Journal of Food Technology 10 (3): 97-102, 2012
ISSN: 1684-8462

Effect of *Aframomum danelli* and Black Pepper Crude Extracts on Physico-Chemical and Sensory Properties of Kunun-Zaki During Storage

[1]I.I. Adedokun, [2]S.U. Okorie, [1]B.C. Nwokeke and [2]E.N. Onyeneke
[1]Department of Food Science and Technology, Imo State Polytechnic, Owerri, Nigeria
[2]Department of Food Science and Technology, Imo State University, Owerri, Nigeria

Abstract: Kunun-zaki spiced with crude extracts from *Aframomum danelli* and black pepper spices was produced from three cereal grains, respectively and subjected to ambient, refrigeration and freezing conditions for 4 weeks. The samples of Kunun-zaki generally showed a significant variation ($p<0.05$) in proximate composition during storage the protein content under ambient declined from 1.81% control sample to 0.28% at 2nd week, similarly, fat 0.82- 0.28%, carbohydrate 11.38-5.53% and ash content varied from 1.38-0.82% while the variation was less pronounced in samples under refrigeration and freezing conditions. The pH content declined during storage period and was found significant at $p<0.05$, under ambient condition the pH decreases steadily from 4.92 at 1st day of storage (control) to 2.01 at 2nd week of storage while under refrigeration and freezing conditions the pH declined from 4.92 control to 3.96 (at 4th week). Similar trend was observed on percentage Total Titrable Acidity (TTA%), there was a steady increase in TTA% of samples from 0.46% (control) to 6.14% sample under ambient condition at 4th week of storage while 0.46-1.03% was found in samples kept under refrigeration and freezing conditions. A significant difference ($p<0.05$) was observed only on mouth-feel and overall acceptability throughout storage period. Samples stored at freezing condition at 4th week with mean scores of 8.3 (appearance); 8.0 (for each mouth-feel and aroma) and 8.3 (overall acceptability) was the most preferred next to the control sample. The use of local spice extracts in addition to the effects of refrigeration and freezing favor the shelf-stability of physico-chemical and sensory parameters of Kunun-zaki, thereby promote its keeping qualities during storage and distribution.

Key words: Kunun-zaki, spices, black pepper, *Aframomum danelli*, Nigeria

INTRODUCTION

Kunun-zaki is traditional fermented non-alcoholic beverage mostly consumed in Northern Nigerian especially during fasting and dry season periods. Kunun-zaki is a Hausa world meaning sweet beverage. It is mostly produced from millet, sorghum and maize. Cereals used in Kunun production caused the nutritional value to be lower in protein (0.1%), fat (0.6%), carbohydrate (9-12%) and moisture content range between 85-87% content and eventually affect their storage stability during distribution and sales (Ayo and Okaka, 1998).

Despite the fact that Kunun-zaki is becoming increasingly popular in Nigeria as a result of economic hardship and high cost of most conventional carbonated beverage yet Kunun-zaki is still far behind competing with carbonated beverage because of some identified problems such as inconsistency in quality, specification and standards on production, packaging system and storage associated with Kunun. The product is offered for sale in cup, transparent Polyethylene sachets and used Pet plastic bottle. Because of short shelf-life, the production of Kunun-zaki is still in small scale level and these limit its marketing within local communities and resort (Gaffa *et al*., 2002).

Adeyemi and Umar (1994) recorded a shelf-life 24 h for Kunun-zaki stored at ambient condition which was extended to 8 days by pasteurization at 60°C for 1 h and refrigeration of the product as post-pasteurization condition for storage. Shortage in keeping quality still offered threat to the qualities and acceptance of Kunun-zaki in term of the stability of the nutritional value while on shelf or retail. This factor affects the chance of market competition of Kunun-zaki among other carbonated and non-alcoholic beverages especially in developing countries. This present research investigate the stability of physico-chemical and sensory qualities of Kunun-zaki produced from raw maize, millet and sorghum, respectively during storage and distribution.

Corresponding Author: I.I. Adedokun, Department of Food Science and Technology, Imo State Polytechnic, Owerri, Nigeria

MATERIALS AND METHODS

Material collection

Cereal grains: Sorghum (*Sorghum bicolor*), maize (*Maize mays*) and Millet (*Pennisetum americanum*) were purchased at Ama-Hausa market. Cloves, potato chips, black pepper and granulated sugar was purchased from Owerri main market in Imo State while *Aframomum danelli* spices was obtained from Warri market, Delta State all in Nigeria.

Preparation of spice extracts: The procedure described by Falola *et al*. (2008) was modified for the crude extract of water fractions from black pepper and *Aframomum danelli* (Urima), respectively.

Procedure: About 500 g of each sun-dried black pepper and Urima (*Aframomum danelli*) was screened, respectively winnowed and hand-picking of foreign matters (stones, dust and filth), respectively. Each screened spices was grinded using hammer mill into fine powder and suspended in 750 mL of warmed water at 40°C in a separating funnel for each spices. Each spice suspensions were kept at tropical ambient temperature (30±2°C) for 7 days with regular shaking. The suspensions were filtered and concentrated by evaporation at room temperature and finally obtained black pepper and *Aframomum danelli* extracts, respectively which was used in Kunun-zaki processing.

Production of non-alcoholic Kunun-zaki: The traditional production steps described by Adebayo *et al*. (2010) was modified (Fig. 1) for the preparation of Kunun-zaki samples from each cereals used in this study.

Procedure: About 3 kg of each cereal (maize, sorghum and millet) were screened manually by winnowing to remove foreign matters (sand, filth, dust, etc.) and washed with portable water. Each cleaned cereals was steeped, respectively in a warm water 30±2°C (at ratio 1:3 w/v) with the addition of 4% potato chips and 1% of cloves for 48 h and wet-milled using hammer mill into mash. The mash slurry from each cereals was further fermented at ambient temperature for 12-24 h before wet sieved (212 μm aperture) into fine slurry. The sieved slurry was allowed to stand for 6 h, decanted the supernatant then, the slurry was divided into two equal parts (Slurry I and II). The first part of the raw slurry was dispersed in a small quantity of cold water followed by addition of boiled water and stirred to give partly gelatinized cooked Slurry I. The Slurry II was prepared by dispersed the second part slurry in cold water. The two

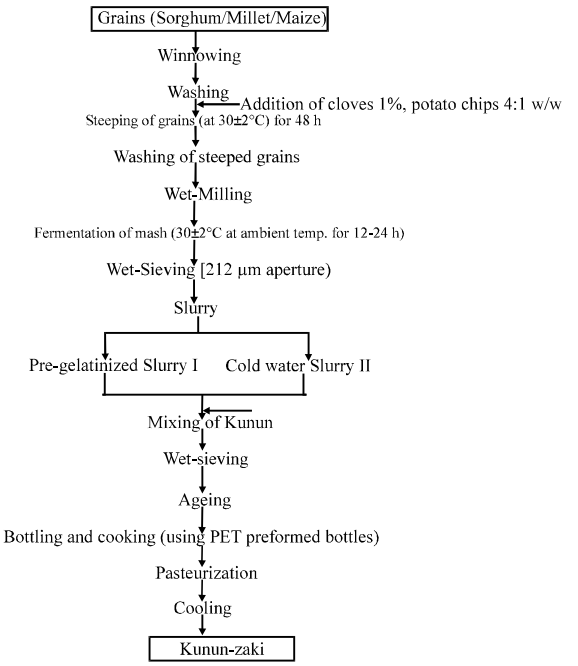

Fig. 1: Flow chart Kunun-zaki preparation from cereal grain (Sorghum, millet and maize)

Slurry I and II prepared were mixed together thoroughly at ratio 1:1 with the addition of 2% of each spice extracts from black pepper and *Aframomum danelli* (Urima) simultaneously. The mixture was sweetened at 8% with sugar syrup, wet-sieved and allowed to undergo ageing for 6-12 h before bottled using PET reformed bottle with tampered-proof cap. The bottled samples were subjected to pasteurization at 63±2°C for 60 min.

Storage stabilty study of Kunun-zaki: The Kunun-zaki samples produced from each cereal were labeled accordingly and stored at three different conditions namely: ambient condition of 30±2°C; refrigeration condition and freezing condition of -7°C for 4 weeks. During this period samples were examined for proximate composition at every 2 weeks interval, chemical properties such as pH, total titrable as lactic acid % and percentage dry matter at every 1 week interval and sensory quality of the stored Kunun-zaki at 4th week of storage.

Sensory evaluation: The procedure described by Okaka was followed for the organoleptic assessment of Kunun-zaki. The scoring test was adopted for the determination of preference of stored Kunun-zaki samples and freshly prepared Kunun-zaki (control) from each cereal used. A total of twelve coded samples (of which four was from each cereal) were presented in identical

containers to ten trained panelists selected from academic staff of Imo State Polytechnic College who were familiar with Kunun-zaki beverage. The randomized sample order was simultaneous presented to the panelists for evaluation. The characteristics evaluated were appearance, mouth-feel, flavor and overall-acceptability. Nine point hedonic scale with assigned numerical figure range from 9 points for excellent good to 1 point for extremely poor.

Proximate ND chemical analysis: The moisture content, crude protein, ash, crude fat content, pH and total titrable acid (lactic acid %) was determined by the methods described by AOAC (2000). The percentage total carbohydrate content was determined by total difference. The pH was analyzed by standardized the electrode of the pH meter (Orion Research Inc. USA, Model T20A) with buffer 7.0.

Statistical analysis: The data obtained on proximate, chemical and sensory evaluation were subjected to Analysis of Variance (ANOVA) and the means were separated by Duncan multiple range test using (SPSS 17.0, Microsoft Inc., USA).

RESULTS AND DISCUSSION

Proximate composition of Kunun-zaki stored under three storage conditions: The proximate composition Table 1 of Kunun-zaki under different storage conditions showed a significant difference ($p<0.05$). Generally, the moisture content varied between 86.05-93.27% for control and samples under ambient condition. The variation in percentage moisture content may be due to the activity of microorganisms (Ashaye *et al*., 2006) which is more pronounced under ambient temperature storage. No significant difference ($p<0.05$) was observed between samples under the two low temperature storage conditions used from the control sample. There was a steady declined from 1st to 2nd week of storage in crude protein content of samples (from 1.18-0.34%) under ambient storage. While those samples under refrigeration and freezing conditions shown better crude protein stability when compared with control sample up till 4th week of storage. General observation on protein content under these two conditions showed variation from 1.81-0.68% for control and refrigerated samples, respectively at 4th week of storage on all Kunun-zaki produced from the three cereal used in this research work. This results may be attributed to the combined preservative effects of extracts of *Aframomum danelli* and black pepper used and as well as low temperature conditions on the activity of spoilage microorganisms and enzyme during storage. The low crude protein values discovered in each samples may be attributed to chemical composition of cereal (Ihekoronye and Ngoddy, 1985). However, the steady declined in protein content observed under ambient storage condition may be due to microbial activity which was favored with rise in room temperature.

The ash content varied slightly with no significant variation among the samples during storage period. Onyeka reported that ash content is an index of inorganic mineral elements in food. The ash content generally falls within the range of 1.39% (sample under

Table 1: Proximate composition of Kunun-zaki under three different storage conditions

	Period and storage conditions for Knunu-zaki						
	At 2nd week of storage			At 4th week of storage			
Parameters (%)	Control	Ambient	Refrigeration	Control	Ambient	Refrigeration	Freezing
Kunun-zaki from maize							
Moisture	88.54^{a}	90.16^{b}	88.74^{a}	88.58^{a}	93.18^{c}	90.06^{b}	89.28^{ab}
Crude protein	1.81^{a}	0.34^{c}	1.58^{a}	1.74^{a}	ND	0.98^{b}	1.26^{a}
Ash content	1.38^{a}	1.30^{a}	1.34^{a}	1.39^{a}	1.29^{a}	1.36^{a}	1.33^{a}
Crude fat	0.82^{b}	0.43^{c}	0.72^{a}	0.78^{bc}	ND	0.48^{c}	0.71^{a}
Carbohydrate	7.45^{a}	7.77^{a}	7.62^{a}	7.51^{a}	5.53^{c}	7.12^{a}	7.42^{a}
Kunun-zaki from millet							
Moisture	89.47^{a}	90.96^{a}	89.62^{a}	89.46^{a}	90.88^{a}	89.81^{a}	89.62^{a}
Crude protein	0.96^{a}	0.28^{c}	0.82^{a}	0.91^{a}	ND	0.68^{b}	0.90^{a}
Ash content	0.98^{a}	0.82^{c}	0.91^{b}	0.96^{ab}	1.0^{a}	1.04^{a}	0.98^{a}
Crude fat	0.41^{a}	0.30^{b}	0.32^{b}	0.39^{a}	ND	0.31^{b}	0.40^{a}
Carbohydrate	8.18^{a}	7.64^{b}	8.33^{a}	8.31^{a}	8.12^{a}	8.16^{a}	8.20^{a}
Kunun-zaki from sorghum							
Moisture	86.05^{a}	89.87^{b}	86.58^{a}	86.21^{a}	93.27^{c}	89.03	87.52^{a}
Crude protein	1.06^{a}	0.31^{b}	0.98^{a}	1.03^{a}	ND	0.87^{a}	1.00^{a}
Ash content	1.12^{a}	0.96^{a}	1.10^{a}	1.10^{a}	1.06^{a}	1.11^{a}	1.18^{a}
Crude fat	0.39^{a}	0.28^{b}	0.33^{a}	0.35^{a}	ND	0.32^{a}	0.38^{a}
Carbohydrate	11.38^{a}	8.58^{c}	11.01^{a}	11.31^{a}	5.67^{c}	9.03^{b}	9.99^{b}

Any two sample means not followed by the same superscript letter are significantly different ($p<0.05$) across the rows

freezing condition) and 0.82% (sample under ambient condition). The indication from the results implies that mineral elements in Kunun-zaki are more stable significantly ($p<0.05$) during storage irrespective of the type of cereal and spices used in the production. The crude fat content of the samples under ambient condition declined sharply from 0.82-0.28% within the 1st 2 weeks of storage and finally disappeared from the sample. The presence of fat within the 1st 2 weeks under ambient condition may be attributed to the anti-oxidant action of *Aframomum danelli* and preservative action of extracts from both spices used while the disappearance of crude fat at the 2nd week may be due to the activity of microorganisms during storage. This result was in line with the observation of Ashaye *et al.* (2006) on the antioxidant effectiveness of 1-3% of *Aframomum danelli* extracts on lipid oxidation of Warankashi while Adegoke *et al.* (2000) confirmed the anti-oxidant action of *Aframomum danelli* extract at low concentration under low temperature as found in Kunun-zaki kept in refrigeration and freezing conditions.

The total carbohydrate content varied significantly ($p<0.05$) among the samples, this range from 11.38-5.53% for samples under ambient condition. The decrease in carbohydrate content is more pronounced under ambient storage condition and the extent of decline depends on metabolic activity of microorganisms under the influence of increase in storage temperature. While the rate of this change was found low and the carbohydrate values were insignificant in samples under refrigeration and freezing conditions when compared with control sample.

Chemical properties of Kunun-zaki stored under three storage conditions: The results of chemical properties (Table 2) of Kunun-zaki samples showed a significant variations ($p<0.05$). Generally, pH of samples under ambient temperature was not carried beyond 2nd week of storage because of spoilage. However, the pH of samples under refrigeration and freezing conditions was found similar in values and no significant variation when compared with control sample during the storage period. The pH drop 3.56-2.01 throughout the storage period, this decline in pH to 2.01 was observed in samples under ambient condition at 2nd week while samples under refrigeration and freezing temperature showed stability in pH when compared with freshly prepared Kunun-zaki. Adeyemi and Umar (1994) recorded pH stability of commercial and pasteurized Kunun-zaki till 3rd and 7th day of storage, respectively under ambient temperature. However, 2nd week Kunun-zaki pH stability discovered in this research under ambient condition may be attributed to the combined preservative effects of extracts from black pepper and *Aframomum danelli* as well as the pasteurization treatment used. The slight drop in pH (4.92-3.96) under low temperature conditions used showed no significant different ($p<0.05$) with the control sample during the storage period.

The percentage total titrable acidity of samples were varied significantly ($p<0.05$) from the control sample except those samples under freezing condition. The samples stored at low temperature conditions (refrigeration and freezing) showed a range of 0.41-1.02% while samples at ambient temperature showed a range between 0.98 and 6.14% for periods of 1st and 4th week of storage, respectively. Adeyemi and Umar (1994) reported 0.14 and 0.59% for the commercial and pasteurized Kunun-zaki stability till 3rd day. The stability observed on percentage total titrable acidity of refrigerated and frozen samples may be due to the effects of low temperature conditions on spoilage micro-organisms and as well as the preservative action of *Aframomum danelli* and black pepper spices used.

Table 2: Chemical properties of Kunun-zaki under three different storage conditions

		1st week			2nd week			3rd week			4th week		
Parameters	Control	Ambient	Refig.	Freezing	Ambient	Refig.	Freezing	Ambient	Refig.	Freezing	Ambient	Refig.	Freezing
Kunun-zaki from maize													
pH	4.81^{a}	3.56^{b}	4.66^{a}	4.80^{a}	2.80^{c}	4.61^{a}	4.81^{a}	ND	4.28^{a}	4.72^{a}	ND	3.96^{b}	4.51^{a}
TTA %	0.46^{a}	0.98^{b}	0.51^{a}	0.43^{a}	3.12^{c}	0.67^{a}	0.41^{a}	4.66^{c}	0.72^{a}	0.49^{a}	5.17^{c}	0.82^{ab}	0.51^{a}
Dry matter	11.46^{a}	11.25^{a}	11.39^{a}	11.42^{a}	9.84^{c}	11.26^{a}	11.42^{a}	8.87^{c}	10.98^{b}	10.98^{b}	6.82^{d}	9.94^{c}	10.72^{b}
Kunun-zaki from millet													
pH	4.62^{a}	3.23^{b}	4.59^{a}	4.58^{a}	2.01^{c}	4.56^{a}	4.58^{a}	ND	4.18^{a}	4.48^{a}	ND	4.08^{a}	4.39^{a}
TTA %	0.62^{a}	1.02^{b}	0.75^{ab}	0.63^{a}	3.74^{c}	0.81^{a}	0.61^{a}	5.12^{d}	0.92^{a}	0.69^{a}	6.14^{d}	1.03^{b}	0.74^{ab}
Dry matter	10.53^{a}	10.06^{a}	10.41^{a}	10.51^{a}	9.04^{b}	10.38^{a}	10.54^{a}	9.23^{b}	10.58^{a}	10.43^{a}	6.12^{c}	10.19^{a}	10.38^{a}
Kunun-zaki from sorghum													
pH	4.92^{a}	3.43^{b}	4.68^{a}	4.88^{a}	2.98^{c}	4.58^{a}	4.84^{a}	ND	4.24^{a}	4.74^{a}	ND	4.01^{a}	4.68^{a}
TTA %	0.71^{a}	1.13^{b}	0.78^{a}	0.74^{a}	3.84^{c}	0.84^{a}	0.76^{a}	5.74^{d}	0.90^{ab}	0.81^{a}	6.03^{d}	1.02^{ab}	0.89^{a}
Dry matter	13.95^{a}	12.95^{ab}	13.54^{a}	13.81^{a}	10.13^{b}	13.42^{a}	13.79^{a}	9.82^{c}	12.01^{ab}	13.18^{a}	6.73^{d}	10.97^{b}	12.48^{a}

Any two sample means not followed by the same superscript letter are significantly different ($p<0.05$) across the rows; TTA % = Percentage Total Titrable Acidity (as lactic acid %); Control = Freshly prepared Kunun-zaki sample; Ambient = Samples under ambient storage condition; Refrig. = Samples under refrigeration storage condition; Freezing = Samples under freezing storage condition

Table 3: Sensory quality of Kunun-zaki under three different storage conditions

Attributes	MKA	MKR	MKF	MKC	SKA	SKR	SKF	SKC	MLKA	MLKR	MLKF	MLKC
Appearance	8.0^{a}	7.8^{a}	8.0^{a}	8.1^{a}	8.0^{a}	8.3^{a}	8.3^{a}	8.5^{a}	8.0^{a}	7.9^{a}	8.3^{a}	8.3^{a}
Mouth-feel	7.1^{b}	7.4^{ab}	7.8^{a}	7.9^{a}	7.4^{b}	7.9^{a}	8.1^{a}	8.1^{a}	7.6^{b}	7.6^{b}	8.0^{a}	8.0^{a}
Aroma	8.0^{a}	8.3^{a}	8.3^{a}	8.4^{a}	8.0^{a}	8.1^{a}	8.1^{a}	8.3^{a}	7.9^{a}	8.0^{a}	8.0^{a}	8.2^{a}
Overall accp.	8.0^{a}	8.2^{ab}	8.4^{a}	8.5^{a}	7.9^{b}	8.1^{a}	8.5^{a}	8.7^{a}	7.8^{b}	8.0^{ab}	8.3^{a}	8.4^{a}

Any two sample means not followed by the same superscript letter are significantly different ($p<0.05$) across the rows; MKA = Maize Kunun-zaki under Ambient storage condition; MKR = Maize Kunun-zaki under Refrigeration storage condition; MKF = Maize Kunun-zaki under Freezing storage condition; MKC = Maize Kunun-zaki Control sample; SKA = Sorghum Kunun-zaki under Ambient storage condition; SKR = Sorghum Kunun-zaki under Refrigeration storage condition; SKF = Sorghum Kunun-zaki under Freezing storage condition; SKC = Sorghum Kunun-zaki Control sample; MLKA = Millet Kunun-zaki under Ambient storage condition; MLKR = Millet Kunun-zaki under Refrigeration storage condition; MLKF = Millet Kunun-zaki under Freezing storage condition; MLKC = Millet Kunun-zaki Control sample

Sensory evaluation of stored Kunun-zaki: The mean scores of sensory attributes of Kunun-zaki spiced with black pepper and *Aframomum danelli* extracts subjected to 4 weeks storage under three different conditions (Table 3) showed significant difference ($p<0.05$). The appearance and the aroma attributes of Kunun-zaki samples under storage showed no significant difference with the control samples as observed in each cereal grains used while samples at freezing condition gave the highest rating for the same attributes, respectively. This observation may be attributed partly to the proportions of the spice extracts (2% each) and effects of processing treatment adopted therefore shows the stability of appearance and aroma (flavor) during storage, distribution and when offered for sales. The mouth feel and overall acceptability of Kunun-zaki samples at both ambient and refrigeration conditions varied significantly from control sample except those under freezing condition was found the same with the control. These observations on the organoleptic assessment of Kunun-zaki samples under different storage conditions were found similar irrespective of the type of cereal used in this research.

Ihekoronye and Ngoddy (1985) reported that members of cereal family showed similar chemical constituents but differs in their morphology. Therefore, the interaction or behavior among chemical components, spice extracts and other ingredients used in Kunun-zaki may be similar from one cereal to another during processing, ageing and storage conditions and consequently affect the storage stability of sensory attributes of Kunun-zaki. Falola *et al.* (2008) examined the effect of *Aframomum danelli* crude extract on sensory qualities of Akara (Bean cake) while Ashaye *et al.* (2006) discovered the organoleptic properties stability of Warakashi (local cheese) treated with 1% *Aframomum danelli*. Samples stored at freezing condition at 4th week with mean scores of 8.3 (appearance); 8.0 (for each mouth-feel and aroma) and 8.3 (overall acceptability) was the most preferred next to the control sample.

CONCLUSION

The findings from this research work has shown the potential of using local spices (Black pepper and *Aframomum danelli*) extracts, there use is not only to impact characteristic flavour in Kunun-zaki beverage but also serve as additional means of preservation with a relatively sensory, chemical and proximate properties shelf-life stability when combined with low temperature preservation during storage. It is desirable however to improve the storage stability of Kunun-zaki beverage by reducing the initial microbial load of raw materials perhaps through controlled fermentation of grains use of portable water during slurry preparation and addition of spice extracts just before final mixing of Slurry I and II together. This will greatly appreciate the marketing chances of Kunun-zaki among other beverages.

REFERENCES

AOAC, 2000. Official Methods of Analysis of the Association of Official Analytical Chemists. 17th Edn., AOAC International, Maryland, USA.

Adebayo, G.B., G.A. Otunola and T.A. Ajao, 2010. Physico-chemical, microbiological and sensory characteristics of Kunun-zaki prepared from millet, maize and guinea corn and stored at selected temperature. Adv. J. Food Sci. Technol., 2: 41-46.

Adegoke, G.O., R. Gbadamosi, F. Evwoerhurhoma, P.I. Uzo-Peters and K.O. Falade *et al.*, 2002. Protection of maize (*Zea mays*) and soybeans (*Glycine max*) using *Aframomum danielli*. Eur. Food Res. Technol., 214: 408-411.

Adegoke, G.O., S.B. Fasoyiro and B. Skura, 2000. Control of microbial growth browning and lipid oxidation by the spice *Aframomum danielli*. Eur. Food Res. Technol., 211: 342-345.

Adeyemi, I.A. and S. Umar, 1994. Effect of manufacture on quality characteristics of Kunun-zaki. Nig. Food J., 12: 34-41.

Ashaye, O.A., O.O. Taiwo and G.O. Adegoke, 2006. Effect of local preservative (*Aframomum danielli*) on the chemical and sensory properties of warankashi. Afr. J. Agric. Res., 1: 10-16.

Ayo, J.A. and J.C. Okaka, 1998. Interaction of cadaba farinose crude extract and pH level on physio-chemical properties of Kunun-zaki. Proceeding of the 22nd Annual Nigerian Institute of Food Science and Technology, November 23rd-26th, 1998, Abeokuta, pp: 31-33.

Falola, A.O., C.C. Okoro and G.O. Adegoke, 2008. Shelf-life extension studies of akara spiced with crude extract of *Aframomum danielli*. Niger. Food J., 26: 19-31.

Gaffa, T., I.A. Jideani and I. Nkama, 2002. Traditional production, consumption and storage of kunun: A non alcoholic cereal beverage. Plant Food Hum. Nutr., 57: 73-81.

Ihekoronye, A.I. and P.O. Ngoddy, 1985. Food Lipids: Integrated Food Science and Technology for the Tropics. Macmillian Publishers, India, pp: 58-85.