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Full Length Research Paper

Effect of sesame seed addition on the chemical and sensory qualities of sorghum based kunun- zaki drink

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Kunun- zaki was prepared using sorghum as the base and supplemented with sesame seeds at varied level (0-50%). The drink was produced by cleaning, washing, steeping, wet milling, sieving, mixing, cooking and filtering to obtain the liquor. The effect of added sesame seed on chemical and sensory quality attributes was evaluated. The results obtained from chemical analysis shown that sorghum–sesame products have range of p^H (3.70- 3.83), total solid (29.53-40.10%) and titratable acidity (3.27-3.43g/ml). The addition of sesame seed brought about significant decrease in moisture and carbohydrate from 80.67-63.59%, 9.27-1.73% respectively with increasing concentration (0-50%) while protein, ash and fat increased from 7.57-15.43%, 1.07-4.07% and 1.13- 14.60% respectively. Furthermore, a similar increase was observed in mineral (calcium, phosphorus, potassium, magnesium and iron) contents. The sensory analysis showed that there was no significant difference observed between the whole sorghum kunun- zaki and the sesame supplemented samples in the sensory attribute of colour while significant difference ($p<0.05$) was observed in taste, aroma, texture and overall preference respectively. It was concluded that a substitution of 20% sesame into sorghum gave the kunun- zaki with the best overall quality acceptability.

Keywords: Nutrient composition, kunun- zaki, fermentation, sensory quality.

INTRODUCTION

Kunun-zaki drinks are locally produced beverages which of recent have become popular among the various non-alcoholic drinks in the northern part of Nigeria. (Ayo,1998, Gaffa, 2000). Millet, sorghum and maize grains are the three principal cereals from which Kunun-zaki can be produced (Adeleke et al., 2004; Inatimi et al., 1988; Gaffa et al., 2002). It is usually flavoured with such spices as ginger, black pepper and tamarind for improvement in its taste and aroma, and also to serve as purgative and cure for flatulent conditions (Omakwu, 1980). The component of kunun-zaki generally include 85.0-87% moisture, 9.0-12.0% carbohydrate, 1.6-8.0% protein, 0.1% fat, 0.6% ash (Ayo, 1998). It is a considerably cheap beverage drink because the ingredients used for the preparation are cheap and available anywhere in the market and stores. The traditional production of Kunun-zaki is still at village technology level. The process of production involves wet milling of the cereal, wet sieving, partial gelatinization of the slurry, sugar addition and bottling (Adejuyitan et al., 2008). The fermentation process may last for 12-72 hours (Gaffa and Ayo, 2002), after which it is kept for acidification to develop. Brief fermentation, involving mainly lactic acid bacteria and yeast, usually occurs during steeping of grains in water over 8 – 48 hour (Odunfa and Adeleye, 1985). Wide varieties exist in the methods of preparation depending on taste, cultural norms and habits (Abulude et al., 2006). Additives used in fortification are used to compensate for loses during processing, addition at levels higher than those found in the original food and includes adding nutrients that are not present in the original and to levels specified in the standard of identity (Nieman et al.,1992).

Studies have reported on Kunun-zaki. Adeyemi and Umar, 1994 reported the effect of methods of manufacturing on the quality. Bankole et al., 1999 studied the anti-microbial effect of spices on Kunun-zaki. Onuorah et al., 1987 reported on the occurrence of staphylococci and coliforms on utensils used in the preparation in Samaru. The consumption rate of the beverage has also been studied (Gaffa et al., 2002). Abulude et al., (2006) improved the nutritional value by fortification with vitamin C, calcium iron, flavour and

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preservatives. Hydrolytic enzymes have been used by several workers to produce Kunun-zaki which increased the nutritional and sensory quality of the product (Ayo and Okaka, 1998; Gaffa and Ayo, 2002; Akoma et al., 2002).Tahir and Oyewole, 1993 reported on bacteriological studies. Sathe et al. (1981) highlighted the significance of rheological characteristics in processing, quality control, sensory evaluation and structural analysis of kunun-zaki.

The basic ingredients of Kunun-zaki are low in protein and some essential minerals and increasing prices of protein rich foods continue to force greater percentage of the populace, to eat food supplying less of the required dietary nutrient. This may have a negative effect on the nutritional status of the people who drink it, especially on the growth rate of infants who are given kunun-zaki as a weaning drink (Akintunde, 2005). Research work carried out on the improvement of the nutritional value of cereals, shows that the fortification of carbohydrate-rich foods with protein-rich foods improves its nutritious values. Due to inadequate supplies of animal proteins, there has been a constant search for new protein sources, for use as both functional food ingredients and nutritional supplements, (Obizoba and Atti 1994). Plant protein products are gaining increased interest as ingredients in food systems throughout many parts of the world. Sesame seed (*Sesamum indicum*) contains about 25% crude proteins (Asogwa et al., 2005) and 50% fat (Akinoso et al., 2008). Sesame seeds are also a good source of manganese, copper, calcium, magnesium, iron, phosphorus, vitamin B1 and zinc. However, Phillips et al (2005) reported that the seeds contain phytic and oxalic acids, which are anti-metabolite; most of which are eliminated by dehulling and heat treatment. There are no reports in the literature on the production of sorghum-sesame seed composite Kunun-zaki. This research work aimed at strategic use of sorghum and sesame seed in the production of kunun-zaki, a non-alcoholic beverage consumed in Nigeria.

MATERIALS AND METHODS

Materials

Sorghum (*Sorghum bicolour*), Cloves, red pepper (*Capsicum anuum*), ginger (*Zingiber officinale*) and sugar were purchased at Igbona market in Osogbo, Osun state. White variety of sesame (*Sesamum indicum*) seeds was purchased from a local market in Kaduna metropolis.

Sample preparation

Figure 1 depicts the flow chart of kunun-zaki production according to Adeyemi and Umar (1994). Sorghum grains were washed, cleaned and steeped in water for 24 hr. Sesame seed was screened and steeped in water for 4 hr and dehulled. This process involves the wet milling of the sorghum and sesame seed at different levels (0-50%) with spices (ginger, cloves, and pepper, filtered (cloth sieve) and divided into four parts. The larger parts (¾) was gelatinized by addition of hot water cooled to 40 °C and added to the ungelatinized portion, mixed thoroughly, fermented (left for 12h), followed by the addition of sugar and bottling.

Chemical Analysis

p^H determination

The p^H of kunun-zaki was determined using a p^H meter (WPA pH Meter, India). The pH meter was first standardized with a buffer solution of p^H 4.0 and 7.O (BDH, England) and then introduced into a small beaker containing 100ml of kunun-zaki.

Total acidity (as lactic acid)

A portion (10ml) of kunun-zaki was measured into a 250ml conical flask and four drops of phenolphthalein indicator was added. This was titrated with the standard 0.1N NaOH to distinct faint pink point. The total titratable acidity was expressed as lactic acid (g/100ml) as described by (Agarry et al., 2010).

Total solids

Total solid was determined by evaporating 25ml of kunun-zaki to dryness on boiling water bath which was followed by drying to constant weight in an oven at 130 °C for 2-3 hr.

$$\% \text{ Total solid} = \frac{\text{Dry weight}}{\text{Weight of sample}} \times 100$$

Proximate composition

Crude protein and crude fat of samples (10 ml) were determined with standard macro-Kjeldahl and soxhlet procedures, respectively (AOAC, 1990; Pearson, 1976). Total ash was obtained by igniting 10 ml sample at 600 °C using muffle furnace (Pearson, 1976). Crude fibre was determined according to the procedure of (AOAC 1990). Moisture content was determined by weighing and drying to constant weight. The carbohydrate content was estimated by difference.

Mineral composition

Analysis of potassium content of the samples was carried

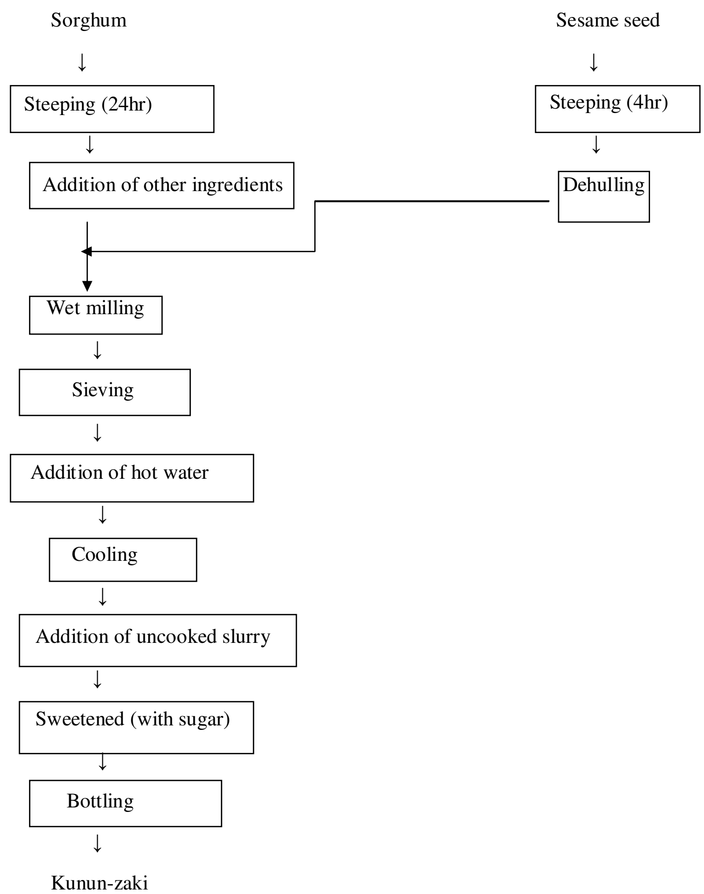

Figure1. Flow chart of Kunun-zaki production

out using flame photometry, while phosphorus was determined by the phosphovanado-molybdate (yellow) method (AOAC, 2005). The other elemental contents (Ca, Mg and Fe) were determined, after wet digestion of sample ash with an Atomic Absorption Spectrophotometer (AAS, Hitachi Z6100, Tokyo, Japan). All the determinations were carried out in triplicates.

Anti-nutrients analysis

Phytate content

The phytate content was determined by the method of Maga (1982). Two grams of each finely ground sample was soaked in 20 ml of 0.2 N HCl and filtered. After filtration, 0.5 ml of the filtrate was mixed with 1ml ferric ammonium sulphate solution in a test tube, boiled for 30 min in a water bath, cooled in ice for 15 min and centrifuged at 3000 rpm for 15min. One millilitre of the supernatant was mixed with 1.5 ml of 2, 2- pyridine solution and the absorbance measured in a spectrophotometer at 519 nm. The concentration of phytic acid was obtained by extrapolated from a standard curve using standard phytic acid solution.

Oxalate content

The titration method described by Day and Underwood (1986) was used to determine the oxalate content. To 1 g of the ground powder, 75 ml of 15N H_2SO_4 was added. The solution was carefully stirred intermittently with a magnetic stirrer for 1 h and filtered using What man No 1 filter paper. Filtrate (25 ml) was then collected and titrated against 0.1 N $KMnO_4$ solutions till a faint pink colour appeared that persisted for 30 s.

Sensory analysis

Quality attributes including colour, aroma, taste, flavour and overall acceptability of five (5) types of Kunun-zaki produced in this study were evaluated by 25 member panellists comprising of some trained students and staff members of department of Food Science and Technology, Bowen University. Coded samples were assigned to each panellist. A 9-point hedonic scale was

Table 1. Recipe for the production of kunuzaki

MATERIALS	CONTROL	A	B	C	D
Sorghum	100%	80%	70%	60%	50%
Sesame	-	20%	30%	40%	50%
Clove	1.60g	1.60g	1.60g	1.60g	1.60g
Ginger	4.82g	4.82g	4.82g	4.82g	4.82g
Red pepper	0.70g	0.70g	0.70g	0.70g	0.70g
Sugar	10.00g	10.00g	10.00g	10.00g	10.00g

Table 2. Effect of sesame addition on chemical characteristics of kunun-zaki

	SAMPLES				
Parameters	**Control**	**A**	**B**	**C**	**D**
p^H	$3.90^b \pm 0.04$	$3.83^b \pm 0.01$	$3.70^a \pm 0.02$	$3.71^a \pm 0.01$	$3.73^a \pm 0.01$
Tit. Acidity(g/ml)	$3.30^a \pm 0.01$	$3.37^a \pm 0.01$	$3.40^a \pm 0.03$	$3.43^a \pm 0.02$	$3.40^a \pm 0.02$
Total solids (%)	$19.30^a \pm 0.03$	$29.53^b \pm 2.03$	$32.20^c \pm 2.24$	$35.03^d \pm 2.07$	$40.10^e \pm 1.54$

Values in the same column with different superscript are significantly different ($p<0.05$)
Control: 100% Sorghum
A: 80% Sorghum : 20% Sesame
B: 70% Sorghum : 30% Sesame
C: 60% Sorghum : 40% Sesame
D: 50% Sorghum : 50% Sesame

used where 1 = dislike extremely to 9= like extremely.

Statistical analysis

The results were analyzed using sing the Statistical Package for Social Sciences (SPSS) Version 16.0 (SPSS Inc., Chicago, IL USA). Statistical differences between means were compared using paired T-test. Differences in means were considered statistically significant at $p < 0.05$.

RESULTS AND DISCUSSION

Physicochemical properties of kunun zaki

The result of the variation in p^H, titratable acidity and total solids values of kunun zaki were presented on Table 1. The p^H values obtained for all the samples ranged between 3.70 and 3.90.These values were comparable to p^H 3.9 observed by (Oshoma et al., 2009). The recorded p^H values of all the kunun-zaki samples in this study were, however, found to be lower than (4.0-4.14) recorded by (Ayo et al., 2004) for locally produced kunun-zaki. Higher p^H value of 6.50 was reported tigernut based kunun- zaki by Belewu and Abodunri (2008). The substantiated self-sanitizing role of Kunun-zaki is attributed to its acid p^H 3.9 to 5.6 (Adeyemi and Umar, 1994), various fermentation products (Bangert, 1989, Ashiru et al., 2003) with antimicrobial activity, the volatile oils and constituent acids of the spices –tamarind, ginger and black pepper (Frazier and Westhoff, 1986).

The Titratable acidity (TTA) found in the kunun-zaki drink samples ranges between 3.30 and 3.43g/100ml. The acidity of the samples can be attributed to the added species. It can also be traced to the presence of some bacteria like lactobacillus, acidophillus, candida species and *Saccharomyces cerevisiae* which help in acid fermentation of kunun-zaki. These bacteria do not encourage wide range of microorganisms particularly the non- acid ones in kunun-zaki and are non pathogen as they are beneficial to human being (Ayo et al., 2004).

The total solid content of kunun-zaki samples ranges between 19.30% and 40.10%. The result showed that the total solid content of the sample significantly increased as the level of sesame substitution increased. The addition of sesame seeds to sorghum in the preparation of kunun-zaki therefore had some positive effect on the total solid. The higher total solid content had effect on consumer acceptability as it imparted taste to the beverage. Earlier work reported a total solid of 13.42% for Kunun-zaki prepared from wet milled sorghum (Adejuyitan et al., 2008).

Proximate composition of Kunun zaki

The result of the variation in proximate compositions of kunun zaki is presented on Table 2. The moisture content of the kunun-zaki prepared from 100% sorghum was higher compared to products with added sesame

Table 3. Effect of sesame addition on proximate composition of kunun-zaki

	SAMPLES				
Parameters	**Control**	**A**	**B**	**C**	**D**
Moisture	80.67^{a}±0.12	69.47^{b}±0.12	68.85^{b}±0.08	67.65^{b}±0.38	63.59^{b}±4.64
Fat	1.13^{a}±0.04	10.47^{b}±0.12	10.83^{c}±0.04	12.13^{d}±0.04	14.60^{e}±0.16
Protein	7.57^{a}±0.09	11.60^{b}±0.03	12.87^{c}±0.05	13.77^{d}±0.05	15.43^{e}±0.05
Fibre	0.27^{a}±0.01	0.30^{a}±0.01	0.30^{a}±0.01	0.33^{a}±0.01	0.27^{a}±0.04
Ash	1.07^{a}±0.05	2.05^{b}±0.08	2.93^{c}±0.05	3.02^{d}±0.07	3.57^{e}±0.05
Carbohydrate*	9.27^{e}±0.05	6.30^{d}±0.14	4.20^{c}±0.08	2.73^{b}±0.17	2.23^{a}±0.17

Values in the same column with different superscript are significantly different (p<0.05)
*Calculated by difference

paste. Kunun-zaki prepared from 100% sorghum had the highest moisture (80.67%) and the least value was recorded for sample containing 50% sesame seed - 63.59%. Similar values were reported by Enegbede, 1999; Sopade and Kassum, 1992. This implies that the drink will have a short shelf life as high moisture content typically allows microbial growth (Battey et al., 2002; Elmahmood and Doughari, 2007). Kunun-zaki prepared from 50% sorghum and 50% sesame seed had the highest ash content-3.57% while that of 100% sorghum had least value- 1.07%. The ash content of the kunun-zaki prepared from the blends further confirms its high mineral content as shown on Table 2. This is in agreement with the finding that high amount of ash contained in plants, is an indication that the plant provides appreciable quantity of minerals essentially required by the body (Rao-Pu, 1996). In terms of crude fat, there is an increase from 1.13 to 14.60% with the addition of sesame (0-50%). The increase in the fat content of kununzaki was as a result of inclusion of sesame seed. Compared with many oil seeds, sesame seeds contain more oil with a greater yield of oil on per hectare basis and the oil content varies, from 56.15-63.4% as reported by Oresanya and Koleoso (1990). The seed also contains antioxidants called lignin which are also anti-carcinogenic and contain phytosterols which block cholesterol production. The kunun-zaki produced by the addition of sesame seed had higher protein range (11.60-15.43%) compared to the control (7.57%). The low protein content of the control is attributed to the low protein content of sorghum seeds (Hulse et al., 1980). The nutrient composition of sorghum is influenced by both the environmental factors and genetic factors (Asiedu, 1989). The most common source of variation is soil fertility, soil moisture and cultural practices. According to (Hamad and Fields, 1979) considerable nutrient losses also occur during conventional processing of Kunun drinks, this is because much of the protein in cereal grains is usually located in the testa and germ which are usually sifted off during processing. However, the protein content was observed to increase with increase in amount of sesame added. Sesame seed was noted to be a good source of protein (Eneche, 1999). Sesame protein has a good balance of amino acids with a chemical score of 62%, and a net protein utilization of 54% (Alobo, 2006). These characteristics give sesame the potential of being as source of protein supplementation in cereal based foods. This shows that addition of sesame can be used to supplement the protein content of sorghum, thus increasing its nutritious content. The crude fibre content ranged from a mean value of 0.27% to 0.33%. Dehulling and milling of sorghum grains had been shown to reduce the crude fibre content of the flour (Adeyemi, 1983). The carbohydrate content of the samples ranged from 2.23% to 9.27% with the control having the highest percentage of carbohydrate when compared to the sesame supplemented samples. The difference in the carbohydrate of the Kunun-zaki samples may be due to the difference in the cereal starting materials which may have different carbohydrate contents. Invariably, sesame seeds contain relatively lower carbohydrate resulting in lower carbohydrate content of the kunun-zaki but significant increase in protein. The difference may also be due to presence of spoilage microorganisms that use the carbohydrate for their metabolism (Egwaikhide and Faremi, 2010).

Mineral composition of Kunun- zaki

The concentrations of different mineral elements in the kunun-zaki samples were reported in Table 3.The calcium content increases from 11mg/100g as recorded in the control to 23mg/100g as the level of sesame substitution increases and this is as a result of the high calcium content in sesame seeds as sorghum seed is low in calcium (Rooney and Serna-Saldivar, 1990). Calcium help in regulation of muscle contractions transmit nerve impulses and help in bone formation (Cataldo et al., 1999). Calcium also assists in teeth development (Brody, 1994). In terms of phosphorus content, the mean value ranged from 20.01 to 25.67 mg/100g with the control having the least phosphorus content. Phosphorus is

Table 4. Effect of sesame addition on some mineral contents of kunun-zaki

	SAMPLES				
Parameter	**Control**	**A**	**B**	**C**	**D**
Calcium	11.00^{a}±0.82	12.67^{a}±0.92	17.67^{b}±2.05	21.67^{bc}±1.25	23.00^{c}±0.82
Phosphorus	20.01^{a}±0.94	21.33^{b}±0.94	23.02^{c}±0.94	24.00^{c}±0.07	25.67^{d}±0.47
Potassium	24.53^{a}±0.33	25.10^{b}±0.56	27.4^{c} ± 0.05	28.03^{d}±0.23	30.02^{e}±0.47
Magnesium	25.40^{a}±1.12	26.34^{b}±0.97	27.12^{c}±1.02	29.11^{d}±0.77	31.23^{e}±0.05
Iron	2.70^{a}±0.14	3.00^{ab}±0.08	3.50^{b}±0.24	4.07^{c}±0.09	4.20^{c}±0.10

Values in the same column with different superscript are significantly different (p<0.05)

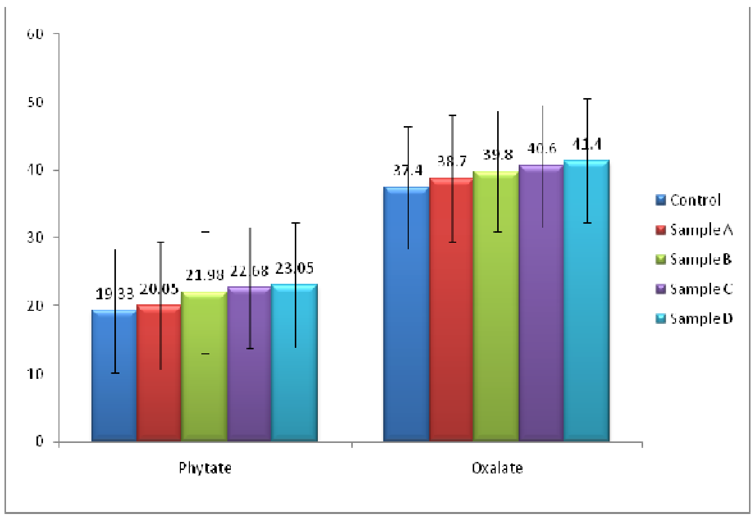

Figure 2. Phytate and oxalate contents of Kunun-zaki

needed for bone growth, kidney function and cell growth. It also plays a role in maintaining the body's acid-alkaline balance (Fallon, 2001). A similar trend was observed in the potassium content. Potassium is an essential nutrient and has an important role is the synthesis of amino acids and proteins (Malik and Scrivastava 1982). The kunun-zaki produced by the addition of sesame seed had higher magnesium range (26.34-31.23mg/100g) compared to the control (25.40 mg/100g). Magnesium helps in keeping the muscle relaxed and the formation of strong bones and teeth. It plays fundamental roles in most reactions involving phosphate transfer, believed to be essential in the structural stability of nucleic acid and intestinal absorption while deficiency of magnesium in man is responsible for severe diarrhea, hyper-tension and stroke (Appel, 1999). The iron content increases from the range of 2.70 to 4.20mg/100g with the control having the lowest value since sorghum seeds contain small amount of iron (Shobha et al., 2006). Similar result was observed by Kayode, 2006 who reported that iron concentration of the sorghum grains ranged from 3.0 to 11.3 mg/100g. However, sesame seeds are very rich in the mineral (Deosthale, 1981). Iron is an important element in the diet of pregnant women, nursing mothers, infants convulsing patients and elderly to prevent anaemia and other related diseases (Oluyemi et al., 2006). Mineral compositions of cereals increase significantly during fermentation according to Obizoba and Atii (1994) and Fasasi (2009) due to the activity of the fermenting micro organisms more so when mineral dense oilseed such as sesame was added.

Anti nutrients composition of Kunun zaki

The result of the variation in anti- nutrient contents of kunun-zaki is presented on Table 4. The total phytate and oxalate content of the samples ranged from a mean value of 19.33 to 23.05mg/100g and 37.40 to 41.40mg/100g respectively. The phytate and oxalate content of the

Table 5. Effect of sesame addition on sensory mean scores of kunun-zaki

	SAMPLES				
Parameter	**A**	**B**	**C**	**D**	**E**
Colour	7.7^a	7.6^a	7.3^a	7.2^a	7.1^a
Taste	7.9^c	6.6^{bc}	6.3^b	6.0^a	5.8^a
Aroma	7.5^c	7.2^b	7.1^b	6.5^{ab}	6.2^a
Texture	7.7^c	7.3^c	6.6^b	6.1^b	5.9^a
Overall acceptability	8.4^d	7.3^c	7.0^c	6.2^b	5.7^a

Different subscripts down a row indicate significant difference at 5% level.

kunun-zaki prepared from 100% sorghum was lower compared to products with added sesame paste. Sorghum and sesame seeds usually contain anti-nutritional factors; oxalate and phytate which either forms complex with protein or binds with metal ions such as calcium and magnesium inhibiting the absorption of these important minerals. Cereals, however, contain an endogenous phytase. Because the endogenous cereal phytase has a p^H optimum of 5.15, it is probably inactivated in the low p^H of the stomach (Afify et al., 2011). Thus, there has been some interest in reducing the phytate content of cereals by soaking or germination or by adding a commercial phytase enzyme. Cooking as a processing method also reduces oxalic and phytic acid of food stuff inherent in the seed by leaching as they are thermolabile in nature (Fasasi et al., 2003) and much more effect is expected when followed by fermentation. However, the values of phytic and oxalic acids recorded in the kunun-zaki samples were lower as the daily intake of inhabitants of rural areas in developing countries, on mixed diets is 150–1400 mg (Reddy and Sathe, 2001).

Sensory properties of kunun zaki

The sensory scores of kunun-zaki are presented on Table 5. The average mean scores of colour remain the same with increasing percentage of added sesame seed (0-50%) as shown in Table 3. There was no significant difference in all the kunun-zaki samples. White varieties of sorghum and sesame seed respectively used in this study complement each other resulting in no change in the colour of kunun-zaki even with increasing concentration of sesame seeds. Increase in the concentration of sesame seed from 0-50%, however decreased the mean score for taste from 7.9 to 5.8.This could be as a result of the inherent bitter taste of sesame as earlier reported by Douglas and Glenn (1982). The average mean score of aroma of the kunun-zaki decreased from 7.5 to 6.2. This result agrees with the finding of Douglas and Glenn (1982) that sesame has its inherent flavour that was noticeable in the blends containing sesame. The average mean score of texture decreased from 8.4 to 5.9 with increasing concentration of sesame seed (0-50%). This could be as a result of higher fibre content of sesame seed (6.3-8.6%) as earlier reported by Sweiss (1983). General acceptability sores decreased from 8.4 to 5.7 with increase in the concentration of sesame seed. The control (100% sorghum) had the highest acceptability (8.4), while sample containing 50% sesame seed had the least acceptability (5.7). Generally, this implies that replacement of sorghum with sesame seed above 20% grossly affected the sensory attribute of kunun-zaki.

CONCLUSION

The study showed that supplementation of sorghum with sesame seed had significant effect on the nutritional and sensory properties of kunun-zaki drink. The addition of 20% sesame resulted in kunun-zaki with high nutritional value and good overall acceptability.

RECOMMENDATION

Further studies should be done to determine the microbial analysis and the shelf-life of kunun-zaki made from sorghum and sesame seed and ways by which its shelf life can be prolonged.

REFERENCES

Abulude FO, Ogunkoya MO, Oni VA (2006). Mineral composition, shelf-life, and sensory attributes of fortified 'Kunuzaki' beverage. Acta Sci. Pol., Technol. Aliment. 5 (1):155-162.

Adejuyitan JA, Adelakun OE, Olaniyan SA, Popoola FI (2008). Evaluating the quality characteristics of kunun produced from dry-milled sorghum. Afr. J. Biotechnol. 7(13):2244-2247.

Adeleke OE, Olaitan JO, Olubile O (2004). Microbial isolates from Kunnu-zaki and their antibiotic sensitivities. Adv. Food Sci. 26(4): 168-170.

Adeyemi IA (1983). Drymiling of sorghum for "Ogi" manufacture. J. Cereal sci.1: 221-226.

Adeyemi IA, Umar S (1994). Effect of method of manufacture on the quality characteristics of Kunun zaki Nig. Food J. 12: 34-40.
Afify AE-MMR, El-Beltagi HS, Abd El-Salam SM, Omran AA (2011). Bioavailability of Iron, Zinc, Phytate and Phytase Activity during Soaking and Germination of White Sorghum Varieties. PLoS ONE 6(10): e25512. doi:10.1371/journal.pone.0025512.
Agarry1 OO, Nkama I, Akoma O (2010). Production of Kunun-zaki (A Nigerian fermented cereal beverage) using starter culture. Int. Res. J. Microbiol. 1(2):018-025 May 2010.
Akinoso R, Olayanju TA, Idehai JO, Igbeka J (2008). The Effects of Varieties and Moisture Content on Some Physical and Aerodynamic Properties of Sesame Seeds (*Sesamum indicum L*) as Related to Cleaning. Int. J. Food Eng.4:8.
Akintunde TY (2005). Nutritional and sensory qualities of soymilk-kunnu blends. Afr. J. Food Agric. Nutrition and Dev. 5:2, ISSN: 1684-5358.
Akoma O, Onuoha SA, Ajiboye MO, Akoma AO, Alawoki AM (2002). The nutritional and sensory quality characteristics of kunun-zaki produced with the addition of hydrolytic enzymes from malted rice (Oryza sativa). J. Food Technol. Afr. 7 (1):24-26.
Alobo AP (2006). Effect of sesame seed on millet biscuit. J. Plant Food Plant Foods for Human Nutr. 64:21-27.
AOAC (1990). Official Methods of Analysis (15th ed). Association of Official Analytical Chemist, Washington D.C. pp. 808, 831-835.
AOAC (2005). Official Methods of Analysis. 19th Edn. Association of Official Analytical Chemists, Washington, DC., USA.
Appel LJ (1999). Nonpharmacologic therapies that reduce blood pressure: a fresh perspective. Clin. Card., 22: 1-5.
Ashiru AW, Olaleye OO, Uaboi Egbenni PO (2003). Occurrence of Pathogenic organisms in kunun drink sold within Lagos Metropolis Proceeding of the 27th Annual Nifst Conference. Pp 84.
Asiedu JJ (1989). Processing Tropical Crops. A Technological Approach, Macmillian Education Ltd. pp. 189-222.
Asogwa MO, Onu FN, Uchenwa EN, Unigwe CR (2005). Effect of Partial replacement of foundation meal with sesame seed (Sesame indicum) in low broiler starter diets on their performance. Proceedings of the 39th Ann. Conf. Agricultural Society of Nigeria, University of Benin, Nigeria. Pp.46–47.
Ayo JA (1998). Effect of C. Farinose crude extract on the quality of Kunun zaki. M.Sc Thesis. Dept.of Food Science and Tech., University of Science and Tech. Enugu, Nigeria.
Ayo JA, Okaka, JC (1998). Interaction effect of Candaba farinose extract and pH levels on some physiological properties of kunun-zaki. Proceedings of the 22nd annual conference of the Nigerian Institute of Food Science and Technology (NIFST) Abeokuta, Nigeria. 23rd-26th, November.
Ayo JA, Umaianze G, Gaffa T (2004). Microbiological evaluation of kunun zaki and Zoborodo drink (beverage) locally produced and sold in a polytechnic community in Nigeria. Nigerian Food J. 22.ISSSN 189-7241.
Bangert BA (1989). The quality of cereal foods. Food Chem. 33: 15-26.
Bankole MO, Akpan I, Atanda OO (1999). The anti-microbial effect of spices in kunutsamiya. Nigerian J.Microbiol.13:95-97.
Battey AS, Duffy S, Schaffner DW(2002). Modeling Yeast spoilage in cold-filled ready-to- drink beverages with Saccharomyces cerevisiae, Zygosaccharomyces bailii and Candida lipolytica. Appl. Environ. Microbiol. 68(4): 1901-1906.
Belewu MA, Abodunrin OA (2008). Preparation of Kunun from unexploited rich food source: Tiger nut (Cyperus esculentus). Pak. J. Nutr., 7(1), 109-111
Brody T (1994). Nutritional Biochemistry, San Diego, CA: Academic Press. 2nd Edn., pp: 761-794.
Cataldo CB, DeBruyne LK, Whitney, EN (1999). Nutrition and diet therapy principles and practise 5th edition. Wadsworth Publishing Company and International Thomason Publishing Company. USA. pp: 35-204.
Day RA, Underwood AL (1986). Qualitative Analysis. 5th Ed. New Delhi, India: Prentice Hall Publications. Pp.701.
Dendy DAV, editor. Structure and chemistry of sorghum and millets. St Paul, MN, USA: Am. Assoc. Cereal Chem. pp. 69–124.
Deosthale YG (1981). Trace element composition of common oilseeds. J. Am. Chem. Soc., 58: 988-990.
Douglas M, Glenn DD (1982). Food and food production Encyclopedia. First Edn., Van Most Rand, Reinhold, pp: 131-592.
Egwaikhide PA, Faremi AY (2010). Proximate nutrient compositions and microbiological qualities of kunun aya, kunun dawa, kunun zaki and kunun gyeda. EJEAFChe, 9(11), 1686-1692.
Elmahmooda AM, Doughari JH (2007). Microbial quality assessment of kunun zaki beverage sold in Girei town of Adamawa State Nigeria. Afri. J. Food Sci. pp.011-015.
Eneche EH (1999). Biscuit making Potential of Millet/pigeon Pea flour Blends. Plant Foods for Human Nutrition 54:21-27.
Enegbede OL (1999). Comparative sensory evolution on the production of kunun-gyada from different cereals. HND Thesis. Federal Polytechnic, Bauchi, pp. 3, 8-11.
Fallon S, Enig MG (2001). Nourishing Traditions. The Cookbook that Challenges Policitally Correct Nutrition and the Diet Dictocrats. Revised 2nd Edn., pp.40-45.
Fasasi OS (2009). Proximate, Antinutritional Factors and Functional Properties of Processed Pearl millet Pennisetum glaucum. J. Food Technol. 73: 92-97.
Fasasi OS, Eleyinmi AF, Fasasi AS, Karim OR (2003). Chemical properties of raw and processed breadfruit (*treculia africana*) seed flour. African Crop Science Conference Proceedings, 6:547-551.
Frazier WC, Westhoff DC (1986). Food Microbiology. Tata Mc Graw-hill New Delhi, pp. 51-55.
Gaffa T, Ayo JA (2002). Innovations in the traditional kunun zaki production process. Pak. J. Nutr. 1(5):202-205.
Gaffa T, Jideani IA Nkama I (2002). Traditional production, consumption and storage of kunu- a non alcoholic cereal beverage. Plant Food Human Nutr., 57: 73-81.
Hamad AM, Fields ML (1979). Evaluation of protein quality and available lysine of germinated and fermented cereal. J. Food Sci., 44: 456-459.
Hulse JH, Learning EM, Pearson OE (1980). Sorghum and the millets: Their composition and nutritive value. New York: Academic Press.
Inatimi EB, Abasirkong SF, Chiernaka I (1988). Kunnu-zaki and tsamiya: Some non-alcoholic beverages prepared from Sorgum grains. Nig. J. Biotech. 5: 21-22.
Kayode APP (2006). Diversity, users' perception and food processing of sorghum: Implications for dietary iron and zinc supply. pp. 1–151. Ph.D thesis Wageningen University, Wageningen, The Netherlands.
Maga JA (1982). Phytates: Its chemistry, occurrence, food interactions. Nutritional significance and method of analysis. *J. Agric. Food Chem.*, 30(1):1-7.
Malik CP, Srivastava AK (1982). Text Book of Plant Physiology. Ludhiana, New Delhi.
Nieman DC, Butterworth DE, Nieman CN (1992). Nutrition. Brown Publ.USA, 164-166.
Obizoba IC, Atti JV (1994) Evaluation of the effect of processing techniques on the nutrient and anti-nutrient contents of pearl millet Pennisetum glaucum seeds. Plant Food Human Nutrition 45: 23-24.
Odunfa SA, Adeleye S (1985). Microbiological changes during the traditional production of Ogi –baba. J. cereal sci.: 3: 173 – 180.
Oluyemi EA, Akinlua AA, Adenuga AA, Adebayo MB (2006). Mineral contents of some commonly consumed Nigerian Foods. Sci. Focus. 11 (1): 153-157.
Omakwu J (1980). The preservation effect of spices in Kunnu-samiya. A B. Sc. dissertation in the Department of Microbiology, Ahmadu Bello University, Zaria, Nigeria.
Onuorah SI, Adesiyun AA, Adekeye JO (1987). Survival and multiplication of Staphylococcus aureus and Escherichia coli in a Nigerian cereal drink (kunun-zaki): Effect of spices, Ph and temperature. J. Food Agric., 1:31-34.
Oresanya MO, Koleoso OA (1990). Benniseed processing and utilization. An animal report submitted to the Federal Institute of Industrial Research (FIIRO), Oshodi, Lagos.
Oshoma CE, Aghimien MO, Bello ZO (2009). Growth and Survival of Escherichia coli in Kunun Zaki During Storage. World Journal of Agricultural Sciences. 5(4): 494-497.
Pearson D (1976). The Chemical Analysis of Foods (7th ed). Churchill Livingstone, London. pp. 6-25.
Phillips KM, Ruggio DM, Ashraf-Khorassani M (2005). Phytosterol composition of nuts and seeds commonly consumed in the United

States. J. Agric. Food Chem. 53(24): 9436-9445.

Rao-pu (1996). Nutrient composition and biological evaluation of Mesta (*Hibiscus sabdariffa*) seeds*. Plant Food for Human Nutr. 49: 34-37.*

Reddy NR, Sathe SK (2001). Food Phytates. 1st Edn., CRC Press, New York, pp: 30-32.

Rooney LW, Serna-Saldivar ET (1990). Sorghum. In:Lorenz.K.L and Kulp.K (Eds).Handbook of Cereal Science and Technology. Marcel Dekker, New York.

Sathe SK, Lyer V, Salunkhe DK (1981). Investigation of great Northern bean (Phaseolues vulgaris L) starch solubility, swelling interaction with free fatty acids and alkaline water retention capacity. J. Food Sci. 46: 1914- 1917.

Shobha V, Kasturiba B, Naik RK, Yenagi N (2008). Nutritive Value and Quality Characteristics of Sorghum Genotypes. Karnataka J. Agric. Sci. 20: 586-588.

Sopade PA, Kassum AL (1992). Reological characterization of Nigerian liquid and semi- liquid foods. Kunun zaki and kunun gyada. Nig. Food J. 10: 23-33.

Tahir F, Oyewole O (1993) Bacteriological studies of kunuzaki. Nig. J.Microbiol. 9:47-53.