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Full Length Research Paper

Quality assessment and safety of street vended '*aadun*' (a maize-based indigenous snack) from selected states in Nigeria

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"*Aadun*" is a maize-based snack commonly consumed in Nigeria (South west). In this study, the chemical (proximate composition, fat quality indices and mineral elements), microbiological (total plate, coliform and fungal counts) and sensory qualities of twenty eight street vended "*aadun*" samples collected from six (Ekiti, Kogi, Kwara, Ogun, Osun, and Oyo) states in Nigeria were investigated, using a laboratory sample as control. Results showed that "*aadun*" is rich in crude fibre, calorie, iron, magnesium and phosphorus. Fat quality indices, total plate and fungal counts of all the samples were within codex permitted levels, but twelve samples showed presence of coliforms. Significant differences ($p < 0.05$) exist among the samples in their chemical composition and sensory qualities. Incidence of heavy metals (lead, arsenic and tin) in some of the samples above codex permitted level however calls for safety precautions and control in the processing and distribution of the snack.

Key words: Quality, street vended, *"aadun",* maize-based snack, Nigeria, heavy metals.

INTRODUCTION

"*Aadun*" is a snack prepared from roasted whole meal maize (*Zea mays*) flour, red pepper and salt thoroughly mixed in palm oil to obtain a uniform product. It is popular among Yoruba speaking people of Nigeria. It is traditionally used for marriage, naming ceremony, and twins' festival and eaten by past warriors, children, women and people of all ages (Akinjogbin, 1984; Adedokun, 2006). "*Aadun*" is a good source of energy, phosphorus and magnesium but it is low in protein and it is often sold with minimal packaging under conditions which may lead to its rapid deterioration (Adedokun, 2006).

FAO (1998) defined street vended food as ready to eat foods and beverages prepared and/or sold by vendors and hawkers especially in streets around markets and other public places; with this definition, "*aadun*" can be classified as a street vended food. Street vended food, even when produced under low level of hygiene, is usually consumed regardless of the source of production or quality of raw materials used. The choice of a particular street food thus depends on taste, economic power and availability at the point of consumption (Sobukola et al., 2008). Street vended foods are perceived to be a major health risk, as studies conducted to assess the quality of different street foods in several countries have shown that these foods were positive vectors of food borne illnesses (Umoh and Odoba, 1997; Edema and Omemu, 2004; Freese et al., 2005; Omemu et al., 2005). Thus, every person eating street vended food is at the risk of food borne illness. When a food is contaminated with unsafe level of pathogens and/or chemical contaminants, they pose substantial risk to consumer and place severe economic burden on individuals, communities or nation. Apart from poor hygiene, contamination of food could come from inadequate management of thousands of industrial

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Table 1. Metal, flame, wavelength and lamp current.

Metal	Flame	Wavelength (nm)	Lamp current (mA)
Arsenic	Air acetylene	193.7	12
Cadmium	Air acetylene	228.8	6
Calcium	Air acetylene	442.7	10
Iron	Air acetylene	248.3	15
Lead	Air acetylene	217.0	6
Magnesium	Air acetylene	285.2	4
Manganese	Air acetylene	279.5	12
Tin	Air acetylene	224.6	8
Zinc	Air acetylene	213.9	10

agricultural and household chemicals which often results in unnecessary exposure to toxic chemicals (WHO, 2000). Accumulation of heavy metals can cause irreversible damages to the body (Mercola and Droege, 2003), hence not only food-borne pathogens are of major concern to people everywhere but also food exposure to pesticides, chemicals and heavy metals is a concern all over the world (Johnson, 1997).

Although Idowu and Adedokun (2011) reported the process technology and sensory quality of "*aadun*" obtained directly from some processors, information is scanty on the quality and safety of street vended "*aadun*" samples despite its wide consumption. The objective of this work therefore is to evaluate the chemical, microbiological and sensory qualities of street vended "*aadun*" obtained from six selected states in Nigeria with a view to bring awareness of its nutritional benefits and health implications to readers and hence consumers of the product.

MATERIALS AND METHODS

Sources of raw materials

White variety of maize (*Zea mays*) and palm oil were purchased from Adatan market, Abeokuta, Ogun State, Nigeria. Pepper, salt and low-density polyethylene (0.01 mm thickness) were purchased from Abubakar Gumi Central market, Kaduna, Kaduna State, Nigeria.

Sample collection

A total of 28 "*aadun*" samples were collected from hawkers including 3 samples from Kogi and 5 each from Ekiti, Osun, Ogun, Oyo and Kwara states of Nigeria. The samples were packaged either in leaves or in low density polyethylene plastic film by the processors. A laboratory sample was used as control. All samples were stored at -18°C in a REFCO freezer until use.

Preparation of laboratory "*aadun*" samples

Laboratory "*aadun*" samples were prepared by using the recipe and method of Adedokun (2006). The ingredient composition consists of roasted maize flour (71.0%), palm oil (27%), pepper (1.57%) and salt (0.34%). Maize grains were cleaned, roasted [using an electric hot plate (NAKAI model) at 260 to 270°C] for 10 min, milled (Attrition disc mill) with dry pepper, sieved (<0.4 mm), mixed with red palm oil and salt, molded and packaged in low density polyethylene (0.01 mm) and kept at -18°C inside a REFCO freezer until use.

Chemical analyses

Moisture, crude protein, crude fat, crude fibre and total ash were determined using the AOAC (1990) methods; carbohydrate was determined by difference, while energy values were calculated using the Atwater factor (FAO/WHO, 1998). Free fatty acid, peroxide values and unsaponifiable matter were determined as described by Kirk and Sawyer (1991).

Calcium, magnesium, iron, zinc, manganese, lead, arsenic, cadmium and tin were determined after wet ashing using a PYE UNICAM (model 969) Atomic Absorption Spectrophotometer. Air acetylene flame was used and elemental determinations were made at different wavelength and lamp current (Table 1). Vanado-molybdate colorimetric method was employed for determination of phosphorus using a PYE UNICAM (model SP 6450) UV-visible colorimeter (Kirk and Sawyer, 1991).

Sensory evaluation

A taste panel evaluation of "*aadun*" was conducted using a panel of 50 judges made up of staff and students of the Federal University of Agriculture, Abeokuta, who are regular consumers of the product. The attributes evaluated were colour, aroma, taste, texture and overall acceptability. "*Aadun*" samples were placed in white ceramic plates at ambient temperature before each tasting session. Panelists were asked to score samples using a 5-point [1 = Poor, 2 = Satisfactory, 3 = Good, 4 = Very good and 5 = Excellent) scale (Stone and Sidel, 1993). Responses of the panelist were collated and subjected to statistical analysis of variance using the Microsoft Excel statistical package for data analysis. Means were separated using Duncan's Multiple Range Test (DMRT) to establish if there were significant differences between the samples (Larmond, 1977; Iwe, 2002).

Microbial analyses

Total plate and fungi counts were determined using the method of Harrigan and McCance (1982) as described by Atanda and Akano (1997). Coliform counts were determined using the method of most

Table 2. Proximate composition of "*aadun*" samples (%).

Samples	Moisture	Protein	Ash	Fat	Crude Fibre	CHO	Energy (kcal/g)
Ekiti I	3.39^{cde}	9.16^{d}	3.92^{a}	36.24^{j}	10.08^{efghij}	36.44^{abcde}	468.69^{cd}
Ekiti II	2.74^{ab}	8.59^{c}	4.75^{defs}	28.57^{e}	10.46^{hijklm}	44.26^{cde}	468.69^{cd}
Ekiti III	10.59^{j}	8.40^{c}	5.37^{bi}	36.56^{jk}	10.22^{fghijk}	44.95^{e}	483.81^{e}
Ekiti IV	2.42^{a}	10.65^{ghi}	3.95^{a}	26.84^{c}	8.98^{b}	47.16^{e}	472.74^{d}
Ekiti V	3.07^{bc}	10.82^{hi}	4.77^{defs}	32.97^{h}	9.05^{bc}	39.31^{abcde}	497.10^{f}
Kogi I	4.04^{f}	13.41^{k}	4.81^{efs}	37.231	9.50^{cd}	31.20^{abc}	513.58^{ikj}
Kogi II	2.74^{ab}	7.23^{a}	3.92^{a}	37.61^{lm}	9.90^{defs}	37.95^{abcde}	518.50^{k}
Kogi III	3.31^{cde}	9.19^{d}	4.75^{defs}	27.94^{d}	10.48^{hijklm}	31.67^{abcd}	468.30^{cl}
Kwara I	3.33^{cd}	10.91^{i}	4.18^{ab}	41.64^{p}	10.01^{efgh}	29.93^{ab}	538.11^{m}
Kwara II	3.53^{cde}	8.84^{cd}	5.20^{hi}	24.87^{a}	10.80^{lm}	46.96^{e}	447.05^{a}
Kwara III	6.56^{i}	8.59^{c}	4.55^{cde}	37.04^{k}	8.17^{a}	35.29^{abcde}	508.62^{ghi}
Kwara IV	3.20^{cd}	9.64^{e}	4.96^{gh}	30.82^{f}	9.76^{def}	41.62^{bcde}	482.41^{e}
Kwara V	2.75^{ab}	13.83^{l}	4.02^{a}	28.87^{e}	9.08^{ab}	41.56^{bcde}	481.17^{e}
Ogun I	3.80^{ef}	7.49^{b}	4.63^{cdef}	36.10^{j}	10.92^{m}	36.83^{abcde}	503.06^{fg}
Ogun II	2.49^{a}	7.51^{ab}	4.33^{bc}	34.94^{i}	10.15^{fghijk}	41.58^{bcde}	510.86^{hij}
Ogun III	3.83^{ef}	7.90^{b}	4.58^{cdef}	40.79^{o}	10.03^{efghi}	29.74^{ab}	527.801
Ogun IV	3.65^{def}	10.45^{gh}	4.51^{cde}	40.91^{o}	10.80^{lm}	29.69^{ab}	527.071
Ogun V	3.13^{bc}	7.89^{b}	4.52^{cde}	46.11^{q}	10.96^{m}	27.58^{a}	556.90^{n}
Osun I	3.37^{cde}	8.67^{c}	4.71^{defs}	36.29^{j}	10.17^{fghijk}	36.77^{abcde}	508.37^{ghi}
Osun II	2.54^{a}	8.53^{c}	4.89^{fs}	36.16^{j}	10.10^{efghij}	37.78^{abcde}	510.66^{hij}
Osun III	2.48^{a}	8.69^{c}	5.77^{j}	31.39^{g}	10.39^{ghijkl}	41.44^{bcde}	481.56^{e}
Osun IV	2.65^{ab}	12.50^{g}	4.48^{cd}	25.88^{b}	9.62^{de}	45.26^{de}	462.19^{bc}
Osun V	10.54^{j}	10.65^{ghi}	4.95^{gh}	33.53^{h}	10.95^{m}	29.40^{ab}	461.94^{bc}
Oyo I	5.08^{g}	9.67^{e}	4.53^{cde}	32,98^{h}	10.18^{fghijkl}	37.46^{abcde}	485.36^{e}
Oyo II	3.82^{ef}	9.95^{ef}	4.49^{fs}	38.29^{n}	10.50^{hijklm}	32.96^{abcd}	516.28^{ik}
Oyo III	5.19^{g}	10.32^{fg}	4.47^{ed}	27.71^{d}	10.09^{efghij}	42.22^{bcde}	459.52^{b}
Oyo IV	3.49^{cde}	10.65^{ghi}	4.67^{def}	36.32^{j}	10.63^{klm}	34.24^{abcde}	512.43^{hijk}
Oyo V	5.89^{h}	10.63^{gh}	4.59^{cdef}	38.03^{mn}	10.55^{jklm}	30.29^{ab}	506.01^{gh}
Control	3.25^{cd}	9.71^{e}	4.66^{defs}	34.84^{i}	10.53^{ijklm}	37.00^{abcde}	499.11^{f}

Data represent means of 3 replicates. Means with same letters in a column are not significantly different (P < 0.05).

probable number (MPN). Each of 3 tubes of Lauryl Sulphate tryptose (LST) broth containing inverted Durham tube was inoculated with 1.0 ml from the serial dilution. The LST tubes were incubated at 37°C for 48 h. The tubes showing acid and gas production was recorded while the MPN values were calculated (FAO, 1979).

RESULTS

Chemical composition of "*aadun*"

"*Aadun*" samples were significantly different ($p < 0.05$) in their proximate composition (Table 2). The snack was generally low in moisture (2.42 to 10.59%), protein (7.23 to 13.81%) and ash (3.92 to 5.77%) contents; but high in fat (24.87 to 46.11%), carbohydrate (27.58 to 47.16%), energy (447.05 to 556.90 kcal/100g) and crude fibre (8.16 to 10.96%). However, two samples (Osun V and Ekiti III) showed higher moisture (10.54 and 10.59%), while three samples (Osun IV, Kogi I, and Kwara IV) had higher protein (12.50, 13.41 and 13.83%) contents than other samples. Analysis of fat quality indices showed that palm oil samples used as ingredient in the "*aadun*" samples were significantly different ($p < 0.05$) in their peroxide values, percentage free fatty acid and unsaponifiable matter (Table 3). "*Aadun*" samples were also significantly different ($p < 0.05$) in their elemental composition (Table 4). The snack was found to be particularly rich in iron (111.93 to 424.38 mg/kg), magnesium (935.10 to 1460.45 mg/kg) and phosphorus (1240 to 2150.17 mg/kg) but it is low in zinc (12.63 to 19.44 mg/kg) and manganese (6.10 to 12.33 mg/kg), while calcium (13.70 to 68.41 mg/kg) was detected only in eight samples including five samples from Ogun state (Table 4). Heavy metal composition of "*aadun*" is as shown in Table 5. Sixteen of the samples were found to contain lead (0.15 to 9.96 mg/kg); arsenic (0.16 to 3.07 mg/kg) was detected in three samples, while cadmium

Table 3. Fat quality indices of "*aadun*" samples.

Samples	Unsaponifiable matter (%)	Free fatty acid (%)	Peroxide value (mEq/kg)
Ekiti I	0.72^{efg}	0.39^{def}	5.64^{bcd}
Ekiti II	0.72^{efg}	0.46^{ij}	4.77^{a}
Ekiti III	0.42^{ab}	0.45^{ghij}	4.86^{a}
Ekiti IV	0.82^{ghijk}	0.36^{bcd}	6.04^{defg}
Ekiti V	0.68^{e}	0.40^{def}	6.44^{gh}
Kogi I	0.40^{ab}	0.37^{bcde}	6.67^{hi}
Kogi II	0.44^{abc}	0.29^{a}	6.32^{fgh}
Kogi III	0.51^{bcd}	0.47^{j}	6.93^{i}
Kwara I	0.57^{d}	0.41^{efghi}	5.70^{bcde}
Kwara II	0.84^{ijkIII}	0.36^{bcd}	5.70^{bcde}
Kwara III	0.54^{cd}	0.33^{ab}	5.45^{bc}
Kwara IV	0.71^{efg}	0.38^{cde}	5.49^{bc}
Kwara V	0.44^{abc}	0.33^{abc}	5.83^{bcde}
Ogun I	0.95^{m}	0.39^{def}	4.73^{a}
Ogun II	0.88^{jkIM}	0.35^{bcd}	5.44^{b}
Ogun III	0.77^{efghi}	0.42^{efghi}	5.93^{cdef}
Ogun IV	0.92^{klm}	0.40^{defg}	5.75^{bcde}
Ogun V	0.95^{lm}	0.40^{def}	4.72^{a}
Osun I	0.69^{ef}	0.45^{hij}	5.74^{bcde}
Osun II	0.71^{efg}	0.45^{hij}	4.82^{a}
Osun III	0.72^{efg}	0.41^{efgh}	6.67^{hi}
Osun IV	0.80^{fghij}	0.40^{def}	4.49^{a}
Osun V	0.54^{cd}	0.30^{a}	4.87^{a}
Oyo I	0.73^{fgh}	0.39^{def}	6.16^{efg}
Oyo II	0.80^{fghi}j	0.44^{fgij}	5.65^{bcd}
Oyo III	0.91^{klm}	0.41^{efghi}	6.68^{hi}
Oyo IV	0.83^{hijk}	0.399^{def}	5.63^{bcd}
Oyo V	0.78^{efghij}	0.44^{fghij}	4.67^{a}
Control	0.36^{a}	0.30^{a}	5.65^{bcd}

Data represent means of 3 replicates. Means with same letters in a column are not significantly different ($P < 0.05$).

(0.00025 mg/kg) and tin (36.26 mg/kg) were present in only one sample each.

Microbial and sensory qualities of "*aadun*"

Table 6 shows the microbial load of the street vended "*aadun*" samples and the control. Total aerobic plate and fungal counts were (4.3×10^1 to 9.7×10^2 cfu/g) and (1×10^1 to 3.1×10^2 sfu/g), respectively. Thirteen samples showed presence of coliforms (4 to 75 MPN/g) with two (Osun V and Oyo IV) of them above Codex Alimentarius limit of 50 MPN/g. One sample (Ekiti III) showed high fungal (3.1×10^2 sfu/g) count probably because of its high moisture (10.59%) content.

Table 7 shows the mean scores of sensory evaluation of street vended "*aadun*" samples and the control. The samples were found to be significantly different ($p > 0.05$) in all their sensory attributes. The control sample was rated highest in colour, taste, texture aroma and overall acceptability and was significantly different from all the street vended samples ($p > 0.05$). Ogun samples (I to V) generally had poor mean scores for colour but were rated better in taste, texture aroma and overall acceptability. Ekiti and Kogi samples were generally rated high for colour, taste, texture, aroma and overall acceptability. Taste and aroma of all the "*aadun*" samples were also generally acceptable with scores ranging from 2.76 to 3.80 and 2.48 to 3.58, respectively.

DISCUSSION

High moisture content in "*aadun*" is unacceptable and may predispose samples to microbial infection because of high water activity (Jay et al., 2005). The higher protein

Table 4. Elemental composition of "aadun" samples (mg/kg).

Samples	Zinc	Iron	Magnesium	Phosphorus	Manganese	Calcium
Ekiti I	18.49^{l}	111.93^{a}	1009.91^{c}	1366.83^{b}	7.29^{d}	ND
Ekiti II	14.73^{f}	305.14^{i}	1179.49^{h}	1680.33^{g}	6.78^{c}	ND
Ekiti III	16.87^{j}	349.15^{m}	1231.83^{ij}	1461.17^{c}	6.77^{c}	ND
Ekiti IV	16.65^{ij}	349.88^{m}	1290.05^{l}	1771.17^{h}	6.85^{c}	ND
Ekiti V	16.74^{ij}	347.10^{m}	1242.98^{jk}	1756.67^{h}	9.97^{kl}	15.51^{b}
Kogi I	12.63^{b}	219.33^{f}	1191.04^{h}	1644.67^{f}	10.29^{i}	ND
Kogi II	18.70^{i}	319.31^{jk}	1158.08^{g}	2020.37^{j}	8.81^{ij}	ND
Kogi III	16.61^{ij}	318.31^{jk}	1150.64^{jk}	1880.52^{j}	6.61^{bc}	ND
Kwara I	15.45^{g}	257.30^{g}	1185.17^{h}	2090.00^{k}	8.52^{hi}	ND
Kwara II	19.44^{m}	348.00^{m}	1186.86^{h}	2085.oo^{k}	6.74^{c}	ND
Kwara III	18.65^{l}	362.56^{n}	1335.04^{m}	1763.50^{h}	6.10^{a}	ND
Kwara IV	17.53^{k}	345.10^{n}	1257.20^{k}	1865.33^{i}	6.87^{c}	ND
Kwara V	18.47^{l}	340.15^{lm}	1188.90^{h}	2103.50^{k}	7.43^{de}	ND
Ogun I	14.55^{f}	245.62^{g}	935.10^{a}	1363.33^{b}	12.33^{m}	68.41^{f}
Ogun II	13.40^{c}	150.60^{cd}	1080.36^{e}	1609.70^{e}	6.32^{ab}	67.92^{f}
Ogun III	13.96^{de}	134.11^{b}	1128.80^{f}	1241.50^{a}	9.99^{kl}	48.72^{d}
Ogun IV	14.74^{f}	153.65^{d}	985.15^{b}	1459.00^{c}	7.90^{fg}	47.72^{cd}
Ogun V	14.32^{ef}	150.68^{cd}	1057.00^{d}	1618.33^{ef}	9.04^{j}	46.85^{c}
Osun I	11.61^{a}	313.26^{ij}	1372.52^{n}	2010.00^{j}	10.28^{l}	ND
Osun II	16.89^{j}	213.95^{ef}	1241.77^{jk}	2075.20^{k}	9.62^{k}	ND
Osun III	15.72^{g}	279.10^{h}	1255.61^{k}	2018.40^{j}	7.47^{def}	ND
Osun IV	16.66^{ij}	204.29^{e}	1460.45^{o}	2023.33^{j}	12.50^{m}	68.37^{f}
Osun V	15.80^{gh}	330.11^{kl}	1189.54^{h}	2150.17^{l}	7.84^{efg}	ND
Oyo I	13.53^{cd}	216.24^{ef}	985.29^{b}	1251.67^{a}	7.89^{efg}	ND
Oyo II	14.59^{f}	139.34^{bc}	1080.37^{e}	1608.33^{e}	7.47^{def}	ND
Oyo III	16.35^{ij}	145.11^{bcd}	1128.53^{f}	1240.00^{a}	7.86^{efg}	ND
Oyo IV	17.55^{k}	148.32^{cd}	1231.83^{ij}	1243.33^{a}	8.20^{gh}	ND
Oyo V	15.60^{g}	143.40^{bcd}	1233.85^{ij}	1512.00^{d}	8.20^{gh}	ND
Control	0.36^{a}	0.30^{a}	5.65^{bcd}	CI	0.36^{a}	0.30a

Data represent means of 3 replicates. Means with same letters in a column are not significantly different ($P < 0.05$).

range of 12.50 to 13.83% found in some samples may be due to inclusion of cooked cowpea in them. Inclusion of cooked cowpea in "*aadun*" is a variation in the ingredient formulation that is practiced by some processors of "*aadun*" to enhance its acceptability (Atolagbe, 2010). The high calorie content of "*aadun*" may be due to high fat and carbohydrate contents of the samples and this may be desirable as the value represent about 1/3 of the daily energy intake of an adult (1255 kcal/100g) as earlier reported (Akinyele, 1998; Addo, 1998). The high fat content however may predispose the snack to rancidity particularly where the ambient temperature and humidity is high (Berk, 1991). The values obtained for the fat quality indices also suggest that good quality palm oil samples were used in the preparation of all the "*aadun*" samples. For instance, the peroxide value range of 4.49 to 6.93 mEq/Kg obtained for "*aadun*" samples is within the Codex standard of 2 to 10 mEq/Kg (Codex, 1982; Lange, 1994), while percentage free fatty acid and unsaponifiable matter ranges of 0.29 to 0.47 and 0.36 to 0.95, respectively, were below 2% permitted for most oils or fat of normal purity (Kirk and Sawyer, 1991). High content of magnesium and phosphorus in "*aadun*" were consistent with earlier report (Idowu and Adedokun, 2011), but high content of iron in "*aadun*" has not been reported. The high content of iron in "*aadun*" is desirable since the product is usually consumed by women and children whose daily requirement of iron is greater than men (Ihekoronye and Ngoddy, 1985). The iron present in "*aadun*" is probably the non-heme type which is usually derived from plant foods (Miret et al., 2003). Iron is one of the most abundant metals on earth and it is essential to life of normal human physiology. Presence of calcium in some samples particularly from Ogun state may be connected with the inclusion of high amount of spices in the ingredient formulation of "*aadun*" (Adedokun, 2006). Calcium and phosphorus form the dense, hard material of the teeth and bones; while magnesium plays an

Table 5. Heavy metal composition of “aadun” samples (mg/kg).

Samples	Lead	Arsenic	Cadmium	Tin
Ekiti I	4.52[g]	0.16[a]	ND	36.26 ± 1.06mg/kg
Ekiti II	3.30[e]	ND	ND	ND
Ekiti III	5.20[h]	ND	ND	ND
Ekiti IV	8.48[i]	ND	ND	ND
Ekiti V	1.85[c]	ND	ND	ND
Kogi I	2.62[d]	ND	ND	ND
Kogi II	9.96[j]	3.07[c]	ND	ND
Kogi III	4.02[f]	1.03[b]	ND	ND
Kwara I	1.78	ND	ND	ND
Kwara II	2.73[d]	ND	ND	ND
Kwara III	ND	ND	ND	ND
Kwara IV	ND	ND	ND	ND
Kwara V	ND	ND	ND	ND
Ogun I	ND	ND	ND	ND
Ogun II	0.15[a]	ND	ND	ND
Ogun III	ND	ND	0.00025 ± 0.00005	ND
OGUN IV	ND	ND	ND	ND
Ogun V	0.45[a]	ND	ND	ND
Osun I	3.50[e]	ND	ND	ND
Osun II	2.60[d]	ND	ND	ND
Osun III	ND	ND	ND	ND
Osun IV	0.94[b]	ND	ND	ND
Osun V	ND	ND	ND	ND
Oyo I	ND	ND	ND	ND
Oyo II	3.35[e]	ND	ND	ND
Oyo III	3.35[b]	ND	ND	ND
Oyo IV	ND	ND	ND	ND
Oyo V	ND	ND	ND	ND
Control	ND	ND	ND	ND

Data represent means of 3 replicates. Means with same letters in a column are not significantly different ($P < 0.05$). ND = Not detectable.

important role in carbohydrate metabolism (Miret et al., 2003). Although zinc and manganese in "*aadun*" were present in small amounts, only trace amounts of these minerals are required for metabolic activities and consumption of about 100g of "*aadun*" could be enough to satisfy recommended daily allowance for an adult male (Ihekoronye and Ngoddy, 1985).

All the heavy metals detected except cadmium were present at concentrations above the Codex permitted (Codex, 2001) level of 0.1 mg/kg. Earlier report showed that acute lead exposure can cause serious physiologic effects, including death or long term damage to brain function and organ systems (ATSDR, 1989). Lead can get into food through dust containing lead on the crops while growing or during food processing particularly milling or packaging (Johnson, 1997). Although arsenic intake is more associated with sea food than with drinking water, arsenic could also be present in ground water (WHO, 2000) and this may get into food while washing with ground water during food preparation. Tin, on the other hand, may get into food during roasting, milling or packaging especially where tin coated cans are used as packaging material. The presence of tin in one of the "*aadun*" samples however may not be related to the packaging material since most of the samples were either packaged in leaves or low density polyethylene. Generally, heavy metals can get into food through soil and post harvest treatments of grains including storage conditions or through the use of fertilizers, pesticides and even organic manure. Industrial wastes and effluents that are not properly treated before discharging into the environment could also introduce toxicants into food (Sobukola et al., 2008). It was observed that the three samples (Ekiti I, Kogi II and Kogi III) that showed detectable arsenic also contain lead while Ekiti I contained lead, arsenic and tin. It is suspected that the

Table 6. Total mould and coliform counts of "*aadun*" samples.

"*Aadun*" samples	Total plate count (cfu/g)	Fungal count (sfu/g)	Coliform count (MPN/g)
Ekiti I	2.3×10^2	$<1 \times 10^1$	23
Ekiti II	8.0×10^2	$<1 \times 10^1$	23
Ekiti III	2.4×10^2	3.1×10^2	4
Ekiti IV	3.2×10^2	$<1 \times 10^1$	0
Ekiti V	9.2×10^2	$<1 \times 10^1$	11
Kogi I	1.8×10^2	$<1 \times 10^1$	0
Kogi II	1.9×10^2	$<1 \times 10^1$	0
Kogi III	9.7×10^2	$<1 \times 10^1$	4
Kwara I	1.9×10^2	$<1 \times 10^1$	14
Kwara II	5.3×10^2	$<1 \times 10^1$	0
Kwara III	1.0×10^2	$<1 \times 10^1$	0
Kwara IV	3.1×10^2	$<1 \times 10^1$	14
Kwara V	1.8×10^2	$<1 \times 10^1$	0
Ogun I	2.0×10^2	$<1 \times 10^1$	0
Ogun II	1.6×10^2	$<1 \times 10^1$	0
Ogun III	7.2×10^2	$<1 \times 10^1$	0
Ogun IV	1.0×10^2	$<1 \times 10^1$	0
Ogun V	1.1×10^2	$<1 \times 10^1$	0
Osun I	2.0×10^2	$<1 \times 10^1$	4
Osun II	1.1×10^2	$<1 \times 10^1$	0
Osun III	9.3×10^2	$<1 \times 10^1$	39
Osun IV	1.7×10^2	$<1 \times 10^1$	0
Osun V	1.0×10^2	$<1 \times 10^1$	75
Oyo I	1.1×10^2	$<1 \times 10^1$	4
Oyo II	2.2×10^2	$<1 \times 10^1$	0
Oyo III	5.7×10^2	$<1 \times 10^1$	23
Oyo IV	2.1×10^2	$<1 \times 10^1$	64
Oyo V	1.4×10^2	$<1 \times 10^1$	0
Control	4.3×10^1	$<1 \times 10^1$	0

heavy metal contamination of "*aadun*" in these locations may be connected to their sources of water supply since many of the processors of "*aadun*" live in rural areas where well water or flowing river usually serve as the sources of water for cooking or cottage level processing of food (Atolagbe, 2010). Information obtained from rural appraisal of the manufacturers revealed that fine sand from river bed is often used for roasting the maize for "*aadun*" production. Microbial counts were low and well within the permitted limits of Codex Alimentarius (10^5 cfu/g) for cereals and derived products (Codex, 1990). The low microbial counts of the "*aadun*" samples may be due to the high fat content. Oils and fats are known inhibitors of microbial growth (Jay et al., 2005), while salts and spices used as ingredients of "*aadun*" could also serve as preservatives. The control (laboratory) sample had the least total aerobic plate count and zero coliform growth. This may be due to better hygiene rules observed during processing. The presence of coliform in some of the street vended "*aadun*" samples is undesirable and suggests possible feacal contamination (Atanda and Akano, 1997). The unacceptable colour of the Ogun samples could be due to frying of the palm oil which may have led to destruction of the carotenoid pigment in palm oil (Berk, 1991) and hence the dark colour of the samples. All the "*aadun*" samples were acceptable in terms of texture while the overall acceptability scores were above satisfactory.

Conclusion

"*Aadun*" samples obtained from six selected states in Nigeria are significantly different in their chemical, microbiological and sensory qualities. "*Aadun*" is a good source of energy, phosphorous and magnesium; it contains appreciable iron and traces of zinc and manganese. Although, "*aadun*" is low in microbial count, the presence of heavy metals in some of the samples above permitted Codex level gives concern for safety of

Table 7. Sensory quality of "*aadun*" samples.

Samples	Colour	Taste	Texture	Aroma	Overall acceptability
Ekiti I	3.16^{bcd}	3.00^{abcdefg}	3.30^{ab}	2.88^{bcd}	3.36^{fg}
Ekiti II	3.27^{bcde}	3.18^{bcdefghi}	3.10^{a}	3.10^{bcdefgh}	3.38^{fg}
Ekiti III	3.32^{bcde}	3.38^{ghi}	3.42^{ab}	3.30^{efghi}	3.34^{fg}
Ekiti IV	3.48^{cde}	3.28^{efghi}	3.30^{ab}	3.24^{defghi}	3.46^{g}
Ekiti V	3.56^{e}	3.50^{ij}	4.02^{c}	3.26^{defghi}	3.37^{fg}
Kogi I	3.16^{bcd}	2.76^{a}	2.86^{a}	2.48^{a}	3.02^{bcdef}
Kogi II	3.22^{bcde}	3.20^{cdefghi}	3.38^{ab}	3.16^{cdefgh}	3.38^{fg}
Kogi III	3.32^{bcde}	2.96^{abcdef}	3.18^{a}	2.90^{bcde}	3.08^{cdefg}
Kwara I	3.50^{de}	2.84^{abcd}	3.20^{a}	3.00^{bcde}	3.18^{efg}
Kwara II	3.54^{e}	3.10^{abcdefgh}	3.02^{a}	3.02^{bcdef}	3.28^{fg}
Kwara III	3.52^{e}	2.82^{abcd}	3.14^{a}	3.18^{defgh}	3.22^{efg}
Kwara IV	3.48^{cde}	3.02^{abcdefg}	3.20^{a}	2.98^{bcde}	3.18^{efg}
Kwara V	3.40^{bcde}	3.00^{abcdefg}	3.14^{a}	2.96^{bcde}	3.20^{efg}
Ogun I	1.66^{a}	3.42^{hi}	3.00^{a}	3.08^{bcdefg}	2.82^{abcde}
Ogun II	1.50^{a}	3.48^{hij}	2.98^{a}	3.40^{fghi}	2.68^{ab}
Ogun III	1.54^{a}	3.52^{ij}	2.94^{a}	3.50^{hi}	2.62^{a}
Ogun IV	1.58^{a}	3.48^{hij}	3.08^{a}	3.44^{ghi}	2.76^{abcd}
Ogun V	1.71^{a}	3.31^{fghi}	3.20^{a}	3.57^{i}	2.73^{abc}
Osun I	3.42^{bcde}	2.86^{abcd}	3.06^{a}	3.08^{bcdefg}	3.28^{fg}
Osun II	3.14^{bc}	3.00^{abcdefg}	3.22^{a}	2.86^{bcd}	3.40^{fg}
Osun III	3.44^{bcde}	2.80^{abc}	3.14^{a}	2.92bcde	3.32^{fg}
Osun IV	3.12^{b}	1.82^{abcd}	3.08^{a}	3.24^{defghi}	3.18^{efg}
Osun V	3.28^{bcde}	2.78^{ab}	3.16^{a}	2.96^{bcde}	3.30^{fg}
Oyo I	3.50^{de}	3.22^{defghi}	3.06^{a}	2.90^{bcde}	3.14^{defg}
Oyo II	3.26^{bcde}	2.90^{abcde}	2.98^{a}	2.88^{bcd}	3.12^{defg}
Oyo III	3.30^{bcde}	2.84^{abcd}	2.96^{a}	2.72^{ab}	3.14^{defg}
Oyo IV	3.41^{bcde}	2.94^{abcdef}	3.06^{a}	2.92^{bcde}	3.18^{efg}
Oyo V	3.42^{bcde}	2.76^{a}	2.84^{a}	2.76^{abc}	3.08^{cdefg}
Control	4.14^{f}	3.80^{j}	3.80^{bc}	3.58^{i}	4.22^{h}

Data represent mean scores (n = 50). Mean scores with same letters in a column are not significantly different ($P < 0.05$). 1 = Poor, 2 = Satisfactory, 3 = Good, 4 = Very good and 5 = Excellent.

the product.

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