 100 g of sorted soybean seeds to soymilk) was added to 100 g of PKC and mixed thoroughly. The mixture was filled into a plastic container without any compaction and covered firmly with the lid. This was replicated sixteen times and allowed to ferment at room temperature (25 – 31 °C). On days 0, 3, 6 and 9, four samples were selected at random and sundried into a friable and crisp mass.

Physical Characteristics

The samples were analyzed for Bulk Density (BD) and Specific Gravity (SG) using the method described by Makinde and Sonaiya (2007) and modified by Omede (2010). SG was determined as the ratio of the weight of the sample to the weight of equivalent volume of water using the formula;

S G = weight of feed ÷ weight of water

The filtration method described by Makinde and Sonaiya (2007) and modified by Omede (2010) was used to determine the water holding capacity (WHC) and determines as thus

WHC = Volume of water ÷ weight of feed.

Particle size distribution (PS) was determined using sieve analysis method (ASAE, 1983, Jillavenkatesa *et al.*, 2001). The weights of each particle size groups (coarse, fine and smooth) were expressed as a percentage of the initial weight. A suspension of 10 g sundried okara in 100 ml of distilled water was made and the pH was determined using a pH meter (Jenway – 3520 pH meter) using the electrode apparatus. Trypsin Inhibitor level was determined following the method described by Prokopet and Unlenbrunck (2002). The trypsin inhibitor content was calculated as using the formula:

Trypsin inhibitor content (mg/kg)
= Conc. obtained in (mg/l) x volume of sample / sample weight

The proximate compositions of the experimental materials (dried fermented mixture of Okara and PKC) were determined in triplicates using the procedures of AOAC (1990).

Experimental design and data analysis

Data on physical characteristic, pH, trypsin inhibitor levels and proximate composition of the test material were subjected to analysis of variance (ANOVA) in a completely randomized design (CRD) and significantly different means were separated using the Least Significant Difference (LSD) method as described by Little and Hills (1978

RESULTS AND DISCUSSIONS

Physical Characteristics of Fermented Co-products

The bulk density, specific gravity and water holding capacity of the fermented samples are shown in Table 1. The bulk density decreased progressively with period of fermentation until 6 days of fermentation and after which it did not vary further ($P>0.05$) till the 9th day of fermentation. The specific gravity decreased progressively up to the 9th day of fermentation. Period of fermentation did not affect particle size distribution and water holding capacity of the fermented mixtures after drying. Water holding capacity values were not significantly affected by fermentation period. This implies that mixing of okara with palm kernel cake and sun drying the product with or without fermentation will enhance physical characteristics of the co-product for incorporation into poultry diets.

Chemical characteristics of the fermented co-products

The effect of period of fermentation on the pH and proximate composition of the fermented mixture of okara and palm kernel cake is shown in Table 2. Significant differences ($P<0.05$) were found for the pH, trypsin inhibitor levels and crude fibre contents of fermented co-products. The pH levels of the fermented samples were all higher than those of unfermented samples (control). The reason for this is not clear. Fermentation is expected to decrease pH levels due to elaboration of organic acids such as lactic acid, propionic acid and acetic acid (Beal *et al.*, 2005; Canibe *et al.*, 2010). These acids and the lowered pH is known be the basis for the stability and improved shelf life of fermented food products (Sahlin, 1999). Loss of some volatile fatty acids during drying may have led to the increased pH levels among products. There was a steep drop in trypsin inhibitor levels of the fermented co-products during fermentation. The mean trypsin inhibitor level of unfermented sample (206.11 mg/kg) was significantly higher ($P<0.001$) than those fermented for 3 days (40.75 mg/kg) which was in turn higher ($P<0.05$) than those fermented for 6 days (36.38 mg/kg). Further increase in fermentation period however did not significantly reduce ($P>0.05$) trypsin inhibitor level of the product.

The mean crude fibre (CF) content of the unfermented samples (20.53 %) was higher ($P < 0.05$) than the CF content of samples fermented for 6 days (17.45 %) but was similar ($P>0.05$) to those fermented for 9 days (21.67 %). The reason for the high fibre content of samples fermented for 9 days is not clear but may not be unconnected with the drying process. This means that the changes that occurred in samples during fermentation need further evaluation. No significant differences (P>0.05) were found for crude protein, ether extract, ash, NFE and metabolizable energy contents of the fermented samples. Therefore, the major contribution of SSF seems to have been the reduction in trypsin inhibitor level of fermented products.

CONCLUSION AND RECOMMENDATIONS

Based on the results of this work, it is concluded that blending okara and palm kernel cake mixture then sun drying the mixture was effective in enhancing the physical characteristics of the mixture for poultry feeding. However, solid state fermentation of the mixture for 6 days will be needed to reduce trypsin inhibitor content to safe levels and may increase crude fibre digestibility

REFERENCES

Aladi, N.O. (2016). Studies on dietary fermented mixture of cassava and palm kernel cake on carcass characteristics of broilers and pigs. PhD thesis, Federal University of Technology Owerri-Nigeria.

Aladi, N. O., Isinguzo, C., Okorondu, S., Okoli, I. C., & Okeudo, N. J. (2013). Improvements on the physicochemical characteristics of cassava root pulp and palm kernel mixtures under solid state fungal fermentation. *Journal of Agricultural Technology*, 9(5), 1111-1124.

Ali, N. (2010). Soybean processing and utilization. In: Singh, G. (2010). *The Soybean: botany, production and uses*. CAB International, London

AOAC (1990). *Official methods of analyses*, 14th Ed. Association of Official Analytical Chemists, Washington DC.

ASAE (1983), Methods for determining and expressing fineness of feed materials by sieving. American society of Agricultural Engineers Standards 319.2 Yearbook of standards, American society of Agricultural Engineers, St. Joseph

Canibe, N., Pederson, A.O. & Jensen, B.B. (2010). Impact of acetic acid concentration of fermented liquid feed on growth performance of piglets. *Livestock Science* 133, 117–119

Little, T.M. and Hills, J.F. (1978). *Agricultural Experimentation: Design and Analysis*. John Wiley and sons, London UK.

Liu, K.S. (1997). *Soybean: Chemistry, Technology and Utilization*. Chapman and Hall. New York, NY, USA.

Makinde, O.A & Sonaiya, E.B. (2007). Determination of water, blood and rumen fluids absorbencies of some fibrous feedstuffs. *Livestock Rural Res. Dev*., 19,

O'Toole, D.K. (1999). Characteristic and use of okara, the soybean residue from soy milk production-a review. *Journal Agricutural and Food Chemistry*, 47: 363–371.

Omede, A.A. (2010). The use of physical characteristics in the quality evaluation of some commercial poultry feeds and feed stuff. M.Sc. Thesis, Federal University of Technology, Owerri, Nigeria.

Prokopet, G. & Unlenbruck, K.W. (2002). Protectine eine nen kalsse anti-kowperahlich verbindungen dish. *Ges. Heit*., 23: 318

Van Der Riet, W.B., Wight, A.W., Cilliers, J.J.L. & Datel, J.M (1989). Investigation of tofu and its by product okara, *Food Chemistry*, 34, 193-202.

Puechkamut, Y. & Panyathitipong, W. (2012). Characteristics of Proteins from Fresh and Dried Residues of Soy Milk Production. *Kasetsart J. (Nat. Sci.)* 46 : 804 – 811

Jillavenkateesa, A., Dapkuna, S.J. & Lin-sien, L. (2001). Particle size Characterization. NIST Publication, USA. Pp: 960-961.

Kasai, N. Murata, A., Inui, H., Sakamoto, T., & Kahn, R. I. (2004). Enzymatic high digestion of soybean milk residue (okara). *Journal of Agricultural and Food Chemistry*. 52:5709-5716.

Sahlin, P. (1999). Fermentation as a method of food processing: Production of organic acids, pH-development and microbial growth in fermenting cereals. Licentiate thesis, Applied Nutrition and Food Chemistry, Lund University, Sweden

Table 1: Effect of period of fermentation on the physical characteristics of the sundried products

Parameters	Period of fermentation (days)				SEM
	0	3	6	9	
Bulk density	0.39^a	0.34^b	0.33^c	0.33^c	0.001
Specific gravity	0.43^a	0.35^b	0.35^b	0.34^c	0.030
Water holding capacity	1.73	1.79	1.74	1.71	0.025
Particle size distribution					
Coarse (> 2.0 mm)	21.67	23.15	27.72	23.39	3.653
Fine (<2.00>0.05 mm)	72.73	71.86	69.70	71.75	6.532
Smooth (<0.05 mm)	4.44^b	5.90^a	2.58^c	4.69^b	0.287

^{a,b,c} Means within a row with different superscripts are significantly different (P<0.05)

Table 2: Effect of period of fermentation on the pH, trypsin inhibitor levels and proximate composition of okara-PKC mixture

Parameters (%)	Period of fermentation (days)				SEM
	0	3	6	9	
pH	6.85^c	7.25^a	7.12^b	7.21^a	0.002
Trypsin inhibitor	206.11^a	40.75^b	36.38^c	35.33^c	1.005
Moisture	9.63	9.00	8.57	8.90	0.121
Crude protein	21.93	20.85	20.63	21.82	1.697
Ether extract	8.83	9.15	8.78	9.32	0.162
Crude fibre	20.53^a	19.26^{ab}	17.45^b	21.67^a	1.573
Ash	3.86	4.01	3.83	3.95	0.070
Nitrogen Free Extracts	35.20	37.72	39.61	34.34	5.301
Metabolizable energy (Kcal/kg)	2783.82	2854.10	2888.94	2788.63	23.388

^{a,b,c} Means within a row with different superscripts are significantly different (P<0.05)