

ISSN: 2437-1955

IJMNR

International Journal of Moringa and Nutraceutical
Research

Volume 3 | June 2016



A Journal of the
International Moringa and
Nutraceutical Research

**INTERNATIONAL JOURNAL OF MORINGA AND
NEUTRACEUTICAL RESEARCH**

Volume 3 | June, 2016

CONTENTS

- Impact of Defatted Moringa Seed and Plantain Flours Substitution on the Properties of Trifoliate Yam Flour** 1-9
Abiodun O.A., Adegbite, J.A., Amanyunose, A.A. and Olosunde O.O.
- Willingness to Pay for *Moringa oleifera* Leaf Powder Fortification among Bread Consumers in Kwara State, Nigeria** 10-24
Ajibade T.B., Ajibade E.T., Belewu K.Y., Opaleke D.O.
- Assessment of Consumption of Stimulating Foods among Rural Households in Kwara State, Nigeria** 25-37
Omotesho K.F., Omotesho O.A., Muhammad-Lawal, A., Amolegbe K.B. and Ojibara M.A.
- Communication Constraint in Information Dissemination along Moringa Supply Chain in Kwara State, Nigeria** 38-46
Ayinde O. E., Aina I. V., Animashaun J. O., Salami M. F. and Ojo O. E.
- A Review of Production and Marketing Standard of *Moringa oleifera* Lam** 47-61
Babalola, F.D., Eifediyi, E.K., Akeredolu O.E. and Oso A.O.
- * **Effect of Fortification on the Chemical and Sensory Properties of Tigernut Drink (*Kunun-Aya*)** 62-74
Balogun M. A., Kolawole F. L., Oziegbe U. K. and Akintayo O. A.
- Socioeconomic Determinants of Moringa Cultivation among Farmers in Jigawa State, Nigeria** 74-83
Oladipo, F.O., Bello, O.G., Daudu, A.K and Orire, R.O
- Efficacy of aqueous leaf extracts *Azadirachta indica* and *Moringa oleifera* in the control of *Callosobruchus maculatus* (F.) on stored cowpea** 84-93
Uddin II R. O. and Ogundele S. M.

Effect of Fortification on the Chemical and Sensory Properties of Tigernut Drink (*Kunun-Aya*)

Balogun M. A.*, Kolawole F. L., Oziegbe U. K. and Akintayo O. A.

Department of Home Economics & Food Science, University of Ilorin, PMB 1515, Ilorin, Nigeria.

Corresponding author: bmutiatadebanke@yahoo.com, balogun.ma@unilorin.edu.ng,
Phone Number: +234 8055948515

Abstract

Kunun-aya is a traditional non-alcoholic fermented tigernut beverage widely consumed in the Northern parts of Nigeria. Moringa is reported to be rich in vitamins and minerals. The study was designed to evaluate the effect of addition of Moringa seed powder (at 5, 10, 15 and 20%) on chemical and sensory properties of *kunun-aya* using standard methods. Data generated were subjected to analysis of variance (ANOVA) and Turkey test. Results obtained showed that there was a progressive increase in vitamin C (8.80 – 11.48mg/ml) and protein (6.47 – 10.70%) contents with increase inclusion level of Moringa seed powder. Similar increase was observed in mineral (calcium, phosphorus, potassium, magnesium and iron) contents. Phytochemical screening showed an increase in saponins, tannins and phytate but decrease in alkaloids, steroids, resins, cyanogenic glycoside and oxalate. Sensory analysis showed that there was no significant difference ($p > 0.05$) between the control and the Moringa supplemented samples in terms of aroma and consistency while significant difference ($p < 0.05$) was observed in taste, colour and overall acceptability. The study revealed that 5% Moringa seed powder is acceptable for fortifying *kunun-aya* with a significant increase in protein, vitamin C and minerals. Fortification of *Kunun-aya* with Moringa seed is therefore recommended because of its improved nutritive value and potential health benefits.

Keywords: Chemical, fortification, *kunun-aya*, sensory, tigernut.

Introduction

Kunun is a traditional non-alcoholic fermented beverage widely consumed in the northern parts of Nigeria especially during the dry season (Adeyemi and Umar, 1994). It is cheap and the raw materials used in its preparation are widely grown throughout the savannah region of Nigeriasuch as Bauchi, Kano, Sokoto and Katsina States. According to Odunfa and Adeyeye (1985), the traditional processing of *kunun* involves steeping of grains, wet milling with spices (ginger, cloves and pepper), wet sieving and partial gelatinization of the slurry, followed by addition of sugar and then bottling. The processed *kunun* is usually packed for sale either in plastic bottles or in large containers and distributed under ambient temperature or cooled in a refrigerator where available. Besides the fact that the two dominant religious groups, Christianity and Islam, use it as a substitute for alcoholic drinks, it is very nutritious and medicinal (Besthart, 1982). *Kunun* is consumed in Nigeria by both adults and children as a breakfast drink or food complement; it is usually used as an appetizer to entertain visitors in rural and urban centers, and commonly served at social gatherings as well (Onuorah *et al.* 1987; Amusa and Odunbaku, 2009). It can be produced from different raw materials like sorghum, groundnut, tigernut *e.t.c.* Its specific name is derived from the raw material used in its production. Some of the various types of *kunun* processed and consumed in Nigeria are *kunun zaki*, *kunun*

gyada, *kunun akamu*, *kunun tsamiya*, *kunun baule*, *kunun jiko*, *kunun amshau*, *kunun-aya* and *kunun gayamba*. However, *kunun zaki* is the most commonly consumed.

Tiger nut or tigernut (*Cyperus esculentus* L.) is an edible perennial grass-like plant, native to the Old World and a lesser known vegetable that produces sweet nut-like tubers known as "earth almonds" (Coskuner *et al.*, 2002). It is considered as a weed in many countries (De Vries, 1991) and underutilized (Adejuyitan, 2011). It is an excellent source of minerals such as phosphorus, potassium, and vitamins E and C (Belewu and Belewu, 2007).

Moringa oleifera Lam belongs to the *Moringaceae* family, a single genus family with 14 known species, of which *Moringa oleifera* is the most widely known and utilised. Fahey (2005), in his article, refers to popular publications promoting *Moringa* as a nutrient-dense food source, asserting that the importance of *Moringa* lies in the high nutritional value of its leaves, pods and seeds. *Moringa*, according to Fahey (2005) is a relatively good source of vitamins, minerals and essential amino acids. This means it could be used to help alleviate micronutrient malnutrition at household as well as national levels.

This research is designed to increase the utilization of tigernut on one hand and harness the rich nutritional value of *Moringa* on the other hand, by producing *Moringa* fortified *kunun-aya*. The objective of this work is therefore to carry out chemical analysis on fortified *kunun-aya*

and also determine the sensory properties of the product.

Materials and Methods

Moringa seeds were obtained from a *Moringa* farm in Ilorin metropolis. The ingredients (tigernut, sugar, cloves, Benin pepper and ginger) were obtained from a local market in Ilorin, Kwara State.

Preparation of moringa-fortified kunun-aya
The traditional processing method described by Odunfa and Adeyeye (1985) was adopted with few modifications. The tigernut was washed, cleaned and steeped in water for 48 hours. *Moringa* seeds were screened, de-hulled and roasted (to improve its flavor). The process involved a wet milling of 100 % tigernut (the control) and 4 other treatments comprising tigernut substituted with *Moringa* seeds (at 5, 10, 15 and 20% substitution levels). Each of the formulation was spiced with ginger, cloves, and Benin pepper. After milling, sieving was done using a clean cloth sieve; the filtrate obtained was allowed to settle and ferment overnight after which the supernatant was decanted. The fermented filtrate was then sweetened (with sugar) and bottled.

Chemical analyses

The proximate compositions of the kunun-aya samples were determined using the method described by AOAC (2000). Other chemical components analysed were pH (AOAC, 2005), total acidity (Agarry *et al.*, 2010), mineral content (Aqua-ragia method

of AOAC, 2005), tannin content (Islam and Mohammed, 2016), phytate content (Wheeler and Ferrel, 1971), oxalate content (Makinde and Oyeleke, 2012), alkaloids (Adeniyi *et al.*, 2009), cyanogenic glycoside (AOAC, 1990), saponins (Obadoni and Ochuko, 2001), steroids (Sofowora, 1982), and vitamin C (Ayekyaw, 1978).

Total solids: This was determined using the method described by Abel *et al.* (2011). Twenty five (25) ml of *kunun-aya* was evaporated to dryness on a boiling water bath followed by drying to a constant weight in an oven at 130°C for 2 hrs.

$$\% \text{ Total solids} = \frac{\text{dry weight}}{\text{weight of sample}} \times 100$$

Sensory analysis

Quality attributes including colour, aroma, taste, consistency and overall acceptability of the various *Kunun-aya* samples were evaluated by an 18-member panel comprising of 9 students and 9 staff who are familiar with *Kunun*. The panelists were randomly selected from the Department of Home Economics and Food Science, University of Ilorin. A multiple paired comparison test was used with a 9-point hedonic scale ranging between 1 (dislike extremely) and 9 (like extremely).

Statistical Analysis

The results of all the analyses were subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) Version 16.0. The means were separated using Turkey test.

Results and Discussions

Physicochemical properties of kunun-aya

The pH, titratable acidity and total solids values of the various *kunun-aya* samples are presented in Table 1. The pH values which ranged between 4.10 and 4.80 are comparable to those (4.0-4.14) reported by Ayo *et al.* (2004) as the pH of locally produced *kunun zaki*. The substantiated self-sanitizing role of *Kunun-aya* is attributed to its pH (3.9 to 5.6) as reported by Adeyemi and Umar (1994).

The total titratable acidity (TTA) of the *kunun-aya* samples ranged between 3.51 and 8.54 g/100ml. The acidity level of the samples may be attributable to the acid fermentation by microorganisms present in the samples. These non-pathogenic microbes inhibit the growth of other microorganisms, particularly the non-acid ones, in *kunun* and are beneficial to humans (Ayo *et al.*, 2004).

The total solid content of the *kunun-aya* samples significantly increased (20.21 – 30.01%) with increased inclusion level of *Moringa* seed. This is higher than the 13.42% reported by Adejuyitan *et al* (2008) for *Kunun-zaki* produced from sorghum. The difference could be attributed to the inclusion of *Moringa* seed. The higher total solid content had effect on consumer acceptability as it imparted a mouthfeel to the beverage.

Proximate Composition of Kunun-aya

The proximate compositions of the various *kunun-aya* samples are presented in Table 2. There were significant differences in the proximate compositions of all the samples except in crude fibre. The moisture contents ranged between 68.86 and 82.60%, with 100% *kunun-aya* having the highest value while the sample containing 20% *Moringa* seed had the least. The lower moisture content of the *Moringa* fortified samples implies an improved shelf life as a high moisture content typically allows microbial growth (Battey *et al.*, 2002; Elmahmooda and Doughari, 2007).

The crude protein increased from 3.32 to 3.64% as the inclusion level of *Moringa* seed increased. This increased protein content can be attributable to the added *Moringa*. Olugbemi, (2010) reported *Moringa* to be a good source of protein. This shows that addition of *Moringa* seed can be used to supplement the protein content of tigernut, thus increasing its nutritious content.

Values ranging from 2.17 and 11.81% were recorded for the various *kunun-aya* samples. The control had the lowest value and this increased as the inclusion level of *Moringa* seed was increased.

In terms of crude fat, there was a decrease from 3.64 to 3.32% with the addition of *Moringa* seed. The decrease in the fat content of *kunun-aya* can be attributed to the low fat content of *Moringa* seed. Compared with many oil seeds, *Moringa*

seeds contain less oil. It has a lesser yield of oil on per hectare basis when compared to tigernut oil and the oil content varies from 56.15 – 63.4% as reported by Oresanya and Koleoso (1990). Low fat foods are known to reduce cholesterol level (Gordon and Kessel, 2002).

The crude fibre content ranged from 2.02 to 2.04%. Though not significantly, the crude fibre increased with increased inclusion of *Moringa* seed. Tigernut has been reported to be high in crude fibre content (Alegria-Toran and Farre-Rovira, 2003) and *Moringa* seed has also been reported by Olugbemi *et al.* (2010) and Mutayoba *et al.* (2011) to be a good source of fibre. Crude fibre is effective in the treatment and prevention of many diseases including colon cancer (Adejuyitan *et al.*, 2009).

Having the highest ash content (3.27%) was 20% *Moringa* fortified *Kunun-aya* while the control (100% *kunun-aya*) had the lowest (3.10%). This increased ash content is an indication of increased mineral contents. Ash contained in plants is an indication of minerals (Rao-Pu, 1996)

Mineral Composition of Kunun-aya

The mineral contents of the *kunun-aya* samples are shown in Table 3. There were significant differences among the *kunun-aya* samples in terms of all the mineral elements analysed. The control (100% *kunun-aya*) had recorded the least values but these increased with increased inclusion level of *Moringa* seed. This can be attributed to the rich mineral content of

Moringa. The calcium content ranged between 7.27 and 9.25 mg/100g. *Moringa* contains a high level of calcium (Mutayoba *et al.*, 2011), and calcium helps in the regulation of muscle contractions, transmits nerve impulses and helps in bone formation (Cataldo *et al.*, 1999). Calcium also assists in teeth development (Brody, 1994).

Values in the range 5.40 – 42.76 mg/100g were obtained as the phosphorus contents of the various *kunun-aya* samples. Phosphorus is needed for kidney function as well as bone and cell growth. It also plays a role in maintaining the body's acid-alkaline balance (Fallon and Enig, 2001).

The potassium contents were between 17.33 and 39.71 mg/100g. This also shows that *Moringa* inclusion in the production of *kunun-aya* will increase its potassium content. Potassium is an essential nutrient and has an important role in the synthesis of amino acids and proteins (Malik and Scrivastava 1982).

The *kunun-aya* samples contained 6.85 – 7.02 mg/100g magnesium. 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. Deficiency of magnesium in man is responsible for severe diarrhoea, hyper-tension and stroke (Appel, 1999).

The iron contents ranged from 14.16 to 24.76 mg/100g as *Moringa* inclusion increased. Iron is an important element in the diet of pregnant women, nursing mothers, infants, convulsing patients and the elderly to prevent anaemia and other related diseases (Oluyemi *et al.*, 2006).

Phytochemical Screening

The results of the phytochemical tests are shown in Table 4. The various *kunun-aya* samples contained alkaloids (2.02 – 2.25 mg/100g), steroids (1.34 – 2.81 mg/100g), resins (2.88 – 3.04 mg/100g), cyanogenic glycoside (1.65 – 1.88 mg/100g), saponins (0.89 – 1.05 mg/100g), tannins (9.63 – 11.88 mg/100g), oxalate (0.60 – 0.65 mg/100g) and phytate (1.98 – 2.12 mg/100g). Phytochemicals are inhibitory to the growth of bacteria (Mungole *et al.*, 2010). The anti-nutrients in the samples were low, except tannin. Even tannins have been noted to have some beneficial effects in food and humans. It was reported by Sodipo *et al.* (1991) that tannins prevent the development of micro-organisms. Certain bioactive chemical compounds (like saponins, tannins and other phytochemicals), which are known as secondary metabolites of plants have been noted to have pharmacologically active agents (Soetan and Oyewole, 2009).

Vitamin C Content

The result of the vitamin C analysis, as shown in Fig. 1, shows that the control had the lowest vitamin C content. The vitamin C content increased as more *Moringa* seed was added to the tigernut.

The results of the sensory evaluation of the *kunun-aya* samples are presented in Table 5. There were significant differences in all the sensory attributes except in aroma and consistency. Though the sensory qualities of the *kunun-aya* samples reduced with increased inclusion level of *Moringa* seed, 5% *Moringa* fortified *kunun-aya* compared closely with the control (100% *kunun-aya*). This means moderate inclusion of *Moringa* seed in *kunun-aya* production is acceptable by the panelists.

Conclusion

The study revealed the possibility of fortifying *kunun-aya* with *Moringa* seed. The *moringa* fortified *kunun-aya* makes another member of a family of dairy analogues with a lot of health benefits. The study also showed that *kunun-aya* fortified with *Moringa oleifera* seed had appreciable amounts of carbohydrate, protein and minerals, which are nutritional requirements of human. *Kunnu-aya* fortified with 5% *Moringa* seed was the most accepted sample by the panelists. The sample containing 80% tiger nut and 20% *Moringa* seed had the highest nutritional composition when compared to other samples.

Recommendation

Kunun-aya fortified with *Moringa* seed has an added advantage of providing more nutritive and medicinal value. It is therefore recommended as value addition to *Kunun* products. *Moringa* fortified *Kunun-aya* is an excellent choice for people who desire a refreshing and healthy drink.

References

- A.O.A.C. (1990): Official methods of analysis, 15th Edition, Association of Official Analytical Chemistry, Washington D.C, U.S.A.
- A.O.A.C. (2000): Official methods of analysis, 17th Edition, Association of Official Analytical Chemistry, Washington D.C, U.S.A.
- A.O.A.C (2005): Official methods of analysis, 18th Edition, Association of Official Analytical Chemistry, Washington D.C, U.S.A.
- Abel A.M., Omale J. and Okoli E.C. (2011). Effects of chemical treatment and pasteurization on the shelf life of Kunun zaki (Sorghum and maize gruel). *European Journal of Food Research & Review*, 1 (2), 61-70
- Adejuyitan, J.A, Adelakun O.E, Olaniyan, S.A., Popoola, F.I. (2008): Evaluating the quality characteristics of Kunun produced from drymilled sorghum, *Afr. J. Biotechnol.* 7 (13), 2244-2247.
- Adeniyi, S.A., Orjiekwe, C.L. Ehiagbonare, J.E. (2009): Determination of Alkaloids and Oxalates in Some Selected Food Samples, *Nigeria. African J. Biotechnol.*, 8, 110 - 112.
- Adeyemi, I.A. and Umar, S. (1994). "Effect of method of manufacture on the quality characteristics of Kunun zaki". *Nig. Food J.* 12: 34-40.
- Agarry, O.O. Nkama, and Akoma, O. (2010). "Production of Kunun-zaki (A Nigerian fermented cereal beverage) using starter culture", *Int. Res. J. Microbiol.* 1 (2): 018-025.
- Alegria-Toran, A. and Farre-Rovira, R. (2003). "Horchata y salud: Aspectos nutricionales y dieteticos, Fundacion Valenciana de Estudios Avanzados, Tradicion y salud. Valencia, Spain: Conselleria de Agricultura, Pesca y Alimentacion. 55-70.
- Amusa, N.A. and Odunbaku, O.A. (2009). "Microbiological and Nutritional Quality of Hawked Kunun (A Sorghum Based Non-Alcoholic Beverage) Widely Consumed in Nigeria". *Pak. J. Nutr* 8 (1): 20-25.
- Appel, L.J. (1999). "Non pharmacologic therapies that reduce blood pressure: a fresh perspective". *Clin. Card.* 22: 1-5.
- Ayekyaw (1978). "A simple colorimetric method for ascorbic acid determination in blood plasma". *Clin. Chim. Act.* 86, 153 - 157.
- Ayo, J.A., Umaianze, G. and Gaffa, T. (2004). "Microbiological evaluation of Kunun zaki and Zoborodo drink (beverage) locally produced and sold in a polytechnic community in Nigeria". *Nig. Food J.* 22: 189-194.
- Bathey, A.S., Duffy, S. and Schaffner, D.W. (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, M.A. and Belewu, K.Y. (2007): "Comparative physicochemical evaluation of Tigernut, soybean and coconut milk". *Int J. Agric Biol.* 9: 785 – 787.

Bestshart, A.A. (1982). "World food and nutrition problems" *Cereal Food World.* 27: 562.

Brody, T. (1994). "Nutritional Biochemistry". Academic Press, San Diego, CA. 761-794.

Cataldo, C.B., DeBruyne, L.K. and Whitney, E.N. (1999). "Nutrition and diet therapy principles and practice". Wadsworth Publishing Company and International Thomason Publishing Company. USA. 35-204.

Coskuner, Y., Ercan, R., Karababa, E. and Nazlican, A.N. (2002). "Physical and chemical properties of chufa (*Cyperus esculentus* L.) tubers grown in the Cukurova region of Turkey". *J. Sci Food Agric.* 82, 625 – 31.

De Vries, F.T. (1991). "Chufa (*Cyperus esculentus*, Cyperaceae). A weedy cultivar or a cultivated weed?" *Econ. Bot.* 45: 27 – 37.

Egwaikhide, P.A. and Faremi, A.Y. (2010). "Proximate nutrient compositions and microbiological qualities of Kunun-aya, Kunun dawa, Kunun zaki and Kunun gyeda" *EJEAFChe.* 9 (11): 1686-1692.

Elmahmooda, A.M. and Doughari, J.H. (2007). "Microbial quality assessment of Kunun zaki beverage sold in Girei town of Adamawa State Nigeria. *Afri. J. Food Sci.* :011-015.

Fahey, J.W. (2005): *Moringa oleifera*: "A review of the medical evidence for its nutritional, therapeutic and prophylactic properties". *Trees for Life Journal.* 1: 5.

Fallon, S. and Enig M.G. (2001). "Nourishing Traditions". The Cook book that Challenges Politically Correct Nutrition and the Diet Dictocrats. Revised 2nd Edn., pp.40-45.

Gordon, M.N. and Kessel M. (2002). "Perspective in Nutrition". McGraw Hill Company, New York. pp. 257-281.

Islam, I. L. and Mohammed, H.E. (2016). "Evaluation of Secondary Metabolites in Callus and Tissues of *Physalis Peruviana*." *Int. Journal of Modern Botany.* 6 (1):10 – 17.

Makinde, F. and Oyeleke, O. (2012). "Effect of sesame seed addition on the chemical and sensory qualities of sorghum based kunun-zaki drink". *African Journal of Food Science and Technology.* 3 (9): 204-212.

Malik, C.P. and Srivastava A.K. (1982) *Text Book of Plant Physiology.* Ludhiana, New Delhi.

Mutayoba, S.K., Dierenfeld, E., Mercedes, V.A., Frances, Y. and Knight, C.D. (2011). "Determination of chemical composition

and anti-nutritive components for Tanzanian locally available poultry feed ingredients." *Intl Journal of Poultry Science* 10 (5): 350-357.

Mungole, A., Day, S., Kamble, R., Kandafe, H., Charturvedi, A. and Zanwar, P. (2010). "Active Phytochemical Potentiality of In-Vitro Regenerated Plantlets of *Cassia ducurrens* (Dalzell)". *Indian Journal of Science and Technology* 3 (6): 679 - 683.

Obadoni, B.O. and Ochuko, P.C. (2001). "Phytochemical Studies and Comparative Efficacy of the Crude Extract of Some Homeostatic Plants in Edo and Delta States of Nigeria." *Global J Pure Applied Science*. 8: 203 - 208.

Odunfa, S.A. and Adeleye, S. (1985). "Microbiological changes during the traditional production of Ogi-baba." *J. cereal sci.* 3: 173-180.

Olugbemi, T.S., Mutayoba, S.K. and Lekule, F.P. (2010). "Effect of Moringa (*Moringa oleifera*) Inclusion in Cassava based diets to broiler chickens." *Intl Journal of Poultry Science*. 9 (4), 363-367.

Oluyemi, E.A., Akinlua, A.A., Adenuga, A.A. and Adebayo, M.B. (2006). "Mineral contents of some commonly consumed Nigerian Foods." *Sci. Focus*. 11 (1): 153-157.

Onuorah, S.I., Adesiyun, A.A. and Adekeye, J.O. (1987). "Occurrence of Staphylococci and coliform in Kummaki and food utensils used in its preparation in Samaru, Zaria." *J. Food Agril.* 1, 31-34.

Oresanya, M.O. and Koleoso, O.A. (1980). "Benniseed processing and utilization." An animal report submitted to the Federal Institute of Industrial Research (FIRO), Oshodi, Lagos.

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

Sodipo, O.A., Akanji, M.A., Kollawole, F.B. and Odutuga, A.A. (1991). "Sapimin is the active antifungal principle in Garcinia kola, heckle seed." *Biosci. Res. Commun.* 3: 171

Soetan, K.O. and Oyewole, O.E (2009). "The need for adequate processing to reduce the anti-nutritional factors in animal feeds: A review." *African Journal of Food Science* 3 (9), 223-232.

Sofowora, A. (1982). "Medicinal Plants and Traditional Medicine in Africa." John Wiley and Sons, New York. p 256.

Wheeler, E.R. and Ferrel, E.E. (1971). "A Method for Phytic Determination in Wheat and Wheat Fractions." *Cereal Chemistry* 48: 312-32

Table 1: Physicochemical characteristics of *kunun-aya* fortified with *Moringa* seed

Parameter	Control	A	B	C	D
pH	4.10 ^a ±0.00	4.20 ^a ±0.00	4.60 ^b ±0.00	4.70 ^c ±0.00	4.80 ^c ±0.01
TTA (g/100ml)	4.54 ^c ±0.15	4.99 ^b ±0.09	4.83 ^b ±0.45	3.55 ^a ±0.18	3.51 ^a ±0.09
Total Solids (%)	20.21 ^a ±0.48	21.97 ^{ab} ±0.23	25.85 ^{bc} ±0.65	26.99 ^c ±0.78	30.01 ^c ±1.22

Mean values in the same column having different superscripts are significantly different ($p < 0.05$)

Keys: Control: 100% Tigernut; A: 95% Tigernut, 5% *Moringa* seed; B: 90% Tigernut, 10% *Moringa* seed; C: 85% Tigernut, 15% *Moringa* seed; D: 80% Tigernut, 20% *Moringa* seed

Table 2: Proximate composition of *kunun-aya* fortified with *Moringa* seed

Sample	Moisture (%)	Crude Fat (%)	Crude Protein (%)	Crude Fibre (%)	Ash (%)	Carbohydrate (%)
Control	82.60 ^c ±0.80	3.64 ^c ±0.02	6.47 ^a ±0.02	2.02 ^a ±0.00	3.10 ^a ±0.00	2.17 ^a ±0.76
A	79.83 ^c ±0.93	3.55 ^d ±0.00	7.51 ^b ±0.00	2.03 ^a ±0.00	3.14 ^b ±0.00	3.94 ^a ±0.93
B	72.76 ^b ±0.05	3.47 ^c ±0.00	8.57 ^c ±0.02	2.03 ^a ±0.00	3.18 ^c ±0.00	9.99 ^b ±0.56
C	71.95 ^{ab} ±0.31	3.40 ^b ±0.01	9.64 ^d ±0.01	2.03 ^a ±0.01	3.23 ^d ±0.00	9.75 ^b ±0.81
D	68.86 ^a ±0.04	3.32 ^a ±0.00	10.70 ^e ±0.01	2.04 ^a ±0.01	3.27 ^e ±0.00	11.81 ^b ±0.05

Mean values in the same column having different superscripts are significantly different ($p < 0.05$)

Keys: Control: 100% Tigernut; A: 95% Tigernut, 5% *Moringa* seed; B: 90% Tigernut, 10% *Moringa* seed; C: 85% Tigernut, 15% *Moringa* seed; D: 80% Tigernut, 20% *Moringa* seed

Table 3: Mineral contents of *kunun-aya* fortified with *Moringa* seed

Sample	Calcium (mg/100g)	Magnesium (mg/100g)	Potassium (mg/100g)	Iron (mg/100g)	Phosphorus (mg/100g)
Control	7.27 ^a ±0.03	6.85 ^a ±0.02	17.33 ^a ±0.67	14.16 ^a ±0.01	5.40 ^a ±0.05
A	7.35 ^a ±0.03	6.86 ^a ±0.03	19.71 ^b ±0.23	15.02 ^a ±0.01	28.85 ^b ±0.25
B	7.99 ^b ±0.00	6.87 ^a ±0.03	23.31 ^c ±0.26	15.10 ^a ±0.47	42.18 ^b ±6.25
C	8.32 ^c ±0.07	6.94 ^{ab} ±0.01	27.72 ^d ±0.31	15.33 ^a ±0.70	42.63 ^b ±0.51
D	9.25 ^d ±0.01	7.02 ^b ±0.01	39.71 ^e ±0.30	24.76 ^b ±0.01	42.76 ^b ±0.30

Mean values in the same column having different superscripts are significantly different ($p < 0.05$)

Keys: Control: 100% Tigernut; A: 95% Tigernut, 5% *Moringa* seed; B: 90% Tigernut, 10% *Moringa* seed; C: 85% Tigernut, 15% *Moringa* seed; D: 80% Tigernut, 20% *Moringa* seed

Table 4: Phytochemical screening of *kunun-aya* fortified with *Moringa* seed

Sample	Alkaloids (mg/100g)	Steroids (mg/100g)	Resins (mg/100g)	Cyanogenic glycoside (mg/100g)	Saponins (mg/100g)	Tannins (mg/100g)	Oxalate (mg/100g)	Phytate (mg/100g)
Control	2.25 ^c ±0.01	2.81 ^d ±0.01	3.04 ^e ±0.02	1.88 ^e ±0.02	0.89 ^a ±0.01	9.63 ^a ±0.13	0.60 ^a ±0.05	1.98 ^a ±0.01
A	2.19 ^d ±0.00	2.59 ^c ±0.01	3.00 ^{bc} ±0.00	1.83 ^d ±0.00	0.94 ^b ±0.02	10.10 ^b ±0.01	0.65±0.01	2.02 ^b ±0.01
B	2.14 ^e ±0.01	2.54 ^b ±0.00	2.99 ^b ±0.00	1.77 ^c ±0.00	0.97 ^{bc} ±0.01	10.69 ^c ±0.00	0.64 ^a ±0.01	2.05 ^c ±0.00
C	2.08 ^b ±0.00	2.53 ^b ±0.00	2.89 ^a ±0.00	1.71 ^b ±0.01	1.00 ^c ±0.00	11.28 ^d ±0.00	0.63 ^a ±0.01	2.09 ^d ±0.01
D	2.02 ^a ±0.00	1.34 ^a ±0.00	2.88 ^a ±0.01	1.65 ^a ±0.01	1.05 ^d ±0.01	11.88 ^e ±0.01	0.62 ^a ±0.00	2.12 ^e ±0.00

Mean values in the same column having different superscripts are significantly different ($p < 0.05$)

Keys: Control: 100% Tigernut; A: 95% Tigernut, 5% *Moringa* seed; B: 90% Tigernut, 10% *Moringa* seed; C: 85% Tigernut, 15% *Moringa* seed; D: 80% Tigernut, 20% *Moringa* seed

Table 5: Sensory mean scores of *kunun-aya* fortified with *Moringa* seed

Sample	Colour	Taste	Aroma	Consistency	Overall Acceptability
Control	7.17 ^b	7.22 ^b	6.61 ^a	6.50 ^a	7.17 ^b
A	6.83 ^b	6.83 ^b	6.06 ^a	6.50 ^a	6.89 ^b
B	6.33 ^{ab}	6.67 ^b	5.67 ^a	7.00 ^a	6.78 ^b
C	5.89 ^{ab}	6.22 ^{ab}	6.33 ^a	6.83 ^a	6.67 ^b
D	5.44 ^a	4.89 ^a	6.00 ^a	5.89 ^a	5.17 ^a

Mean values in the same column having different superscripts are significantly different ($p < 0.05$)

Keys: Control: 100% Tigernut; A: 95% Tigernut, 5% *Moringa* seed; B: 90% Tigernut, 10% *Moringa* seed; C: 85% Tigernut, 15% *Moringa* seed; D: 80% Tigernut, 20% *Moringa* seed

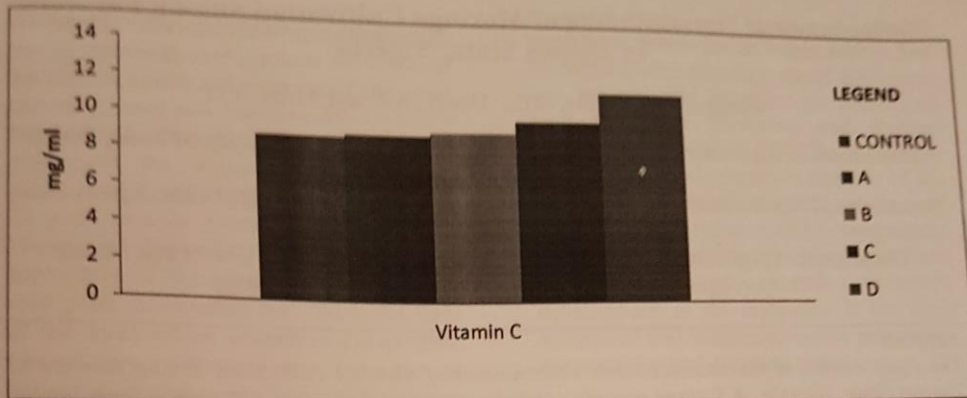


Figure 1: Vitamin C content of *kinun-aya* fortified with *Moringa* seed

Keys:

Control: 100% Tigernut; A: 95% Tigernut, 5% *Moringa* seed; B: 90% Tigernut, 10% *Moringa* seed; C: 85% Tigernut, 15% *Moringa* seed; D: 80% Tigernut, 20% *Moringa* seed