



African Journal of Food Science

Volume 10 Number 8, August 2016
ISSN 1996-0794



*Academic
Journals*

ABOUT AJFS

The **African Journal of Food Science (AJFS)** (ISSN 1996-0794) is published monthly (one volume per year) by Academic Journals.

African Journal of Food Science (AJFS) provides rapid publication of articles in all areas of Food Science such as Sensory analysis, Molecular gastronomy, Food safety, Food technology etc. The Journal welcomes the submission of manuscripts that meet the general criteria of significance and scientific excellence. Papers will be published shortly after acceptance. All articles published in AJFS are peer-reviewed.

Contact Us

Editorial Office: ajfs@academicjournals.org

Help Desk: helpdesk@academicjournals.org

Website: <http://academicjournals.org/AJFS>

Submit manuscript online <http://ms.academicjournals.me/>

Editors

Thaddeus Chukwuemeka Ezeji

*Ohio State University and Ohio State
Agricultural and Development Center (OARDC)
Department of Animal Sciences
1680 Madison Avenue
Wooster, Ohio 44691 USA.*

Prof. Kofi E. Aidoo

*Department of Biological and Biomedical Sciences
Glasgow Caledonian University
Cowcadden Road
Glasgow G4 0BA.*

Dr. Barakat S.M. Mahmoud

*Food Safety/Microbiology
Experimental Seafood Processing Laboratory
Costal Research and Extension Centre
Mississippi State University
3411 Frederic Street
Pascagoula, MS 39567
USA.*

Prof. Dr. A.N. Mirsa

*Department of Biosciences and Biotechnology,
School of Biotechnology
Fakia Mohan University,
Vyasa Vihar, Balsore-756019, India.*

Dr. Neela Badrie

*Department of Food Production,
Faculty of Science and Agriculture,
University of the West Indies,
St. Augustine, Republic of Trinidad and Tobago,
West Indies.*

Prof. Yulong Yin

*Institute of Subtropical Agriculture (ISA),
The Chinese Academy of Science (CAS),
Hunan, Changsha 410125,
Post Box 10,
China.*

Dr. Hu Xiao-Qing

*State Key Lab of Food Science and Technology,
Jiangnan University,
1800 Lihu Ave., Wuxi 214122,
China.*

Dr. R. A. Siddique

*Department of Veterinary Biochemistry
College of Veterinary Science and Animal Husbandry
Navsari Agricultural University,
Navsari, 396450
Gujarat, India.*

Dr. Brnčić Mladen

*Faculty of Food Technology and Biotechnology;
Pierottijeva 6; 10000 Zagreb.*

Dr. Jianbo Xiao

*Institute of Food Engineering
College of Life & Environment Science
Shanghai Normal University
100 Guilin Rd, Shanghai 200234,*

Dr. Petr Konvalina, Ing

*University of South Bohemia in Ceske Budejovice,
Faculty of Agriculture, Studentska 13, České Budějovice,
Czech Republic*

Dr. Ashish Kumar Singh

*Senior Scientist, Dairy Technology Division
National Dairy Research Institute, Karnal-132001
Haryana,
India.*

Dr. K. Pandima Devi

*Department of Biotechnology
Alagappa University
Karaikudi- 630 003
Tamil Nadu
India.*

Editorial Board

Dr. Chakradhar Reddy

*Division of Gastroenterology
University of Miami/Jackson Memorial Hospital
Miami, Florida, U. S. A.*

Dr. Sara Chelland Campbell

*Department of Nutrition, Food and Exercise Sciences
Florida State University
Tallahassee, Florida
U. S. A.*

Dr. Naveen Dixit

*University of Florida
Institute of Food and Agricultural Sciences
Southwest Florida Research and Education Center
U. S. A.*

Dr. M. Ayub Hossain

*Bangladesh Agricultural Research Institute
Gazipur-1701 Bangladesh.*

Dr . Aline Lamien-Meda

*Department of Biochemistry and Phytochemistry
Institut für Angewandte Botanik und Pharmakognosie
Veterinärmedizinische Universität Wien, Veterinärplatz 1,
A-1210 Wien,
Austria.*

Dr. Olalekan Badmus

*Research and development Team,
Thames water,
Leeds University,
United kingdom.*

Dr. Rui Cruz

*ADEA-Escola Superior de Tecnologia
Universidade do Algarve
Campus da Penha, Estrada da Penha
8005-139 Faro
Portugal.*

Prof. Zheng

*Key Laboratory for Biotechnology on Medicinal Plants of
Jiangsu Province, Xuzhou Normal University,
Xuzhou 221116,
China.*

Dr. Khaled A. Osman

*Department of Plant Production and Protection
College of Agriculture & Veterinary Medicine,
Qassim University,
Buriadah, Al-Qassim
P.O. Box 6622
Saudi Arabia.*

Dr. Olusegun Olaoye

*Division of Food Sciences
University of Nottingham
United Kingdom.*

Dr. Anastasios Koulaouzidis

*Staff Gastroenterologist
Centre of Liver & Digestive Disorders
Royal Infirmary of Edinburgh
51 Little France Crescent
United Kingdom.*

Dr. Ding

*Department of Respiratory Diseases,
General Hospital of Chinese People's Armed Police Forces
Beijing,
China.*

Dr. Ashok Kumar Malik

*Department of Chemistry,
CDLU, Sirsa,
Haryana*

Dr. Chongbi Li

*Biotechnology Field.
Institute of Biopharmaceutical Engineering ,
Zhaoqing University,
China.*

Dr. Odara Boscolo

*National Museum / Federal University of Rio de Janeiro)-
Phanerogamic systematic and ethnobotany Laboratory-
Botany Department,
do Rio de Janeiro, Brazil*

Dr. José Lavres Junior

*University of São Paulo,
Center for Nuclear Energy in Agriculture,
São Paulo -Brazil*

Dr. Gokben Ozbey

*Firat University,
Vocational School of Health Services,
Engineering Campus,
Elaziğ
Turkey.*

ARTICLES

- Functional properties of weaning food blends from selected sorghum (*Sorghum bicolor* (L.) Moench) varieties and soybean (*Glycine max*)** 112
Mohammed A. Usman, Mathew K. Bolade and Samaila James
- Beef consumption and consumer's knowledge on meat quality in Maroua in the Far North of Cameroon** 122
Ronald Romuald Bebey Ngom Vougat, Steven Chouto, Harquin Simplicie Foyet, Rebecca Garabed, Roland Ziebe and André Pagnah Zoli
- Crop ash filtrate influence on cooking time and sensory preferences for dried black beans (*Phaseolus vulgaris* L.)** 132
Tara L. Bergeson, Christopher Opio and Peter D. MacMillan

Full Length Research Paper

Functional properties of weaning food blends from selected sorghum (*Sorghum bicolor* (L.) Moench) varieties and soybean (*Glycine max*)

Mohammed A. Usman^{1*}, Mathew K. Bolade² and Samaila James³

¹Department of Food Science and Technology, Modibbo Adama University of Technology, P.M.B. 2076, Yola, Adamawa State, Nigeria.

²Department of Food Science and Technology, Federal University of Technology, P.M.B. 704, Akure, Ondo State, Nigeria.

³Department of Food Science and Technology, Federal University of Technology, P.M.B. 65, Minna, Niger State, Nigeria.

Received 11 December, 2015, Accepted 9 June, 2016.

Weaning food was produced from the blends of sorghum flour, malted sorghum flour and soybean flour. The physicochemical properties of the formulated weaning food were investigated. Flours from three sorghum varieties (local, improved and hybrid sorghum grains) were, respectively, combined with the sorghum malt and soybean flour at different graded levels. The water holding capacity of the weaning food blends ranged between 1.52 and 3.81 ml/g while the viscosity ranged between 14.32 and 33.61 centipoise at 10% (w/v) flour concentration. The least gelation concentration ranged between 8.02 and 20.21 g/ml. The inclusion of sorghum malt in the blends reduced both water holding capacity and viscosity but increased the least gelation concentration. Almost all the pasting variables, except breakdown viscosity, reduced with the inclusion of sorghum malt in the formulations. The range of values for the pasting factors of the weaning food blends include peak viscosity (130.2-532.1 RVU), trough (73.2-335.3 RVU), breakdown viscosity (28.3-97.4 RVU), final viscosity (160.2-826.2 RVU) and setback viscosity (64.1-516.0 RVU). The weaning food blends that could be regarded as appropriate formulation based on the exhibited physicochemical properties are Samsorg 17-(M10) which contained 63, 10 and 27% of raw sorghum flour (RSF), malted sorghum flour (MSF) and soybean flour (SBF), respectively; and Hybrid-(M5) which contained 66.5, 5 and 28.5% of raw sorghum flour (RSF), malted sorghum flour (MSF) and soybean flour (SBF), respectively. Both blends possessed relative low final viscosity, setback value and pasting temperature.

Key words: Weaning food, malting, functional properties, viscosity, soybean.

INTRODUCTION

The consumption of cereal based food products from maize (*Zea mays*), sorghum (*Sorghum bicolor*), millet

(*Pennisetum typhoideum*), rice (*Oryza sativa*), etc is very common and popular worldwide especially in developing

African countries where they constitute a major source of their staple food (Gernah et al., 2011). Due to the prevailing unfavourable economic conditions in most developing countries of the world, Africa and Nigeria in particular where over 40% of the population live below poverty line (Nzeagwu and Nwaejike, 2008), the incidence of protein-energy malnutrition among different age groups particularly children with an estimated 400 million children being reported to be malnourished worldwide is highly prevalent and on the increase on a daily basis (Oji, 1994; Oosthuizen et al., 2006; Agiriga and Iwe, 2009). Weaning of infants is highly critical in the life of children as breast milk feeding (4-6 months), which normally precedes the weaning period, can no longer meet their nutritional requirements (Egounlety, 2002). The nutritional qualities of traditional weaning foods in developing countries, particularly in Nigeria, are low in protein content and also devoid of vital nutrients that are required for normal child growth and development (FAO, 2004).

In developing countries, one of the greatest problems affecting millions of people, particularly children, is lack of adequate protein intake in term of quality and quantity. As cereals are generally low in protein, supplementation of cereals with locally available legume that is high in protein increases protein content of cereal-legume blends. Several traditional fermentations have been upgraded to high technology production systems and this has undoubtedly improved the general well-being of the people as well as the economy (Achi, 2005). For instance, the corn gruel (ogi) is the traditional weaning food of infants in many parts of West Africa countries. 'Ogi', an acid fermented gruel or porridge made from maize (*Zea mays*), sorghum (*Sorghum bicolor*) or millet (*Pennisetum glaucum*) is limited by its low protein content especially amino acids notably lysine and methionine (Inyang and Idoko, 2006).

Studies have shown that corn gruel (ogi) is bulky and devoid of essential nutrients, such as protein and vital micronutrients that is needed for normal child growth and development (Levin et al., 1993; Pinstrup-Andersen et al., 1993; Millward and Jackson, 2004). Efforts have therefore been made to improve on the nutritional quality of the traditional weaning foods and these include the incorporation of protein-rich legumes (Ikujenlola and Fashakin, 2005; Kouakou et al., 2013), fermentation of the cereal component (Amankwah et al., 2009) and incorporation of malt in the weaning foods (Odumodu, 2008). Complementary foods are usually introduced between the ages of six months to three years, this is done with gradual withdrawal of breastfeeding. Infants are able to maintain adequate growth until the age of six

months when additional nutrients are required to complement breastfeeding. During this transitional phase, protein-energy malnutrition occurs (Ijarotimi and Ashipa, 2006; Ijarotimi and Ayantokun, 2006). It is therefore required to feed infants with highly nutritious food during this period. The general acceptability of weaning foods by infants is greatly influenced by the functionality of the ingredients used for their production. Indeed, the functionality of a food is the property of the food ingredients apart from its nutritional value, which has a great impact on its utilization (Kinsella, 1976). Functional properties such as gelation, water holding capacity, viscosity and pasting properties are very important for ensuring the appropriateness of the diet to the growing child. The consistency and energy density (energy per unit volume) of the complementary diet coupled with frequency of feeding are also important factors in determining the extent to which an infant can meet his other energy and nutrient requirements (Kikafunda et al., 1997). In the processing of most complementary foods, emphasis is usually on the nutritional quality and quantity of the ingredients rather than their functional properties (Bookwalter et al., 1987).

In many regions of Africa where the climatic conditions are unfavorable for the growth of other crops, sorghum is the major staple food (Kinyua et al., 2016). Due to high cost and unavailability of animal products such as milk, legumes are largely used as alternative sources of high quality protein. Cereals are relatively poor sources of protein but have been reported to supply over 70% of dietary protein in developing countries (Ijarotimi and Ashipa, 2006). Also, maternal and child under nutrition remain pervasive and damaging conditions in low income and middle-income countries (Black et al., 2008).

The cereal crops from which weaning or complementary foods are prepared have been undergoing series of genetic engineering in most developing countries including Nigeria in recent time. The specific areas of focus in these genetic engineering efforts include the development of high-yielding cereal varieties (Manyong et al., 2000); yield stability of the grain (Hausmann et al., 2000; Pixley and Bjarnason, 2002); disease-resistant variety (Hess et al., 1992; Bosque-Perez, 2000); cereal varieties with improved mineral and vitamin content (Ortiz-Monasterio et al., 2007); drought-tolerant variety (Campos et al., 2004); and cereal varieties with minimal anti-nutrients (Raboy et al., 2001). These cereal varieties have been observed to have diverse yield potentials in different ecological zones of a country and therefore their assessment across a country has become a necessary established practice in cereal genetic engineering efforts (Iken and Amusa, 2004). Due to high cost and

*Corresponding author. E-mail: mohammedusmanatanda@gmail.com.

unavailability of animal products such as milk, legumes and cereals are largely used as alternative sources of protein in many region of Africa. However, due to lack of proper processing techniques to increase the nutritional value of the crops, infant malnutrition rates are high. Identification of the best varieties of sorghum in terms of their nutritional value diverse yield potentials in different ecological zones of a country and therefore their assessment across a country has become a necessary established practice in cereal genetic engineering efforts (Iken and Amusa, 2004).

Grown in this region and use of appropriate food processing techniques can be used in developing complementary food and help solve malnutrition. Sorghum is a staple food in many African countries and contains reasonable amount of protein, ash, oil and fibre, however, is deficient in essential amino acid content, particularly with respect to lysine.

Weaning foods have been formulated from ungerminated locally-available cereal grains in Nigeria but no serious effort has been made to systematically use hybrid sorghum as comparable to local and improved sorghum varieties. Generally, energy and nutrients density of weaning food can be increased by such operations as enzyme treatments, pre-cooking and extrusion (Mosha and Svanberg, 1983). This type of weaning food formulation usually possesses increased energy density and reduced viscosity but may be too expensive for the poor households in the societies. An alternative solution to this high energy density and chemically balanced food can be achieved through the addition of malted cereal and complimenting the weaning food with high protein legumes. Sorghum is an important source of vitamin B-complex and some other minerals like phosphorous, magnesium, calcium and iron. The protein quality of sorghum is also very similar to that of maize with lysine as the limiting amino acid but rich in methionine (FAO, 1995). Soybean (*Glycine max*) is an important legume reported to contain large amount of protein along with other nutrients (IITA, 1990). The protein is high in lysine but low in methionine (Ogazi et al., 1996; Omueti et al., 2000). Malting has been shown to be one of the most effective and convenient ways for improvement of nutritional value of cereals (Adeyemo et al., 1992; Akpapunam et al., 1996; Gernah et al., 2011); and currently there is a growing interest in the formulation of food products using the combination of composite blends of malted cereals and legumes as a way of improving nutritional quality of the product suitable for children (Agu and Aluya, 2004).

Thus, in this study, weaning foods were formulated from locally-available materials in Nigeria (local, improved and hybrid sorghum grains and soybean) with emphasis on the physicochemical properties of their blends. The objective was to evaluate the functional properties of this weaning food in order to know the appropriateness of the diet for infants.

MATERIALS AND METHODS

Three varieties of sorghum grains were used for this study: local sorghum (*Pelipeli*), improved sorghum (Samsong 17, SK5912) and sorghum hybrid. *Pelipeli* was obtained from the Agricultural Development Programmes (ADP) Agency, Yola, Nigeria. The improved sorghum (Samsong 17, SK5912) was gotten from the Institute of Agricultural Research (IAR), Samaru, Zaria, Nigeria; while the sorghum hybrid was sourced from Lake Gerio Research Farm, River Basin Development Authority (RBDA), Yola, Nigeria. Soybean was also obtained from a local market (Yola town main market).

Malting of sorghum grains

Sorted clean grains of sorghum weighing 1000 g were steeped in water (1:3 w/v, grain: water) for 4 h. The steeped grains were then transferred to a wide container with cotton wool to allow for germination at room temperature (30°C) for 5 days. The washed germinated seeds were dried in the oven at 35°C for a total of about 10 to 12 h. The grains were then cleaned of sprouts and hulls by hand rubbing and winnowing, after which they were dried in a forced-air oven at 50°C to a uniform light brown colour. The dried grains were ground to fine flour and passed through a 0.5 mm sieve (Elemo et al., 2011). The modified procedure of Beta et al. (1995) was used for malting the grains from sorghum varieties involved in this study. One kilogramme of grains from each sorghum variety was, respectively, steeped in water at 30±2°C inside a plastic bowl for 20 h. The water in the bowl was replaced with fresh one at 3-h interval to discourage fermentation. After steeping, the grains were immersed in 2% sodium hypochlorite solution for 10 min and then rinsed five times with excess water. The grains were finally spread on damped jute bags for germination at 30±2°C, 95% RH, for five days in a germinating chamber. The germinated grains were eventually dried in a forced-air oven at 50°C for 24 h. The dried malt was cleaned and the roots and shoots were removed by hand using a corrugated, rubber surface; and then kept in a plastic container for subsequent use.

Production of weaning food blends

Flour was, respectively, produced from each varieties of sorghum grain (local, improved and hybrid), soybean and malted sorghum as depicted in Figure 1. Thereafter, weaning food blends were prepared from the flours using the composite formulation as shown in Table 1. Essentially, the raw sorghum grains were sorted, cleaned and dried to prepare them for milling. They were then milled using a disc mill and sieved by passing through a 425 µm-sieve to produce fine raw sorghum flour (RSF) which was then used for subsequent weaning food formulation. The malted sorghum grains initially obtained were milled to produce malted sorghum flour (MSF), also at 425 µm particle size, which was then stored properly under room temperature (30±2°C) and then used for subsequent formulation of weaning food. The processing of the soybean flour was carried out as described by Gbenyi and Wilcox (2002). Three types of weaning food blend were prepared from each sorghum variety containing 0, 5 and 10% of malted sorghum flour (MSF), respectively; in combination with soybean flour at varying levels. This was guided by the expected energy and nutrient density in the weaning food.

Determination of the functional properties of the blends

Water binding capacity

The water binding capacity (WBC) was determined by the modified

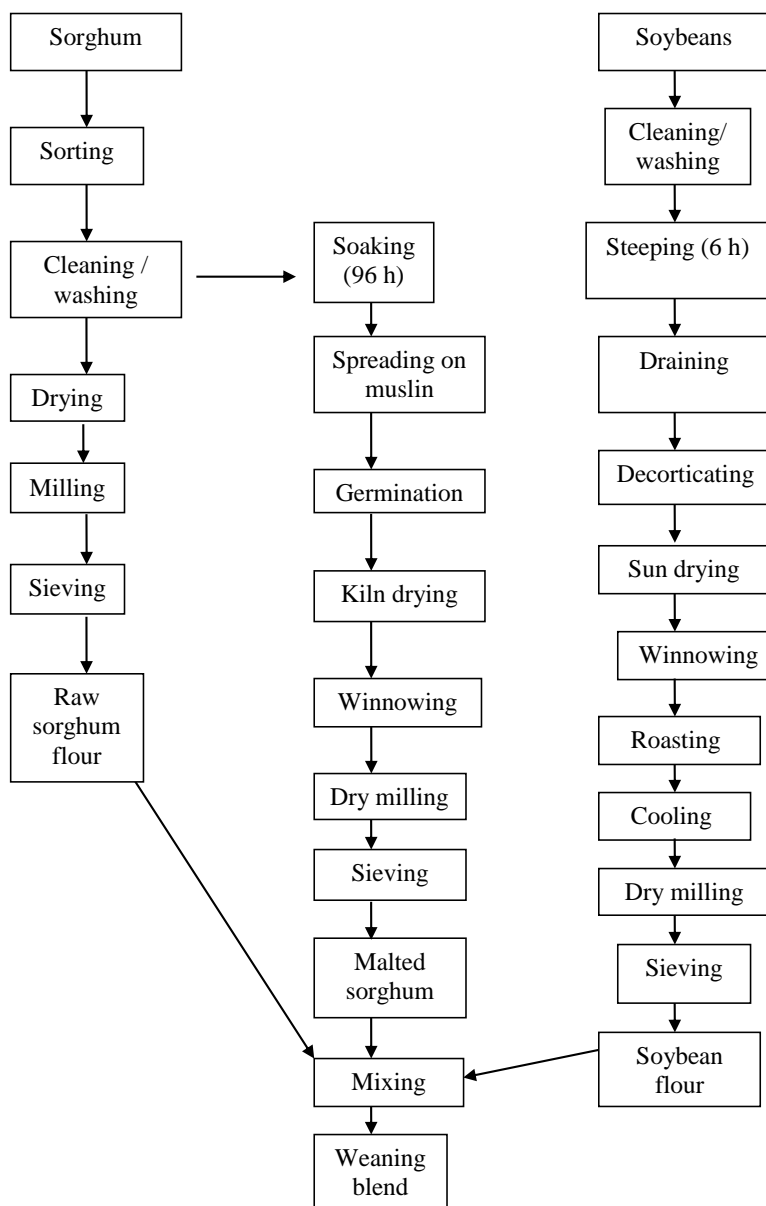


Figure 1. Production of sorghum-soybean weaning food blend.

method of Lin and Humbert (1974). Two grams of the food blend were added to 20 ml of distilled water in a test tube, stirred briefly with a magnetic stirrer and allowed to stand for 1 h at room temperature ($30\pm 2^{\circ}\text{C}$) before being centrifuged at 2460 rpm. The supernatant water was decanted by inverting the tubes over filter paper placed in a volumetric flask. The sample was allowed to drain for about 35 min and the weight of the bound water was determined by the difference between initial and final weight of sample.

Viscosity

The determination of viscosity of the weaning food blend was carried out using the procedure described by Coffman and Gracia (1977). Viscosity of the blend was assessed using rotational viscometer. The gruel from each blend was first prepared by mixing 10% (w/v) of the flour and water in a beaker which was heated in a

boiling water bath to reach a cooking temperature of $95\pm 1^{\circ}\text{C}$. The gruel was kept at this cooking temperature for about 15 min with occasional stirring until it was finally cooled down to 40°C and its viscosity measured in centipoise (cP).

Least gelation concentration (LGC)

Least gelation concentration was determined by using the method described by Malleshi and Desikachar (1982). Sample suspensions of 2-20% (w/v) were prepared in test tubes with 5 ml of distilled water, respectively. The suspension was then mixed using vortex mixer for 5 min. The test tubes containing the suspension were heated for 1 h in boiling water followed by rapid cooling under cold running water. The tubes were further cooled at 4°C for 2 h. The least gelation concentration is the concentration at which the sample from the inverted tube did not slip or fall.

Table 1. Composite formulation of weaning food blends from raw sorghum flour (RSF), malted sorghum flour (MSF) and soybean flour (SBF).

Source of weaning food blend	Raw sorghum flour (RSF) (%)	Malted sorghum flour (MSF) (%)	Soybean flour (SBF) (%)
Local sorghum grain:			
Pelipeli- (M0)	70	0	30
Pelipeli- (M5)	66.5	5	28.5
Pelipeli- (M10)	63	10	27
Improved sorghum grain:			
Samsorg 17- (M0)	70	0	30
Samsorg 17- (M5)	66.5	5	28.5
Samsorg 17- (M10)	63	10	27
Hybrid sorghum grain:			
Hybrid- (M0)	70	0	30
Hybrid - (M5)	66.5	5	28.5
Hybrid - (M10)	63	10	27

Pasting properties

Pasting properties of the weaning food blend were carried out using a Rapid Visco-Analyzer (RVA-Series 4, Newport Scientific, Sidney, Australia). A sample of 4.0 g weaning food (14% moisture-basis) was transferred into a canister and approximately 25 ± 0.1 ml distilled water was added (correction factor was used to compensate for 14% moisture-basis). The slurry was stirred at 160 rpm for 10 s for thorough dispersion and heated to 50°C. The slurry was held at 50°C for up to 1 min followed by heating to 95°C for about 7.3 min and held at 95°C for 5 min, then cooled at the same rate to 50°C. The pasting parameters were obtained automatically and generated from the software attached to the RVA. The parameters were pasting temperature, peak viscosity (the maximum hot paste viscosity), time to peak, breakdown (peak viscosity-holding strength or trough), holding strength or trough, setback (final viscosity – holding strength) and final viscosity (viscosity at the end of the test after cooling at 50°C and holding at this temperature).

Statistical analysis

All determinations reported in this study were replicated three times (performed in triplicate). In each case, a mean value and standard deviation were calculated. Analysis of variance (ANOVA) was also performed and separation of the mean values was by Duncan's Multiple Range Test at $p \leq 0.05$. The Statistical Package for Social Scientists (SPSS) software, version 16.0; was used for the analysis.

RESULTS AND DISCUSSION

Water binding capacity, viscosity and least gelation concentration of weaning food blends from sorghum varieties

Water binding capacity (WBC) measures the amount of water absorbed by starch and used as an index of

gelatinization. WBC also depends on the availability of hydrophilic groups that bind water molecules on the gel-forming capacity of macromolecules (Onyeka and Dibia, 2002). The results of WBC of the blends are shown in Table 2. There were significant differences ($p \leq 0.05$) observed in the water binding capacities of the blends from sorghum varieties. Inclusion of malted sorghum flour (MSF) in the weaning food blends resulted in a decrease in water binding capacity (WBC). The WBC of Samsorg 17-(M0), *Pelipeli*-(M0) and Hybrid-(M0) were 3.81, 3.51 and 3.31 ml/g, as shown in Table 2. The WBC was also observed to decrease with an increase in the quantity of MSF included. This observation essentially conforms to an earlier observation that the inclusion of malt in a flour blend usually tends to lower its water binding capacity (Onyeka and Dibia, 2002). This has to do with possible enzymatic breakdown of the starchy component in the malt flour which might have led to simple sugar availability. A high WBC reflects high starch content and is also dependent on the availability of hydrophilic groups that bind water molecules and on the gel-forming capacity of the macromolecules (Onyeka and Dibia, 2002).

The viscosity of the weaning food blends is shown in Table 2. The values ranged from 14.32 to 33.61 cP with Hybrid-(M10) and *Pelipeli*-(M0) having the lowest and highest values, respectively. At the temperature (40°C) in which the viscosity of the weaning food blends was measured, it was observed that the viscosity of the blends generally decreased with an increase in the quantity of malt added. The implication of this observation is that the inclusion of malt in the blends tends to cause a decrease in the viscosity. This observed decrease in viscosity could be attributed to an increase in amylolytic activity as a result of the increase in the quantity of malt

Table 2. Water holding capacity, viscosity and least gelation concentration of weaning food blends from sorghum varieties.

Source of weaning food blend	Water binding capacity (ml/g)	Viscosity (cP)	Least gelation concentration (g/ml)
Local sorghum grain:			
Pelipeli- (M0)	3.51±0.32 ^{ab}	33.61±0.05 ^a	8.02±0.05 ^g
Pelipeli- (M5)	2.52±0.29 ^c	29.42±0.03 ^d	10.67±0.03 ^f
Pelipeli- (M10)	2.14±0.02 ^{cd}	26.31±0.04 ^e	16.02±1.04 ^c
Improved sorghum grain:			
Samsorg 17- (M0)	3.81±0.48 ^a	32.33±0.11 ^b	14.11±0.11 ^d
Samsorg 17- (M5)	2.32±0.11 ^{cd}	24.42±0.02 ^f	16.05±0.02 ^c
Samsorg 17- (M10)	2.13±0.21 ^{cd}	11.89±0.03 ^l	18.12±0.03 ^b
Hybrid sorghum grain:			
Hybrid- (M0)	3.31±0.05 ^b	30.04±0.05 ^c	12.03±0.05 ^e
Hybrid - (M5)	2.01±0.15 ^d	23.07±0.09 ^g	18.09±0.09 ^b
Hybrid - (M10)	1.52±0.07 ^e	14.32±0.02 ^h	20.21±0.06 ^a

Values are mean ± standard deviation of three determinations. Values with different superscripts in a column are significantly different at $p \leq 0.05$. M0 = Weaning food blend containing 70, 0 and 30% of raw sorghum flour (RSF), malted sorghum flour (MSF) and soybean flour (SBF), respectively. M5 = Weaning food blend containing 66.5, 5 and 28.5% of raw sorghum flour (RSF), malted sorghum flour (MSF) and soybean flour (SBF), respectively. M10 = Weaning food blend containing 63, 10 and 27% of raw sorghum flour (RSF), malted sorghum flour (MSF) and soybean flour (SBF), respectively.

in the blend. It had earlier been observed that the process of cereal malting normally releases certain enzymes such as α -amylase which is capable of digesting amylose and amylopectin to dextrins and maltose. These low molecular weight carbohydrates contribute to reduced viscosity, have less water-binding capacity and may be more easily digested and absorbed as required by infants (Alvina et al., 1990). Therefore, reduced viscosity is a good indicator for the appropriateness of a weaning food blend for infants. Least gelation capacity (LGC), an index of gelling tendency of blends, is very important with respect to porridges (Onyeka and Dibia, 2002). LGC was taken as a measure of the gelation capacity and the lower the LGC, the better the gelation characteristics of the flour. This demonstrated that *Pelipeli*-(M0) blend would have better gelation characteristic than Hybrid-(M10). The LGC of the weaning food blends ranged between 8.02 and 20.21 g/ml with *Pelipeli*-(M0) and Hybrid-(M10) having the lowest and highest values, respectively, at significant level of $p \leq 0.05$ (Table 2). The blends without the inclusion of malted sorghum flour were observed to have lower LGC than their counterparts with malted sorghum flour inclusion. The LGC was increasing with an increase in the quantity of malted sorghum flour added in each of the sorghum varieties used. The LGC measures the concentration of starch at which the slurry, on heating, may form a thick gel. When the LGC is low, it implies that a small amount of the sample flour can easily form a gel. The gel formed from the low LGC sample normally has a low nutrient density and it will be difficult to meet the nutrient requirement of the young child.

However, a high LGC value implies that the gruel will be formed with high quantity of the flour which is desirable for child feeding because it will enhance the nutrient density. The malting of sorghum grains might have resulted in the reduction of hydrophilic sites of the starch granules thereby reducing the gelling capacity (Moorthy et al., 1996). Thus, the gruel is liquefied, making it possible for more solid per unit volume to be added while maintaining the same consistency (Brandtzageg et al., 1981).

Pasting properties of weaning food blends from sorghum varieties

Kinsella (1979) reported that protein gels are composed of three dimensional matrices or networks of interwoven and partially associated polypeptides in which the water is trapped. Gels are characterized by a relatively high viscosity, plasticity and elasticity. The pasting characteristics of the weaning food blends from local, improved and hybrid sorghum grains are presented in Table 3. The peak viscosity (PV) of the blends ranged between 130.2 and 532.1 RVU with Hybrid-(M10) and *Pelipeli*-(M0) having the lowest and highest values, respectively, at significant level of $p \leq 0.05$. Inclusion of malted flour resulted in a reduction of the PV of the blends. The observed decrease in PV can be attributed to the presence of malt which contains degraded starch through the malting process. The reduction in the viscosity of the malted diet is as a result of the activity of

Table 3. Pasting properties of weaning food blends from sorghum varieties.

Source of weaning food blend	Pasting properties						
	Peak viscosity (RVU)	Trough (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (Difference between final viscosity and trough; RVU)	Pasting temperature (°C)	Peak time (min)
Local sorghum grain:							
Pelipeli- (M0)	532.1±4.2 ^a	335.3±2.4 ^a	92.2±1.1 ^b	826.2±5.2 ^a	490.9±3.1 ^c	88.6±0.3 ^{ab}	5.01±0.01 ^c
Pelipeli- (M5)	390.3±1.2 ^c	173.1±2.1 ^d	46.3±2.4 ^d	689.1±2.4 ^b	516.0±2.3 ^b	87.1±0.2 ^{ab}	4.53±0.02 ^e
Pelipeli- (M10)	334.2±1.4 ^d	142.1±1.1 ^e	97.4±3.1 ^a	576.3±2.1 ^c	434.2±1.5 ^e	85.3±1.5 ^b	4.36±0.02 ^f
Improved sorghum grain:							
Samsorg 17- (M0)	526.2±3.3 ^b	294.2±2.1 ^b	48.2±1.1 ^d	391.2±4.7 ^d	97.0±3.4 ^a	89.6±2.2 ^a	5.46±0.04 ^a
Samsorg 17- (M5)	273.1±1.4 ^g	143.1±2.2 ^e	41.3±1.2 ^e	229.3±3.1 ^f	86.2±2.7 ^h	88.3±3.1 ^{ab}	5.13±0.05 ^b
Samsorg 17- (M10)	163.2±1.2 ^h	111.3±2.1 ^f	59.1±2.1 ^c	175.4±3.2 ^g	64.1±2.9 ^g	86.3±2.1 ^{ab}	3.66±0.06 ^g
Hybrid sorghum grain:							
Hybrid- (M0)	310.3±3.2 ^e	181.2±3.2 ^c	28.3±1.1 ^g	248.2±3.8 ^e	67.0±3.2 ^h	86.4±2.4 ^{ab}	4.63±0.03 ^d
Hybrid - (M5)	288.1±1.2 ^f	102.1±3.1 ^g	32.4±2.1 ^f	177.1±3.1 ^g	75.0±3.1 ^f	84.9±2.1 ^b	4.38±0.05 ^f
Hybrid - (M10)	130.2±1.1 ⁱ	73.2±1.1 ^h	35.2±2.3 ^f	160.2±3.1 ^h	87.0±1.9 ^d	84.5±3.1 ^b	2.93±0.01 ^h

amylase enzymes developed during malting process which degrades the starch to simpler units (Fagbemi, 2007; Nnam, 2000). The reduction in viscosity of the diets is advantageous, the gruel prepared from it would be watery and more solid could be added; this will amount to adding more nutrients and energy which is better for the growing children. Similar enzymic breakdown was observed by Onweluzo and Nnabuchi (2009) and this was attributed to the inherent starch in sorghum possessing its viscosifying properties since it was modified during heating and fermentation. This is implication of this decrease in fermentation. This implication of this decrease permits the addition of higher quantity of the solid without a concomitant increase in viscosity. Viscosity values of the samples could probably be attributed to the starch moiety which

was not ruptured by preprocessing to release assimilable sugars (amylose and amylopectin) for gelation and in turn increases the viscosity. During malting, starch degrading enzymes such as α -amylase, β -amylase, limit dextrinase and α -glucosidase are usually activated in the cereal kernel thereby leading to the production of dextrans of lower molecular sizes capable of exhibiting lower PV than that of native starch (Fincher, 1989). There was digestion of the starch by these amylases to dextrin and maltose. The amylases breakdown the starch moiety leading to formation of gel network. Ragae and Abdel-Aal (2006) reported that during the holding period of the viscosity test, the material slurries are subjected to high temperature and mechanical shear, which further disrupt starch granules in the grains, resulting in amylose leaching out and

alignment. The difference in the PV of the weaning food blends indicates that there were differences in the rate of water absorption and starch granule swelling during heating (Ragae and Abdel-Aal, 2006). The importance of peak viscosity in weaning food is that it signifies the ability of the formulation to gel or not (Mazurs et al., 1957).

The breakdown viscosity of the weaning food blends ranged between 28.3 and 97.4 RVU with Hybrid-(M0) and *Pelipeli*-(M10) having the lowest and highest values, respectively, ($p \leq 0.05$). The breakdown viscosity is essentially a measure of the degree of paste stability or starch granule disintegration during heating (Dengate, 1984). Therefore, the weaning food blends from the hybrid sorghum grains with relative low breakdown viscosity (28.3-35.2 RVU) will have a more stable

paste during heating than others with higher breakdown viscosity (Farhat et al., 1999). However, the inclusion of sorghum malt in the blends tends to generally increase the breakdown viscosity thereby making the paste less stable during heating. This period is commonly associated with a breakdown in viscosity. The ability of starch to withstand heating at high temperature and shear stress is an important factor in many processes. Elofsson et al. (1997) noted that gel formation of proteins is the result of a two-step process involving, first, the partial denaturation of individual proteins to allow more access to the reactive side groups within the protein molecules and second aggregation of these proteins by means of reactive side groups into a continuous three dimensional network structure capable of retaining significant amount of water and also exhibiting some structural rigidity. This phenomenon is of importance in foods since it contributes significantly to the textural and rheological properties of various foods.

The final viscosity of the weaning food blends ranged between 160.2 and 826.2 RVU with Hybrid-(M10) and *Pelipeli*-(M0) giving the lowest and highest values, respectively, ($p \leq 0.05$). The inclusion of sorghum malt in the weaning food blends was observed to cause general reduction in the final viscosity. This observation may be attributed to the enzymatic activity that had occurred in the sorghum malt during the malting process whereby the starch molecules were degraded (Juhasz et al., 2005; Xu et al., 2012). Consequently, the degraded starch structure (particularly amylose structure) resulted in reduced final viscosity due to minimized aggregation of the amylose molecules in the gelatinized paste during cooling (Chung et al., 2012). It had also been observed that the exhibition of final viscosity in a gelatinized paste is as a result of the aggregation of the amylose molecules in the paste (Miles et al., 1985). Since the viscosity of infants weaning food plays an important role in the food acceptability as well as on infants' energy intake (Treche and Mbome, 1999), the inference that can be made from these observations is that the weaning food blends from samples Hybrid-(M10), Samsorg 17-(M10) and Hybrid-(M5), which exhibited relative low final viscosity values, might be the most appropriate for developing weaning foods. Final viscosity is usually regarded as an indicator of the stability of the cooked paste in actual use (Ragae and Abdel-Aal, 2006).

The setback viscosity of the weaning food blends ranged between 64.1 and 516.0 RVU with Samsorg 17-(M10) and *Pelipeli*-(M5) giving the lowest and highest values, respectively. The weaning food blends from both improved and hybrid sorghum grains had relatively low setback viscosity than that from the local sorghum grains. This phase is commonly described as the setback region and is related to retrogradation and reordering of starch molecules. The low setback values indicate low rate of starch retrogradation and syneresis. The peak viscosity often correlates with quality of end product and also

provides an indication of the viscous. The setback viscosity is usually regarded as an index of retrogradation tendency of the paste prepared from a starchy food (Sandhu et al., 2007) and the higher the value, the greater the retrogradation tendency. However, the inclusion of sorghum malt in the weaning food blends tends to reduce the setback viscosity when compared with the ones without malt. Ragae and Abdel-Aal (2006) had earlier reported that low setback values indicate low rate of starch retrogradation and syneresis. Therefore, the observed variation in setback values has a strong implication on the variability of retrogradation tendency of the weaning food paste during storage. The deduction that can be made from these observations is that the weaning food blends from samples Samsorg 17-(M10), Hybrid-(M0) and Hybrid-(M5), which exhibited relative low setback viscosity values, might be the most appropriate for developing weaning foods.

The pasting temperature of the weaning food blends ranged between 84.5 and 89.6°C with Hybrid-(M10) and Samsorg 17-(M0) having the lowest and highest values, respectively, ($p \leq 0.05$). Sorghum malt inclusion in the blends resulted in a reduction in the pasting temperatures. The differences in the pasting temperatures of the weaning food blends indicate that the blends exhibited different gelatinization temperatures (Newport-Scientific, 1996). The pasting temperature provides an indication of the minimum temperature required to cook a given sample, which can also have implications on energy usage (Ragae and Abdel-Aal, 2006). The ability of protein to form gel and provide a structural matrix for holding water, flavours, sugars and food ingredients is useful in food application. Protein gel formation usually requires prior heating denaturation or unfolding of the polypeptide chain.

The peak time of the weaning food blends ranged between 2.93 and 5.46 min with Hybrid-(M10) and Samsorg 17-(M0) having the lowest and highest values, respectively, ($p \leq 0.05$). Sorghum malt inclusion in the blends resulted in a decrease in the peak time. The peak time is usually regarded as an indication of the total time taken by each blend to attain its respective peak viscosity. Thus, weaning food blends with a lower peak time will cook faster than that with a higher peak time.

CONCLUSION

This study has shown that sorghum malt flours can be used to improve the physicochemical and rheological properties of cereal-based weaning food blends. Both the water holding capacity and viscosity of the blends decreased as the concentration of malt inclusion was increased. However, the least gelation concentration of the blends was increased with an increase in the quantity of malt inclusion. Almost all the pasting factors of the weaning food blends, except the breakdown viscosity, got

reduced with the inclusion of sorghum malt. Specifically, the weaning food blends from Samsorg 17-(M10) and Hybrid-(M5) could be regarded as appropriate formulations for developing weaning foods due to the exhibited characteristics of relative low final viscosity, setback and pasting temperature.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

- Achi OK (2005). The potential of upgrading traditional fermented foods through biotechnology. *Afr. J. Biotech.* 4 (5):375-380.
- Adeyemo SO, Olayode OB, Odotuga AA (1992). Biochemical analysis of germinating white maize (*Zea mays*). *Niger. J. Nutr. Sci.* 13:18-24.
- Agiriga AN, Iwe MO (2009). Proximate composition of cookies produced from cassava groundnut-corn starch blend. A Response Surface Analysis. *Niger. Food J.* 27(1):102-107.
- Agu HO, Aluya O (2004). Production and chemical analysis of weaning food from maize, soybeans and fluted pumpkin seed flour. *Niger. Food J.* 22:171-177.
- Akpapunam MA, Igbedioh SO, Aremo I (1996). Effect of malting time on chemical composition and functional properties of soybeans and bambara groundnut flour. *Int. J. Food. Sci. Nutr.* 47:27-33.
- Alvina M, Vera G, Pak N, Araya H (1990). Effect of the addition of malt flour to extruded pea-rice preparations on food and energy intake by preschool children. *Ecol. Food Nutr.* 24:189-197.
- Amankwah EA, Barimah J, Nuamah AKM, Oldham JH, Nnaji CO (2009). Formulation of weaning food from fermented maize, rice, soybean and fishmeal. *Pak. J. Nutr.* 8(11):1747-1752.
- Beta T, Rooney LW, Waniska RD (1995). Malting characteristics of sorghum cultivars. *Cereal Chem.* 72(6):533-538.
- Black RE, Allen LH, Bhutta ZA, Caulfield LE, DeOnis M, Ezzati M, Mathers C, Rivera J (2008). Maternal and child undernutrition: Global and regional exposures and health consequences. *The Lancet*, 371:243-260.
- Bookwalter GN, Lyle SA, Warmer K (1987). Millet processing for improved stability and nutritional quality without functionality changes. *J. Food Sci.* 52(2):399-402.
- Bosque-Perez NA (2000). Eight decades of maize streak virus research. *Virus Res.* 71:107-121.
- Brandtzagec B, Malleshi NG, Svanberg U, Desikacher HSR (1981). Dietary bulk as a limiting factor for nutrient intake in pre-school children. *J. Trop. Paediatr.* 27(4):184-189.
- Campos H, Cooper M, Habben JE, Edmeades GO, Schussler JR (2004). Improving drought tolerance in maize: A view from industry. *Field Crop Res.* 90:19-34.
- Chung H, Cho D, Park J, Kweon D, Lim S (2012). *In vitro* starch digestibility and pasting properties of germinated brown rice after hydrothermal treatments. *J. Cereal Sci.* 56:451-456.
- Coffman CW, Gracia VV (1977). Functional properties and amino acid content of protein isolate from mung bean flour. *J. Food Technol.* 12: 473-484.
- Dengate HN (1984). Swelling, pasting, and gelling of wheat starch. In: Pomeranz Y (Ed.). *Advances in cereal science and technology*, USA, American Association of Cereal Chemists, pp49-82.
- Egounlety M (2002). Production of legume-fortified weaning foods. *Food Res. Int.* 35:233-237.
- Elemo GN, Elemo BO, Okafor JNC (2011). Preparation and nutritional composition of a complementary food formulated from germinated sorghum (*Sorghum bicolor*) and steam cooked cowpea (*Vigna unguiculata* Walp). *Am. J. Food Technol.* 6(5):413-421.
- Elofsson C, Dejmek P, Poulson M, Burling H (1997). Characterization of a cold gelling whey concentrate. *Int. Dairy J.* 7:601-607.
- Fagbemi TN (2007). Effects of processing on the nutritional composition of fluted pumpkin (*Telfaria occidentalis*) seed flours. *Niger. Fd J.* 25(1):1-22.
- FAO (1995). Sorghum and millet in human nutrition. *FAO Food and Nutrition Series 27*. FAO, Rome Italy, pp. 49-86.
- FAO (2004). Undernourishment around the world. In: *The state of food insecurity in the world*, Rome.
- Farhat IA, Oguntona T, Neale JR (1999). Characterisation of starches from West African yams. *J. Sci. Food Agric.* 79:2105-2112.
- Fincher GB (1989). Molecular and cellular biology associated with endosperm mobilization in germinating cereal grains. *Ann. Rev. Plant Phys.* 40:305-346
- Gbenyi ID, Wilcox BF (2002). Assessment of physicochemical properties and acceptability of *fufu* from yam-soybean composite flour. *J. Appl. Sci. Manag.* 6:11-15.
- Malleshi NG and Desikahar HS (1982). Formulation of weaning food with low hot paste viscosity based on maltedragi and greengram. *J. Food Sci. Technol.* 19(3):193-198.
- Manyong VM, Kling JG, Makinde KO, Ajala SO, Menkir A (2000). Impact of IITA-improved germplasm on maize production in West and Central Africa. [Internet document]. URL <http://www.cgiar.org/impact/research/maize>. Accessed on 12th July, 2014.
- Mazurs EG, Schoch TJ, Kite FE (1957). Graphical analysis of the Brabender viscosity curves of various starches. *Cereal Chem.* 34: 141-152.
- Miles MJ, Morris VJ, Orford PD, Ring SG (1985). The roles of amylose and amylopectin in the gelation and retrogradation of starch. *Carbohydr. Res.* 135:271-281.
- Millward D J, Jackson AA (2004). Protein/energy ratios of current diets in developed and developing countries compared with a safe protein/energy ratio: implications for recommended protein and amino acid intakes. *Public Health Nutr.* 7:387-405.
- Moorthy SN, Rickard J, Blanshard JMV (1996). Influence of gelatinization characteristics of cassava starch and flour on the textural properties of some food products. In: Dufour D, O'Brien GM, Best R (Eds.). *Cassava Flour and Starch: Progress in Research and Development*, CIAT, Colombia, pp. 150-155.
- Newport-Scientific (1996). *Operational Manual for the Series 4 Rapid Visco Analyser*. Sydney, Australia, Newport Scientific Pty, Ltd, pp. 5-12.
- Nnam NM (2000). Evaluation of effect of sprouting on viscosity, proximate composition and mineral content of hungry rice-acha (*Digitaria exilis*) flours. *Nig. Food J.* 18:57-62.
- Nzeagwu OC, Nwaejike NJ (2008). Nutrient composition, function and organoleptic properties of complementary food s formulated from sorghum, groundnut and crayfish. *Niger. Food J.* 26(1):13-20.
- Odumodu CU (2008). Effects of malt addition and fermentation on sensory characteristics of formulated cereal based complementary food. *Pak. J. Nutr.* 7(2):321-324.
- Ogazi PO, Oyewusi FA, Ozumba AU, Ogundipe HO, OsifoBOA, Lukambi FA (1996). Development and sensory evaluation of soyamusa: a soybean-plantain baby food. In: *International Symposium on Banana: International Conference on Banana and Plantain for Africa* 540:575-582.
- Oji KO (1994). Comparative analysis of rural urban demand for cassava products in Abia State. M.Sc. Thesis, Department of Agricultural Economics, University of Nigeria. Nsukka, Nigeria.
- Omueti O, Oguntona EB, Jayeola O, Ashaye OA (2000). Nutritional evaluation of home prepared soy-corn milk. A protein beverage. *Br. J. Nutr. Food Sci.* 30(2,3):128-132.
- Onweluzo JC, Nwabugwu CC (2009). Development and evaluation of weaning foods from pigeon pea and millet. *Pak. J. Nutr.* 8:725-730.
- Onyeka U, Dibia I (2002). Malted weaning food made from maize, soya bean, groundnut and banana. *J. Sci. Food Agric.* 82(5):34-38.
- Oosthuizen D, Napier C, Oldewage-Theron W (2006). The formulation and development of multi-mix for primary school children within an informal South-Africa. *Nig. Food J.* 24(1):139-147.
- Ortiz-Monasterio JI, Palacio-Rojas N, Meng E, Pixley K, Trethowan R, Pena RJ (2007). Enhancing the mineral and vitamin content of wheat and maize through plant breeding. *J. Cereal Sci.* 46:293-307.
- Pinstrup-Andersen P, Burger S, Habicht JP, Peterson K (1993). Protein-

- energy malnutrition. In: Jamison DT, Mosley WH, Measham AR, Bobadilla JL (Eds.). *Disease control priorities in developing countries*, 2nd ed., Oxford, UK, Oxford University Press pp. 391-420.
- Pixley KV, Bjarnason MS (2002). Stability of grain yield, endosperm modification, and protein quality of hybrid and open-pollinated Quality Protein Maize (QPM) cultivars. *Crop Sci.* 42:1882-1890.
- Raboy V, Young KA, Dorsch JA, Cock A (2001). Genetics and breeding of seed phosphorus and phytic acid. *J. Plant Physiol.* 158:489-497.
- Ragaei S, Abdel-Aal EM (2006). Pasting properties of starch and protein in selected cereals and quality of their food products. *Food Chem.* 95:9-18.
- Sandhu KS, Singh N, Malhi NS (2007). Some properties of corn grains and their flours I: Physicochemical, functional and chapatti-making properties of flours. *Food Chem.* 101:938-946.
- Treche S, Mbome IL (1999). Viscosity, energy density and osmolality of gruels for infants prepared from locally produced commercial flours in some developing countries. *Int. J. Food Sci. Nutr.* 50:117-125.
- Xu J, Zhang H, Guo X, Qian H (2012). The impact of germination on the characteristics of brown rice flour and starch. *J. Sci. Food Agric.* 92:380-387.

Full Length Research Paper

Beef consumption and consumer's knowledge on meat quality in Maroua in the Far North of Cameroon

Ronald Romuald Bebey Ngom Vougat^{1*}, Steven Chouto², Harquin Simplicite Foyet³, Rebecca Garabed⁴, Roland Ziebe¹ and André Pagnah Zoli⁵

¹Department of Agriculture, Livestock and By-Products, The Higher Institute of Sahel, University of Maroua, Cameroon.

²Department of Geography, The Higher Teachers Training College, University of Maroua, Maroua, Cameroon.

³Department of Biological Sciences, Faculty of Sciences, University of Maroua, Maroua, Cameroon.

⁴Department of Veterinary Preventive Medicine, College of Veterinary Medicine, The Ohio State University, OH, USA.

⁵School of Veterinary Medicine and Sciences, University of Ngaoundéré, Cameroon.

Received 20 April, 2016; Accepted 26 May, 2016

The objective of this study was to determine beef consumption and evaluate the knowledge of consumers on meat quality in Maroua city in the Far North Region of Cameroon. To achieve this, 202 households selected using a gridded map and random selection method were surveyed. The cookers or cooks were surveyed and observed in each household. During this survey, the pieces of beef, as cuts before cooking, were weighted and the quantity of beef consumed per person was calculated. The influence of socio economic and demographic factors related to consumer (religion, age, monthly income, number of person in the household and district) on beef consumption was also evaluated. Overall, 96% of the surveyed households consumed meat and among them, 98% eat beef. Beef is consumed the most (72%), followed by goat (21%), sheep (5%), chicken (1%) and pork (1%). In majority of the beef-eating households (39%), cattle meat was eaten two or three times per week. In addition, a person consumed 133.25 ± 33.49 g of beef per day and this consumption rate was affected by the age, monthly income and the district position. During the evaluation of consumer's knowledge on meat quality, color and tenderness were found to be the most important factors for consumers. These findings suggest that meat consumption in the livestock production area in Cameroon is very important as it is higher than that observed in the whole Cameroon and in Africa. Thus Cameroonian government should focus on improving meat consumption in consumption zones.

Key words: Beef, consumer, consumption, household, meat.

INTRODUCTION

Worldwide, meat and meat products are important sources of protein in the human diets. Their consumption varies among and within countries and according to

different factors related to a consumer and his environment. But the perception of their quality by consumers varies according to many factors (intrinsic and

*Corresponding author. E-mail: romsonbey@yahoo.fr. Tel: +237699 44 36 80.

extrinsic) (Van Loo et al., 2010; Font-i-Furnols and Guerrero, 2014).

With about 5.001 million cattle, Cameroon is a great country of livestock production, which occupies a prominent place in the sub region of Central Africa and in the sub-Saharan Africa area (FAOSTAT, 2014b). The meat consumption in Cameroon was 13.3 kg/capita/year in 2010 but this consumption is low according to the worldwide consumption of meat which is 41.9 kg/capita year (FAOSTAT, 2014a). That is why the government of Cameroon through the Ministry of Livestock, Fisheries and Animal industries (MINEPIA) hosts many projects which aimed to improve meat consumption from 13.3 kg/capita/year to 23 kg/capita/year in 2020 (MINEPIA, 2013). However, the problem of the poor consumption rate of meat could not be the same all over the country, especially in the three northern regions (Adamawa, North and Far-North) where the highest potential of livestock production was found (MINEPIA, 2014).

Previous studies conducted in 1980 have shown that the average of beef consumption per capita per year was 30 kg in both Garoua and Maroua, the respective capital cities of the North and the Far North regions of Cameroon (GESEP, 2002). Twenty years after, it reduced to 6.5-7.5 kg (Labonne et al., 2003). The question is: What happened twelve years after? A great deal of information is available on meat consumption in Cameroon but a little is known about the perception of consumer on meat quality.

In the Far North Region, 35.5% of households are food insecure, 5.1% in severe insecurity and 30.4% in moderate insecurity. Also, 37.7% of households have poor or limited consumption (PNSA/WFP, 2015).

The objective of this study was to determine the quantity of beef consumed per capita in the city of Maroua, a regional capital in the Far North Region of Cameroon and to evaluate the knowledge of consumer on meat quality attributes. Maroua is the capital that had an estimate of 713,653 inhabitants in 2010 (NSI, 2010). Maroua was chosen because it is the biggest city of the Far North Region of Cameroon and has the second highest cattle population in the country (MINEPIA, 2003). This city also provided an opportunity to explore beef consumption in an urban and cattle production (Ziebe et al., 2005).

MATERIALS AND METHODS

Study area

This study was conducted in the urban area of Maroua town (Figure 1).

Sample size

The number of households investigated was calculated and set taking into consideration the economic feasibility of our study but also considering the results of the pre-survey that we have done in the city of Maroua. This sample was shown to be sufficient for a

reliable statistical analysis of the results obtained, considering that it obtained a confidence level of 95%. The confidence interval was used in this sample so as to obtain a mean value contained in the interval (Da Fonseca and Salay, 2008):

$$\bar{x} - t \frac{\sigma}{\sqrt{n}} \leq \mu \leq \bar{x} + t \frac{\sigma}{\sqrt{n}}$$

where n is the sample size, r is the standard deviation and t a random variable with a t student distribution of 1.96 for $n > 120$ and a confidence value of 95%. Thus, a total of 200 households were calculated for this study but 202 households were interviewed.

Sampling strategy

Sampling strategy was done using a gridded map and random selection method as described by Profitós et al. (2014) with some modifications. Briefly, the update of the topographic sheet of Maroua NC-000 33-61/250 000 published by Army Map Service (S & H) in 1960 was used. This map was then update. This process helped delimit the contours of the city and also helped to highlight the different districts with their names and their geographic coordinates and new areas.

One hundred numbered points (25 equidistant points on each side) were put along the edges of the map obtained. Two numbers at a time were then randomly selected and a line was drawn between them. A total of 20 couple points were selected. Lots of different kinds of shapes of different sizes found were numbered. Ten numbers of these shapes were randomly drawn. These shapes were considered as "neighborhoods".

In each "neighborhood", grids of 30 x 30 m were drawn and each square numbered again except those located on roads, water points or bridges. Indeed according to study conducted by Mayer (1999) and Yen et al. (2008), a building in urban zone in Africa has an average area of 100 m². The area defined in this study allows accurate detection (which approximates the realities of our study area), knowing that a household can have several compounds and this especially in polygamous households (Devaux et al., 2007). So in this context, a grid in this study corresponds to a household. Finally, in each "neighborhood", a defined number of grid has been randomly drawn taking into consideration the total number of households to investigate, the total number of grid in the 10 selected "neighborhoods" and the number of grids in this "neighborhood". Thus, for "neighborhood A", the number of grids selected were:

$$\text{Number of grids selected in neighborhood (A)} = \frac{\text{Total number of grids in neighborhood A} \times N}{\text{Total number of grids of all the 10 neighborhoods}}$$

Where N is the sample size.

After all the calculations, 202 instead of 200 households were surveyed and their distribution is as shown in Figure 2.

Before the investigation, informed consent was verbally obtained before proceeding with each survey. The investigation was conducted in two phases and lasted four months (July-October 2014). This periods could be considered as a period of food short age, therefore, the consumption should be low.

Beef consumption

To collect data on beef consumption, the cooker or cooks were surveyed and observed in each household. They were sometimes assisted by other family members on some issues that eluded them. During this survey, three (3) pieces of beef selected

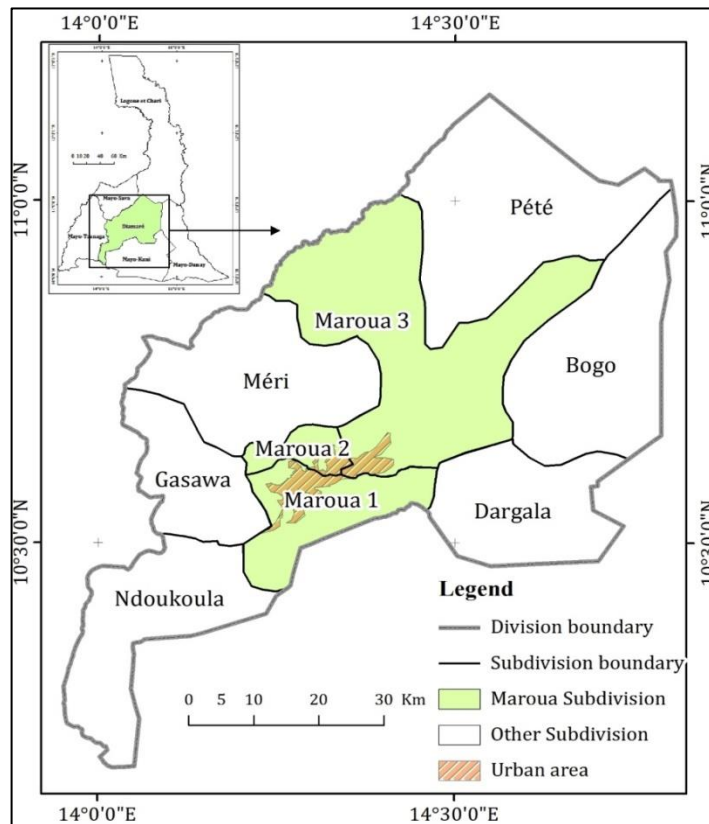


Figure 1. Study area in Diamaré (Far North Region of Cameroon).

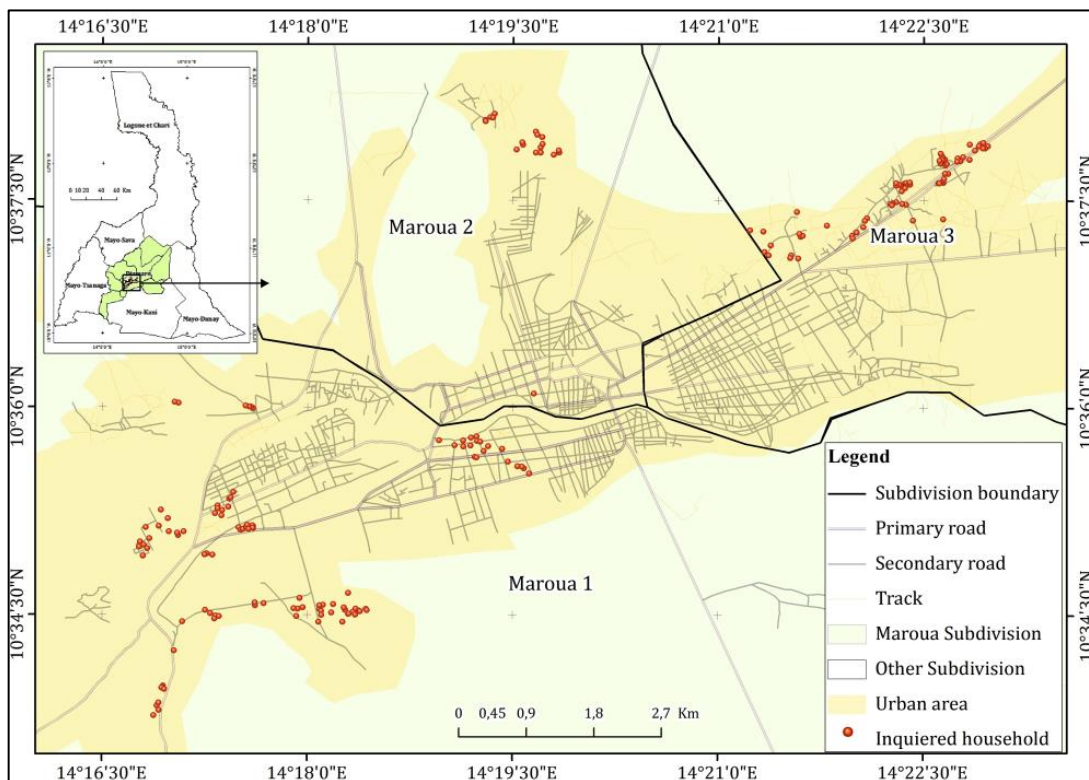


Figure 2. Distribution of households interviewed

randomly, as cut before cooking, were weighted by using a balance (ADAM®, CQT601, Max: 600 g × 0.1 g). The following formulae were used for calculation:

1. Average weight of a piece of beef in a household $M = (m_1 + m_2 + m_3)/3$;
2. Daily consumption per capita = $M \times N$;
3. Monthly consumption per capita = $M \times F$;
4. Annual consumption = monthly consumption $\times 12$

Where F: Frequency of consumption of beef per month in the household; m_1, m_2, m_3 : Weight of pieces 1, 2, 3 of beef sample; and N: number of pieces of beef consumed per day/person.

Consumer's knowledge on meat quality

To achieve the objective, open-ended questionnaires were administered in households in urban areas of Maroua. Thus, the values of variables such as religion and the monthly household income were attributed to those relating to the head of household. They were also asked questions on meat quality attributes.

Determination of the distribution of butchers' shops in Maroua

All the places where fresh beef are sold in Maroua were recorded with GPS.

Data analysis

Data from the field were entered directly on IBM® SPSS® (Statistical Package for Social Sciences) Statistics Ver. 20.0 (<http://www.ibm.com/support> software). This allowed the authors to calculate the descriptive statistics for the entire evaluated variables. Duncan's multiple comparison test performed with Statgraphics Ver. 5.0 (Windows, www.statgraphics.com) was used for the comparison of beef consumption taking into consideration different factors including age, religion, monthly income of the household and number of person in the household.

RESULTS

Characteristics of the interviewees and households

Table 1 shows the general characteristics of the representative sample interviewed. Most of them were more than 25 years old (68%), women (96%) and went to primary school (28%). In general, 55.2% of households were Christian and had an average of 7 peoples.

Frequency of meat consumption in Maroua

As shown in Table 2, in the great majority of households, meat (96%) and beef (98%) were consumed. In 72% of households, beef is mainly consumed. The mean frequency for the consumption of beef in the majority of households (39%) is 2 to 3 times per week.

Beef consumption

Beef consumption by subdivision

In general, it appears as shown in the Figures 3 and 4

that the daily and monthly consumption of beef per capita varied significantly with subdivision. Thus, it appears that this consumption was the same in Maroua I and III. On the contrary, the consumption of beef per person in Maroua II subdivision is significantly different ($p < 0.05$) from those of other.

Beef consumption by socioeconomic characteristics

In general, the average quantity of beef consumed per person is 133.25 ± 33.49 g per day and 1296.5 ± 239.41 g per month (Table 3). The daily consumption increased significantly with age ($p < 0.05$) but the monthly consumption for those who were less than 15 years (524.99 ± 119.80 g) is statistically lower than that of other age groups (16-45 and > 45 years).

Daily consumption of beef per person was statistically higher in households with a lower monthly income (157.21 ± 11.92 g) than the others (Table 3).

Perception on meat quality

For 57.92% households, meat quality is defined by its color. In 21.86% of the households meat quality refers to two factors (color and tenderness) while 1.64% of households refer to the presence or absence of stamping.

Distribution of the butcher shops in the research area

Figure 5 shows the repartition of the butcher shops in the city of Maroua. But this map does not take into consideration the beef hawkers because they are not stable.

DISCUSSION

It was found that, meat is consumed in 96% of households and 98% consume beef. This result is justified by the availability of meat in this part of Cameroon (MINEPIA, 2014). The fact that beef is consumed in the majority of households can be explained by the distribution of beef shop and or slaps. Besides, this area is the second cattle populated zone in the country (MINEPIA, 2003) and beef is not religious taboo. The beef consumption was highly by the majority of households as well as per capita, and sometimes even higher than the total amount of red meat (7.97 kg/capita/year) consumed in Cameroon (FAO, 2013). Similar results had been found in various countries in Africa (Gamba, 2005) and elsewhere (USA and Brazil) (Davis and Lin, 2005; Levy-Costa et al., 2005; USDA Economic Research Service, 2009). On the contrary, the observations of Krystallis and Arvanitoyannis (2006) and

Table 1. Socio-economic and demographic characteristics of the interviewees in the household.

Variables	Percentage (%)	Sample size (No. of household)
Age (years)⁺		202
< 10	0	
[11-15]	4.1	
[16-25]	26.9	
[26-45]	53.8	
>45	15.2	
Religion⁺⁺		201
Christian	55.2	
Muslim	43.8	
Animist	1.0	
Marital status		200
Single	12.0	
Married	81.0	
Divorcee	1.5	
Widowed	5.5	
Educational level		200
No formal education	32.0	
Koranic	10.5	
Primary	28.0	
Secondary	24.5	
University	5.0	
Family income		158
< \$30	15.2	
[\$30-\$120]	44.3	
> \$120	40.5	
Average number of people in the house	6.37	202

(⁺): age of the principal interviewee; (⁺⁺): religion of the head of the household; Sample correspond to the number of household and each of them has an average of 7 persons.

France (2013) have respectively shown that in Greece, between 1997 and 2002 and in France in 2011, pork was the most consumed meat. This disparity would be justified by the importance that each country gives to each animal species production. This situation could be explain as already emphasized in the FAO report in 2011 that "more meat is consumed where it is produced" (FAO, 2011). According to Dettmann and Dimitri (2010) and Van Loo et al. (2010), the socio-economic, demographic and cultural characteristics were strongly influenced by the food preferences of consumers.

In majority of the households of Maroua, beef is consumed 2-3 times a week. A similar result was obtained by Jeremiah et al. (1993) in Canada. This frequency is nevertheless higher than that in Navarra in Spain (once a week) (Barrena and Sanchez, 2009). Yet it is low when

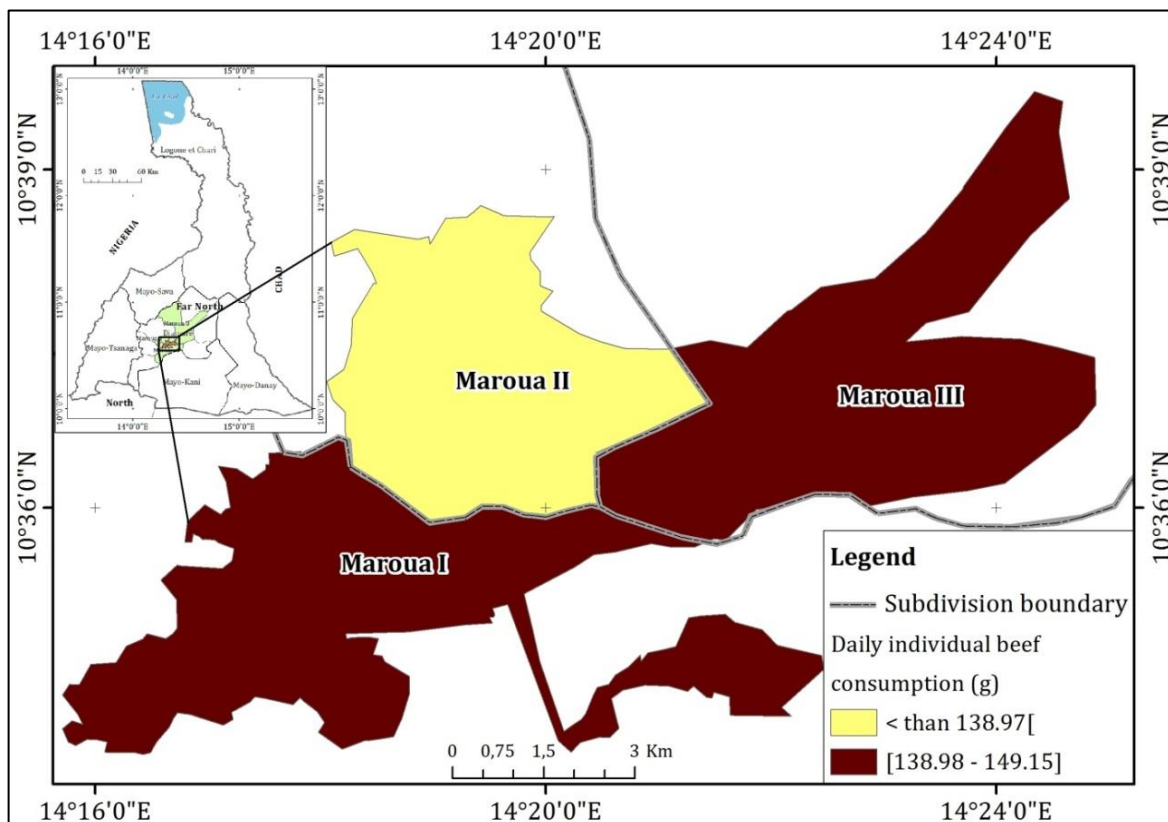
compared to that in Campinas in Brazil (four times a week) (Da Fonseca and Salay, 2008). This differences could be explained firstly in eating habits, demographic structure and socio-economic and environmental factors that characterize each of the cities and countries and secondly in the methodological choices made by the authors in their respective studies.

The daily consumption of beef per capita in Maroua II is significantly lower than those of Maroua I and III. This trend was reversed when considering the monthly per capita consumption. This decrease of the consumption rate could be explained by the occurrence of the majority of butchers' shop localized in Maroua II (Figure 5), which would raise the frequency of purchase of the meat and by extension, their monthly consumption as well as the increment of monthly income of the population of Maroua

Table 2. Some variables of meat consumption.

Variable	Percentage (%)	Sample size (No. of households)
Eat meat**	95.50	202
Meat more eaten**		199
Beef	72.36	
Sheep	5.02	
Goat	20.60	
Chicken	1.01	
Pork	1.01	
Eat beef**	97.90	193
Frequency of beef consumption*		196
Every day	10.7	
Twice or three times a week	38.8	
Once a week	12.8	
Twice or three times a month	10.7	
Once a month	4.1	
Rarely	22.4	
Do not know	0.5	

* $P < 0.05$, ** $P < 0.01$; Sample correspond to household and each of them has an average of 7 persons.

**Figure 3.** Daily consumption of beef (g) per person.

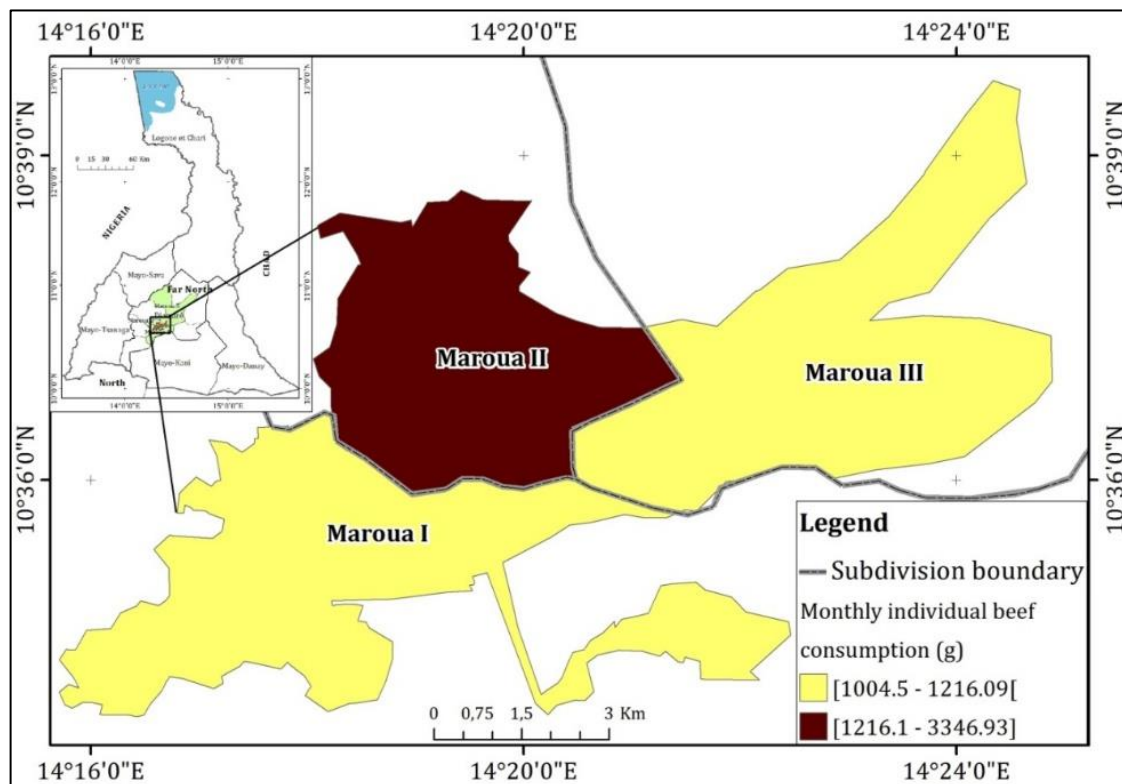


Figure 4. Monthly consumption of beef (g) per person.

Table 3. Quantity of beef consumed per person in Maroua.

Variable	Per day (g)	Per month (g)
Quantity of beef consumed per person	133.25 ± 33.49	1296.50 ± 239.41
Age		
0-15	92.78 ± 6.22 ^c	524.99 ± 119.80 ^b
16-45	151.84 ± 15.63 ^b	1151.10 ± 86.83 ^a
> 45	179.22 ± 40.93 ^a	1332.63 ± 329.72 ^a
Household monthly income+		
Low	157.21 ± 11.92 ^a	1306.65 ± 129.48 ^a
Average	129.77 ± 19.50 ^b	1477.16 ± 380.86 ^a
High	130.0 ± 12.17 ^b	1429.70 ± 152.05 ^a
Religion		
Christian	135.39 ± 10.09 ^a	1861.00 ± 731.62 ^a
Muslim	136.66 ± 15.24 ^a	857.87 ± 32.10 ^b
Number of person in the household		
<5	94.08 ± 17.76 ^a	684.13 ± 155.40 ^a
5≤n<10	94.78 ± 8.08 ^a	579.42 ± 152.49 ^a
≥10	79.96 ± 44.50 ^a	569.00 ± 265.56 ^a

(+) Correspond to the monthly income of the head of the household; Low, less than \$30; Average, \$30-\$120; High, more than \$120. The values represent the average consumption of beef in g. For the same variable, values with different letters of the alphabet in the same column are significantly different ($P < 0.05$).

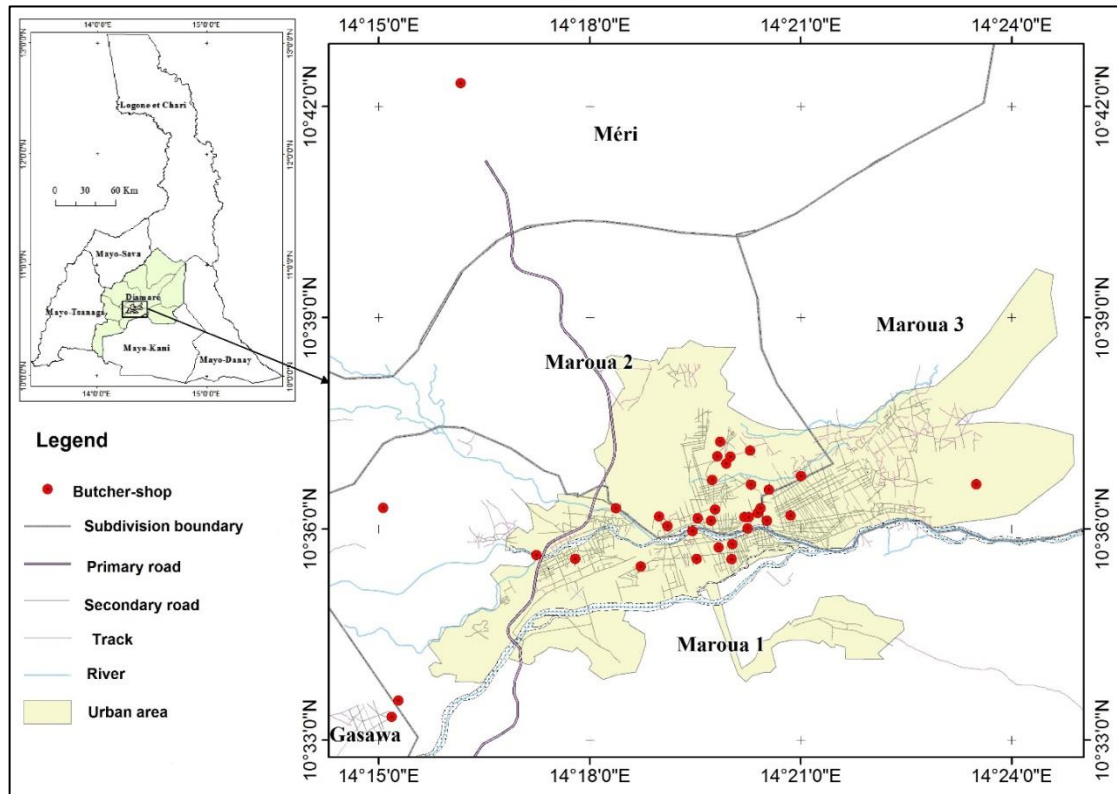


Figure 5. Distribution of butcher shops in Maroua.

II. Indeed, Maroua II is the most urbanized area of this city and it is well known that this factor also influences the meat consumption (Davis and Lin, 2005; Yen et al., 2008). This differential spatial distribution of the annual per capita consumption of beef has also been observed in the US (Davis and Lin, 2005). A person in this study area consumed 133.25 ± 33.49 g of beef per day and 1296.5 ± 239.41 g per month. This consumption is almost three times higher than what is currently observed in Cameroon in general (5.3 kg) (FAO, 2013). Similarly, it is greater than the individual consumption of beef in Africa (6.4 kg) and in sub-Saharan Africa (3.1 kg) in 2015 (FAOSTAT, 2014a; OCDE, 2016). This difference may be due to the fact that Maroua is the capital city of the region and has the second highest cattle population in Cameroon (MINEPIA, 2014). Beef is sold everywhere in Maroua, also explaining this result. Indeed according to Mensah et al. (2012), difficult access to food could influence its consumption by the population.

It is also clear from this study that the daily consumption of beef per capita increased significantly with the age of the person. This result is contrary to that of Yen et al. (2008) in US. This contrast can be as a result of the structural composition of the households where the preference for a food varies also with age (Barrios and Costell, 1996; Lazaridis, 2003).

The daily per capita consumption of beef is statistically

higher in households with lower monthly income as compared to those of middle and higher income households. This result corroborates the findings of Davis and Lin (2005). Indeed, since 2012, Maroua had the highest rise of the consumption in Cameroon (NSI, 2010).

Daily consumption of beef per person was similar whatever the religion. This is justified by the fact that beef is not the subject of any religious taboo. However, the fact that the monthly consumption of beef per capita is less for the Christians would probably be the consequence of having more alternatives to meat consumption (MINEPIA/AMO, 2009) which is not the case for Muslims (Sack, 2001). This adds to the results of several studies (Pettinger et al., 2004; Bonne et al., 2007) which have shown the influence of religion on the feeding behavior of populations.

For majority of the households in this study area, the color (lightness) is the first criterion for defining meat quality while 21.86% of the household attributes it to the color-tenderness. This result is also consistent with that obtained in Europe where according to consumers, color is one of the most important parameters defining the quality of fresh meat (Glitsch, 2000). Indeed, this population is based only on the sensory quality, which represents only a quarter of the criteria to be taken into account (Clinquart et al., 2000; Cartier and Moëvi, 2007). According to Cartier and Moëvi (2007) and Coibion

(2008), the quality of the food groups includes the organoleptic or sensory quality, nutritional or dietary quality, technological quality and hygienic or safety quality. This observation already underlines health risks that could run the population of the town of Maroua following the consumption of beef since the guarantee of its safety is generally dependent on the quality of information that the public receives and how it interprets and their perception of quality (Grunert, 2005; Mazzocchi et al., 2008; Barrera and Sanchez, 2010).

Conclusion

Beef is the meat mostly consumed in Maroua city. The daily and monthly consumption of beef per person in this city is very high. Beef consumption is influenced by the age, monthly income and the district position. The problem of low rate of consumption of meat in Cameroon could only be found in the areas where the potential of livestock production is low. Thus, the government should focus on those zones to improve meat consumption.

Conflict of interest

The authors have no financial or personal conflicts of interest to declare.

ACKNOWLEDGEMENTS

This research was supported by the National Science Foundation (DEB-1015908) via a fellowship from the Disease Ecology and Computer Modeling Laboratory of the Ohio State University (OSU). The authors thank the Regional Delegation of the Ministry of Livestock, Fisheries and Animal Industries and all the sub division officers of Maroua for granting research permission and research affiliation. Thanks to Veronique Houli for the help she provided during the survey and Mark Moritz and Jessica Profitos (OSU) for their contribution during the sampling strategy design.

REFERENCES

- Barrera R, Sanchez M (2009). Consumption frequency and degree of abstraction: A study using the laddering technique on beef consumers. *Food Qual. Prefer.* 20:144-155.
- Barrera R, Sanchez M (2010). Differences in consumer abstraction levels as a function of risk perception. *J. Agric. Econ.* 61(1):34-59.
- Barrios EX, Costell E (1996). Review: Use of methods of research into consumers' opinions and attitudes in food research. *Food Sci. Technol. Int.* 10(6):359-371.
- Bonne K, Vermeir I, Bergeaud-Blackler F, Verbeke W (2007). Determinants of halal meat consumption in France. *Br. Food J.* 109(5):367-386.
- Cartier P, Moëvi I (2007). Le point sur la qualité des carcasses et des viandes de gros bovins. Institut de l'Élevage. Compte rendu final 17:72.
- Clinquart A, Leroy B, Dottreppe O, Hornick JL, Dufrasne IL, Istasse L (2000). Les facteurs de production qui influencent la qualité de la viande des bovins Blanc Bleu belge. 19 p.
- Coibion L (2008). Acquisition of the organoleptic qualities of beef: adaptation to Consumer demand. DVM Thesis, National Veterinary School of Toulouse, France.
- Da Fonseca MCP, Salay E (2008). Beef, chicken and pork consumption and consumer safety and nutritional concerns in the City of Campinas, Brazil. *Food Control* 19(11):1051-1058.
- Davis CG, Lin B (2005). Factors affecting U.S. beef consumption. Electronic outlook report from the economic research service. US Department of Agriculture, Economic Research Service, Washington, DC, LDP-M-135-02. Available at: http://www.ers.usda.gov/media/864436/ldpm13502_002.pdf.
- Dettmann RL, Dimitri C (2010). Who's buying organic vegetables? Demographic characteristics of US consumers. *J. Food. Prod. Mark.* 16(1):79-91.
- Devaux N, Fotsing JM, Chéry JP (2007). Extraction automatique d'habitations en milieu rural de PED à partir de données THRS. *Cybergeo: Euro. J. Geogr.* Available at: <http://cybergeo.revues.org/12581>.
- FAO (2011). Food and Agriculture Organization of the United Nations. Food outlook: global market analysis. Available at: <http://www.fao.org/docrep/014/al978e/al978e00.pdf>
- FAO (2013). Food and Agriculture Organization of the United Nations. Study of slaughterhouse in Central Africa (Cameroon-Congo- Gabon-Chad). Summary. 70p. Available at: <http://faostat.fao.org/site/610/DesktopDefault.aspx?PageID=610#ancor>.
- FAO/STAT (2014a). Food and Agriculture Organization of the United Nations. Available at: <http://faostat.fao.org/site/610/default.aspx#ancor>.
- FAO/STAT (2014b). Food and Agriculture Organization of the United Nations. Available at: <http://faostat3.fao.org/>.
- Font-i-Furnols M, Guerrero L (2014) Consumer preference, behavior and perception about meat and meat products: An overview. *Meat Sci.* 98:361-371.
- France Agri Mer (2013). The spinnerets of French breeding. Pp.1-87.
- Gamba P (2005). Urban Domestic Consumption Patterns for Meat: Trends and Policy Implications. Tegemeo Institute of Agricultural Policy and Development, Egerton University. Working Paper 17. pp. 1-24.
- GESEP (Gestion Sécurisée des Espaces Pastoraux) (2002). Study on meat consumption in Garoua. Garoua, Cameroon, Project Secure management of pastoral areas, MINEPIA/FSD.
- Glitsch K (2000). Consumer requirements for fresh meat: Results of the survey. In: Quality policy and consumer behavior in the European Union. (ed.), [Becker, T.]. Kiel: Wissenschaftsverlag Vauk. pp. 113-156.
- Grunert KG (2005). Food quality and safety: Consumer perception and demand. *Eur. Rev. Agric. Econ.* 32:369-391.
- Jeremiah LE, Tong AKW, Jones SDM, Mcdonnell C (1993). A survey of Canadian consumer perceptions of beef in relation to general perceptions regarding foods. *J. Consum. Stud. Home Econ.* 17(1):13-37.
- Labonne M, Magrion P, Oustalet Y (2003). The livestock sector in Cameroon and in the Northern provinces: current situation, constraints, issues and challenges. In: African grasslands: the changing spaces, actors face to new challenges, Conference Proceedings, 27-31 May 2002, Garoua, Cameroon, Montpellier, France, CIRAD-Prasac. pp. 1-12.
- Lazaridis P (2003). Household Meat Demand in Greece: A demand systems approach using microdata. *Agribusiness* 19(1):43-59.
- Levy-Costa RB, Sichert R, Pontes NS, Monteiro CA (2005). Disponibilidade domiciliar de alimentos no Brasil: distribuição e evolução (1974-2003). *Rev. Saude Publica* 39:530-540.
- Mayer H (1999). Automatic object extraction from aerial imagery-a survey focusing on buildings. *Comp. Vis. Image Und.* 74(2):138-149.
- Mazzocchi M, Lobb A, Bruce Traill W, Cavicchi A (2008). Food scares and trust: a European study. *J. Agric. Econ.* 59(1):2-24.
- Mensah P, Mwamakamba L, Mohamed C, Nsue-Milang D (2012). Public health and food safety in the African region. *Scholarly, Peer*

- Reviewed. *Afr. J. Food Agric. Nutr. Dev.* 12(4):6317-6335.
- MINEPIA (2003). Ministère de l'Elevage, des Pêches et des Industries Animales. Livestock production in Cameroon. <http://www.minepia.gov.cm> (accessed March, 2013).
- MINEPIA (2013). Ministère de l'Elevage, des Pêches et des Industries Animales. MINEPIA Policy Document. 29p.
- MINEPIA (2014). Ministère de l'Elevage, des Pêches et des Industries Animales. Annuaire des statistiques du sous-secteur Elevage, Pêche et Industrie Animales 2013.
- MINEPIA/AMO (2009). Ministère de l'Elevage, des Pêches et des Industries Animales/Programme d'Appui à la Maîtrise d'Ouvrage des Administrations du Secteur Rural. Study of livestock marketing system in Cameroon. Final Report. 97p.
- NSI (National Statistics Institute) (2010). Population and social affairs. Cameroon Statistical Yearbook: Part 2, 39-62. Available at: <http://www.statistics-cameroon.org/downloads/annuaire2010/chap4.pdf>.
- OCDE (2016). Organisation de Coopération et de Développement Economiques. Consommation de viande (indicateur). Available at: http://www.oecd-ilibrary.org/agriculture-and-food/meat-consumption/indicator/french_edbce270-fr
- Pettinger C, Holdsworth M, Gerber M (2004). Psycho-social influences on food choice in Southern France and Central England. *Appetite* 42(3):307-316.
- PNSA/WFP (2015). Programme Nationale de Sécurité alimentaire/Word Food Program. Evaluation de la sécurité alimentaire dans les régions de l'Est, Adamaoua, Nord et Extrême-Nord du Cameroun. Rapport 17p.
- Profitós JMH, Mouhaman A, Lee S, Garabed R, Moritz M, Piperata B, Tien J, Bisesi M, Lee J (2014). Muddying the Waters: A New Area of Concern for Drinking Water Contamination in Cameroon. *Int. J. Environ. Res. Public Health* 11(12):2454-12472.
- Van Loo E, Vincenzina C, Nayga RM (2010). Effect of organic poultry purchase frequency on consumer attitudes toward organic poultry meat. *J. Food Sci.* 75(7):S384-S397.
- Yen ST, Biing-Hwan L, Davis CG (2008). Consumer knowledge and meat consumption at home and away from home. *Food Policy* 33(6):631-639.
- Ziebe R, Thys E, De Deken R (2005). Analysis of livestock production systems on the scale of a canton: The case of Boboyo in the Far north Cameroon. *Rev. Elev. Méd. Vét. Pays Trop.* 58:159-65.

Full Length Research Paper

Crop ash filtrate influence on cooking time and sensory preferences for dried black beans (*Phaseolus vulgaris* L.)

Tara L. Bergeson¹, Christopher Opio^{2*} and Peter D. MacMillan³¹University of Northern British Columbia, Canada.²Faculty of Natural Resources and Environmental Studies, University of Northern British Columbia, Canada.³School of Education, University of Northern British Columbia, Canada.

Received 20 April, 2016; Accepted 21 June, 2016

Filtrate made from the burnt ash of crop plant residue is used in cooking in Northern Uganda. This practice is believed to decrease the cooking time of hard-to-cook legumes and provide a culturally preferred taste. The objectives of this study were to: (1) compare cooking times and sensory preferences for dried black beans (*Phaseolus vulgaris* L.) among four treatments: plain water (control), table salt, crude ground salt, and ash filtrate; and (2) determine demographic factors (gender, age, and education) that may also influence preferences. Sensory preferences for beans cooked across the treatments were evaluated through blind taste tests. Analysis of variance (ANOVA) with post-hoc Bonferroni multiple comparisons showed a statistically significant ($p < 0.01$) 27% reduction in cooking time with the addition of ground salt and 18% shorter cook time with ash filtrate. Contrary to anecdotal belief, participants showed an overall preference for black beans cooked with ground salt and table salt over plain beans or those cooked with ash filtrate. The type of treatment and study site significantly ($p < 0.05$) impacted sensory scores. Demographic factors did not influence sensory preferences within or between communities, suggesting that cultural preference for the use of ash filtrate is being influenced by more than actual taste. The reduction in cooking time has important implications for fuel wood requirements as the majority of households rely on fires for cooking.

Key words: *Phaseolus vulgaris*, crop ash filtrate, cooking time, sensory characteristics, Northern Uganda.

INTRODUCTION

Legumes are one of the best sources of vegetable protein available in developing countries (Siegel and Fawcett, 1976) and are a staple food in Uganda (Mamiro et al., 2011). Black beans (*Phaseolus vulgaris*) are particularly common in Northern Uganda, as both a

domestic crop and commercial product in markets. The typical climate of Uganda, humid and moderately hot (20-30°C), creates poor storage conditions for legumes (Reyes-Moreno and Paredes-Lopez, 1993). Drying and storage in these conditions result in beans becoming

*Corresponding author. E-mail: chris.opio@unbc.ca. Tel: (250) 960-5868.

hard-to-cook; a property which requires extensive cooking time to make them palatable, eliminate toxic components, and allow for the protein to become nutritionally available (Varriano-Marston and de Omana, 1979; de León et al., 1992). Salt is regularly used to decrease the cooking time of dried, hard-to-cook legumes (Uzogara et al., 1990; Onwuka and Okala, 2003; Mamiro et al., 2011). Depending on availability, people of different regions use several different types of salt or salt-like additives for cooking. These may include refined commercial (table) salt (NaCl), a crude indigenous (ground) salt precipitated from saline lakes, and/or the ash of plant parts.

The cooking of legumes involves several processes to render them palatable, digestible, and accessible to nutrient availability. A main component of plant cell wall structure includes pectic substances, which need to be degraded in order for internal cell tissue, and therefore the bean, to soften (Uzogara et al., 1990). Commercial (table) salt decreases cooking time for legumes by accelerating the degradation of this pectin (Van Buren, 1986), through ion exchange and chelation where ions of the 'intercellular cement' are either replaced by sodium ions or leached out (Varriano-Marston and Omana, 1979). In some parts of the world, an indigenous ground salt is also used to speed up cooking time of legumes. Ground salt is composed mainly of trona, a hydrated sesquicarbonate of sodium, which makes it highly alkaline (Makanjuola and Beetlestone, 1975). Alkalinity has been shown to have great influence on the softening of legumes, probably due to an effect on the starch gelatinization process (Wanjekeche et al., 2003) and in turn, decreases the necessary cooking time (Ankrah and Dovlo, 1978; Uzogara et al., 1990; Onwuka and Okala, 2003). As an alternative to ground salt, plant ash and/or plant ash filtrate is used as a traditional cooking additive in some areas of the world, including rural Africa (Kaputo, 1996; Wanjekeche et al., 2003; Mamiro et al., 2011). Plant ash and ground salt are both highly alkaline, and have been shown to have elevated mineral content; both factors which probably contribute to the observed reduced cooking time. Previous research has found no significant difference in the cooking time of beans when either plant ash or ground salt have been added (Mamiro et al., 2011).

In rural Northern Uganda, there is anecdotal information that a filtrate made from residual crop ash also considerably reduces the length of time required to cook dried legumes. The plants most often burnt for ash are crop residues of legumes, and sesame (*Sesamum indicum*). While there is ample information on the use of sodium salts to hasten the cooking of legumes, research on the use of crop ash and filtrate as an additive is limited. Further, there have been no simultaneous direct comparisons of the effect of all three types of salt additives on the cooking time of legumes.

Table salt (NaCl) is also frequently added to a variety of

foods to enhance taste and sensory preference, and to speed cooking. During cooking in Northern Uganda, people may add to their food a combination of commercial table salt and ground salt (precipitate from saline lakes) or plant ash filtrate to infuse a distinct culturally-preferred flavour. In particular, these cooking additives are used with hard-to-cook legumes, which benefit from both time saving and improved taste. While subjective and possibly culturally/geographically dependent, sensory acceptability is key to understanding important reasons for either the use or disuse of specific additives in cooking legumes.

Sensory evaluation for cooked legumes has previously included colour, taste, texture, and overall acceptability (Silva et al., 1981; Onayemi et al., 1986; Onwuka and Okala, 2003). However, relatively few studies have focused on the use of traditional salts in cooking legumes, and even fewer have included sensory evaluation as a component of the study. Comparison of fresh mucuna beans (*Mucuna pruriens*) cooked with ground salt, citric acid, and plant (maize cob) ash showed preference for the texture of beans cooked with ash and the taste of beans cooked with the ground salt (Wanjekeche et al., 2003). Interestingly, taste scores were significantly higher for beans cooked with ground salt (Wanjekeche et al., 2003), despite the fact that these two additives share many common properties (Mamiro et al., 2011). The colour of both treatments was unacceptable to panelists; a result commonly found with alkaline treatments. Onwuka and Okala (2003) looked at four parameters of palatability for different cooking treatments, including plain water, ground salt (*akanwa*), table salt, and two mixed salts (NaHCO₃ and CaCl₂). With respect to the first three treatments, respondents rated the legumes cooked with table salt as the most desirable across all parameters, while the legumes cooked with *akanwa* were deemed least acceptable. The colour of beans cooked with *akanwa* was too dark and the flavour less palatable than either the control or beans cooked with table salt and only the texture of the *akanwa* beans was comparable to the other samples. Onayemi et al. (1986) also found poor acceptability for cowpeas cooked in either local rock salt (ground salt) or alkali potash (sodium carbonate; functionally similar to plant ash). Prior research using sensory evaluation tests have shown that traditional salts are not preferred, despite a strong cultural presence and continued use. Further, over addition of these salts contributes to a sharp, unpleasant taste (Onayemi et al., 1986), possibly due to the high alkalinity. For this reason, bitterness was added as a parameter in this study.

Within these few studies, analysis of sensory preference for common black beans (a staple legume in Uganda) cooked with ash filtrate or ground salt has not been conducted. Also undocumented is the assessment of whether demographic factors (gender, age, and education) may influence preferences.

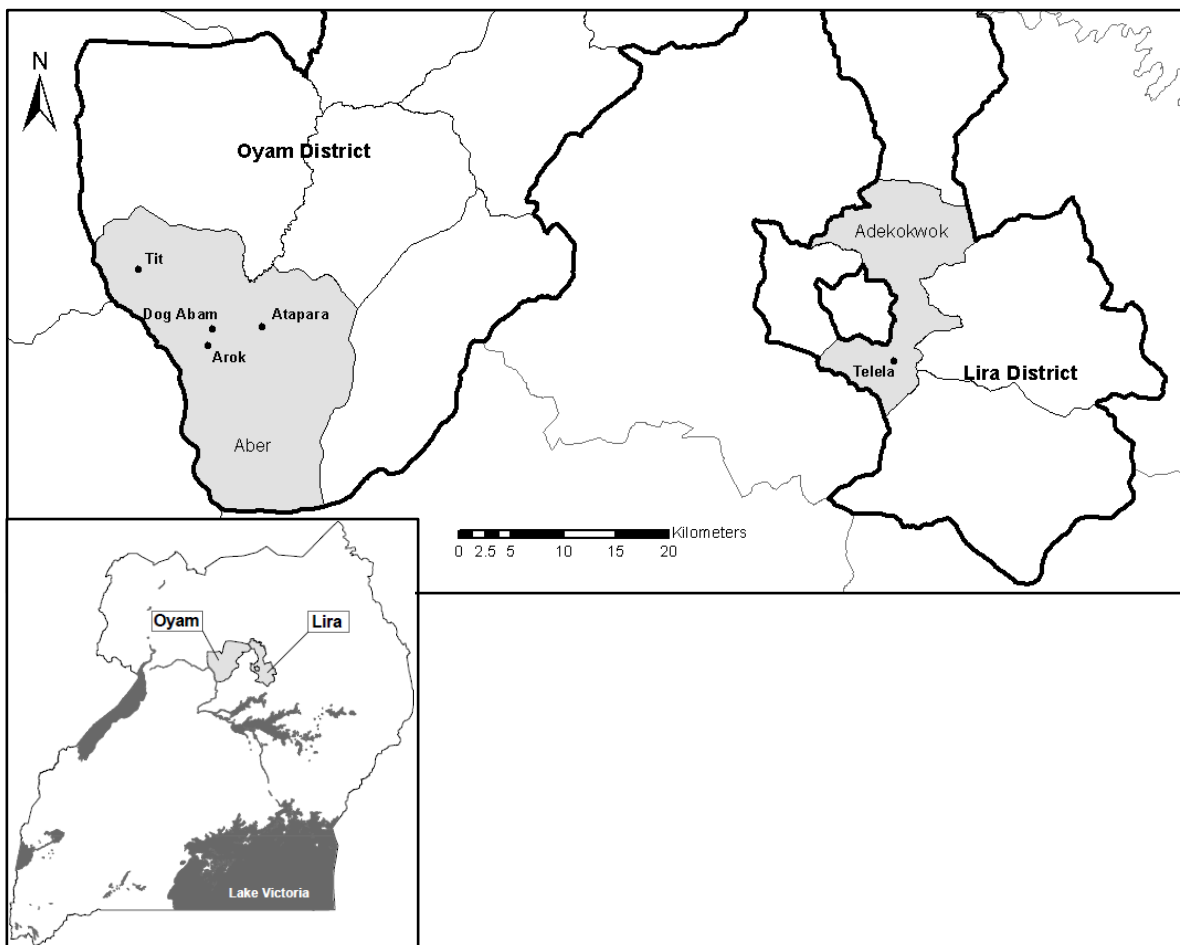


Figure 1. Map of study sites (Dog Abam, Arok, Tit and Telela villages). The primary researcher (first author) was based at Atapara Village.

The objectives of this study were to: (1) compare the time required to cook dried black beans in four treatments: Type 1 water (control) (Ultrapure water filtered with a Millipore® system meeting ASTM® standards for Type 1 water), ground salt, table salt and ash filtrate; (2) determine if beans cooked with ash filtrate are preferred over those cooked in plain water, commercial salt or ground salt; and (3) examine whether demographic factors such as gender, age, or education level influence taste preferences. It was hypothesized that all treatments would decrease cooking time, when compared to the control. It was also hypothesized that beans cooked with the ash filtrate would be the most preferred treatment, and that the demographic factors would influence overall sensory preferences.

Description of the study sites

The field-based part of this study took place in Northern Uganda. The study involved three villages (Dog Abam,

Tit, and Arok) in Oyam District, and Telela Village in Lira District (Figure 1). The choice of study sites was based on previous interaction between a non-governmental organization, the Northern Uganda Development Foundation (NUDF), and local community members. NUDF is a Canadian-based organization with field operations in Northern Uganda. Given the cultural and linguistic challenges, utilizing study sites with established relations to NUDF provided a base from which to begin to ensure a timely method of study. The study sites are characterized by poverty, poor infrastructure, traditions and rituals. The laboratory-based (controlled cooking trials) part of the study took place at the University of Northern British Columbia (UNBC) in Prince George, British Columbia, Canada.

MATERIALS AND METHODS

Observation period

A total of two months, from June to August 2012 were spent in the

villages chosen for the study. The first month (the orientation period) was spent on observing local culture and customs. An effort was made to become familiar with the local staff of NUDF and members of the village communities. Developing relationships with individuals and establishing trust among the villagers was considered an important function of the observation (Pratt and Loizos, 1992). Prior to data collection, a meeting was held with the local research assistant/translator to explain the process and goals of this study, answer any questions, and ensure privacy for all participants through a signed confidentiality agreement. All research methods, including UNBC's Research Ethics Board approval for the study, were discussed with the staff of NUDF and the villagers before implementation.

Qualitative data collection

Many people in the villages in the study area are illiterate and therefore oral research methods (Le Roux, 1998) were used to gain a comprehensive understanding of cooking food using ash filtrate in the region. Video and photo documentation of ash and ash filtrate procurement procedures (from crop harvest through use in cooking) were also used in the study.

Informal semi-structured interviews

Informal semi-structured interviews (Sammy and Opio, 2005) were used in this study to obtain the opinions of the people in the study area about the use of ash filtrate for cooking food in the region. These methods were chosen because of their flexibility in design and implementation (Mikkelsen, 1995). Individual and group interviews were conducted spontaneously whenever an opportunity arose. Informal conversations were also conducted (Pratt and Loizos, 1992; Devereux and Hoddinott, 1993; Stake, 1995; Chambers, 1997). Most village interviews, even if initially conducted with individuals, developed into group interviews. These proved to be more socially acceptable, stimulated greater discussion and generated more information about the use of ash filtrate in the region (Sammy and Opio, 2005).

Preparation of samples for sensory evaluation

The study consisted of four cooking treatments for black beans (*P. vulgaris* L.). Four 240 g samples of dried black beans were sorted by hand and shriveled beans and other detritus were removed. Large aluminum pots were thoroughly washed three times prior to use and rinsed with distilled water. Pots were then prepared with the beans, 2.0 L of distilled water and one of four treatments; plain distilled water – 'control'; water with 5 g of commercial iodized salt – 'table salt', water with 5 g of ground salt – 'ground salt', and water with 45 ml (3 tablespoons) of plant ash filtrate – 'ash filtrate'. The ash filtrate used for this portion of the study was prepared at the Dog Abam site by a local woman and was documented by photo and video. The steps involved in creating ash filtrate included: (1) harvesting leguminous plants and allowing them to dry under the direct heat from the sun; (2) thrashing the plants to release seeds from pods; (3) burning piles of spent plant remains, including leaves and roots; (4) collecting the ash; (5) ripping spear grass (*Pennisetum purpureum*) into soluble length to cover the bottom of a cup with 0.5 cm holes at the bottom; (6) placing 250 g of the ash onto the spear grass filter bed; (7) wetting the loose ash with a small amount of water and pressing into a filter bed; and (8) allowing approximately 200 ml of water to percolate through the ash and collecting it into another cup as filtrate.

The amount of water required for cooking and the treatment concentration was determined by consulting with several women in

the region. Women are responsible for all cooking related activities for the household including collection of firewood and water. These concentrations of table salt (0.25% w/v), ground salt (0.25% w/v), and ash filtrate (2.25% v/v) were also comparable with similar studies (Onayemi et al., 1986; Wanjekeche et al., 2003).

Local charcoal stoves were used due to lack of electricity in the region, as well as to replicate typical cooking conditions. Following the traditional cooking methods and learning how to use local equipment, provided an understanding of the time and energy required for the food preparation done daily by local women. Additional distilled water was added as necessary throughout cooking as follows: plain (control) 1.5 L, table salt 1.5 L, ground salt 1 L, and ash filtrate 1 L. Beans were tested for completion of cooking by hand and mouth feel by the first author and a local woman employed at Pope Paul Hospital, Atapara (Figure 1) who regularly cooks black beans. This method has been previously used for similar tests (Ankrah and Dovlo, 1978; Onwuka and Okala, 2003; Wanjekeche et al., 2003). Once drained and cooled, each pot of beans was divided into four separate airtight plastic containers for individual use at each site. Each lid was labeled with a code letter and number describing treatment sample and intended site. Samples were refrigerated immediately at Atapara Hospital storage refrigerator and all sensory evaluations took place within 36 h.

Sensory evaluation

The sensory rating form, which had been developed prior to conducting the field study, was pre-tested to clarify and assess appropriateness of the form, determine the length of interviews and gain familiarity in working with the research assistant.

The form was completed by 12 people at each of 4 study sites for a total of 48 participants. Participants were chosen by availability and willingness. Random selection of participants was not an option, given logistical and time constraints and lack of sampling frame. There were an equal number of men and women at each site, ranging in age from 18 to 79 years old. Each participant regularly consumed beans prepared with filtrate and so was familiar with the practice of using filtrate for cooking. Signed consent forms were obtained from each person, with an explanation of activities described to them by the research assistant/translator.

Each participant answered questions regarding their demographic status, including age, gender, and education level. At each site, a random number draw dictated the order of placement for samples to minimize potential order bias and lids were placed underneath the sample containers to hide the descriptive code from both the participant and research assistant. Evaluations were conducted in private via translation. Samples were provided to each participant, in each village studied, by disposable spoon, at ambient temperature. Each treatment was tested using a 5-point Likert type scale for sensory properties of smell, colour, flavour, texture, bitterness (chalkiness), and overall acceptability of beans. Texture was measured on two accounts; both for hardness, from too hard (1) to good (5) and for softness, from too soft (1) to good (5), in order to identify beans which were both deemed to be either under or over-cooked. The scale and categories were adapted from previous successful methodologies (Silva et al., 1981; Onayemi et al., 1986; Onwuka and Okala, 2003).

Quantitative data collection on cooking time

This part of the study took place at UNBC, from September to October 2012. The study consisted of four cooking treatments for black beans (*Phaseolus vulgaris* L.) (Type 1 water – 'control', water containing commercial salt – 'table salt', water containing local ground salt – 'ground salt', and water containing plant ash filtrate – 'filtrate'). Dried black beans were sorted by hand, and shriveled

beans and other detritus were removed. Four 2.3 L Starfrut Starbasix® saucepans were thoroughly washed three times prior to use, rinsed with Type 1 water, and dried. They were then prepared with 80 g of dried beans, 1.0 L of Type 1 water, and one of the four treatments. For 80 g of dried beans, the following amounts were used: 2 g of commercial salt, 2 g of ground salt, and 15 ml of ash filtrate. These concentrations of table salt (0.2% w/v), ground salt (0.2% w/v), and ash filtrate (1.5% v/v) are comparable with similar studies (Onayemi et al., 1986; Wanjekeche et al., 2003). Approximately 250 g of loose, dry ash was placed into an unbleached coffee filter. The filter with ash was placed into a perforated (0.5 cm holes at the bottom) plastic cup. A small portion of 200 ml of Type 1 water was added to the ash which was slightly tamped down to form a filter bed. The remainder of the water was slowly added and percolated through, collecting in another plastic cup for use. The Dog Abam ash sample was used for preparing filtrate for the study.

The beans were cooked individually on four separate Toastess® cooking ranges (THP432). Each cooking range was preheated to maximum temperature (550°C), as indicated by the automatic shut off switch, and covered pots were placed simultaneously at the maximum temperature. The pH of cooking water of each treatment was taken using a Bluelab® pH pen immediately after mixing in the respective additive to the cooking water; just prior to placing pots on burners. Values of pH were recorded for each treatment once the reading held steady for 10 seconds, and the pH pen was rinsed in Type 1 water prior to subsequent test. Temperatures of prepared pots were identical at the time of placement, and were recorded at time of boiling and time of completion using individual UEi™ DT15A Digital Thermometers. Beans were considered cooked and the time recorded when puncture force registered as 150 g (Silva et al., 1981), as measured with a Mecmesin gram gauge DGD-6. Beans continued cooking until considered soft by hand and mouth feel (Ankrah and Dovlo, 1978; Onwuka and Okala, 2003; Wanjekeche et al., 2003); and where beans easily ruptured between fingers and had attained a consistent softness, and time was recorded again. This was done for comparative purposes, as the consistency of beans considered cooked at 150 g of puncture force was still chalky, and not palatable according to preference standards observed in Uganda. This cooking time trial procedure was repeated three times for replication purposes.

Data analysis

Cooking time data were tested for normality using the skewness and kurtosis test, and all variables met the assumptions of normality. Homogeneity of variance was confirmed by Levene's statistic. Post-hoc Bonferroni multiple comparison tests were used to determine significant differences among treatment means (Gotelli and Ellison, 2004). The conservative nature of using a Bonferroni test ensured significantly different cooking times as applicable to actual situations where at least a moderate time difference would be required to have noticeable implications for cooking time. Statistical significance was determined with $\alpha = 0.05$ and the null hypothesis was that no difference existed among means between control and treatments.

Analysis of variance (ANOVA) tests were used to assess significant differences among means of response variables associated with cooking treatment. The mathematical model used was:

$$Y_i = \mu + treatment_i + \epsilon_i \quad 1$$

where Y_i = response variable mean (pH, temperature of cooking water treatment at boiling, temperature of cooking water treatment at 15 minutes, cooking time to 150 g puncture force test, or cooking time to palatable); μ = grand mean response variable; $treatment_i$ =

cooking water treatment (Type 1 water [control], commercial salt, ground salt, ash filtrate); and ϵ_i = experimental error.

Statistical analysis was done using Stata® (Version 12). Compilation of interview responses and determination of percent responses were completed using Microsoft® Excel 2010.

The sensory preference data were collected under the assumption of approximating interval level data (Norman, 2010) for analysis with parametric statistical testing. The data did not meet assumptions of normal distribution and primary analysis of treatment means was done through non-parametric measures. Kruskal-Wallis rank tests were performed among treatments with built in post-hoc multiple comparisons to distinguish differing treatments.

Two-factor ANOVA tests were run to further examine whether the site or demographic factors (gender, age, and education level) contributed to the treatment effect on overall acceptability of beans. Despite not meeting assumptions of normality, the ANOVA tests were run under the assumption that data would approximate normal as per the central limit theorem ($n = 48$). Test for statistical significance of the data was set at $\alpha = 0.05$.

The mathematical model used for the two-factor ANOVA between site and treatment was:

$$Y_{ij} = \mu + site_i + treatment_j + (site \times treatment)_{ij} + \epsilon_{ij} \quad 2$$

where Y_{ij} = preference (rating for overall acceptability) mean; μ = grand mean preference; $site_i$ = study site (Dog Abam, Telela, Arok, Tit); $treatment_j$ = cooking water treatment (distilled water [control], commercial salt, ground salt, ash filtrate); $(site \times treatment)_{ij}$ = interaction between site and treatment; and ϵ_{ij} = experimental error. The null hypotheses were that there was no difference in means of site, there was no difference in means of treatment, and there was no interaction between site and treatment.

The mathematical models used for the two-factor ANOVAs between demographic factors and treatments were:

$$Y_{ij} = \mu + factor_i + treatment_j + (factor \times treatment)_{ij} + \epsilon_{ij} \quad 3$$

where Y_{ij} = preference (rating for overall acceptability) mean; μ = grand mean preference; $factor_i$ = demographic factor of either gender, age, or education level; $treatment_j$ = cooking water treatment (distilled water [control], commercial salt, ground salt, ash filtrate); $(factor \times treatment)_{ij}$ = interaction between demographic factor and cooking water treatment; and ϵ_{ij} = experimental error. The null hypotheses were that there was no difference in means of any factor (gender, age, or education level), there was no difference in means of treatment, and there was no interaction between the factor (gender, age, or education level) and treatment.

The analysis was completed using the Stata® (Version 12) software package. Compilation of interview responses and determination of percent responses were completed using Microsoft® Excel 2010.

RESULTS AND DISCUSSION

Properties of beans cooked with water only, table salt, ground salt, and ash filtrate

Differences among treatment solutions are presented in Table 1. Cooking water pH levels were significantly ($p < 0.05$) different among all treatments, with ground salt (9.6 ± 0.06) and ash filtrate (10.5 ± 0.03) being the most alkaline. The temperature of cooking water, both at time of boiling and the average throughout cooking, did not differ significantly ($p > 0.05$) among treatments. However,

Table 1. Mean (\pm standard error) treatment values of pH, temperature, time to boil and cooking times ($n = 3$). Values along rows with the same superscript are not significantly different at $p \geq 0.01$ by the Bonferroni method.

Parameter	Treatment			
	Control	Table Salt	Ground Salt	Ash Filtrate
pH of cooking treatment	7.7* \pm 0.07 ^a	8.2 \pm 0.03 ^b	9.6 \pm 0.06 ^c	10.5 \pm 0.03 ^d
Temperature at boiling ($^{\circ}$ C)	97.6 \pm 0.19 ^a	97.5 \pm 0.13 ^a	97.6 \pm 0.13 ^a	97.6 \pm 0.09 ^a
Temperature at 15 min ($^{\circ}$ C)	97.8 \pm 0.07 ^a	97.9 \pm 0.06 ^a	97.7 \pm 0.09 ^a	97.6 \pm 0.07 ^a
Time to boil (minutes)	9.78 \pm 0.06 ^a	9.21 \pm 0.32 ^{ab}	8.37 \pm 0.27 ^b	9.37 \pm 0.29 ^{ab}
Cooking time to 150 g puncture force (min)	101.0 \pm 0.88 ^a	101.3 \pm 0.88 ^a	82.7** \pm 0.88 ^b	88.3 \pm 0.67 ^c
Cooking time to eating soft (minutes)	113.0 \pm 1.15 ^a	121.7 \pm 1.20 ^b	82.7** \pm 0.88 ^c	92.7 \pm 1.20 ^d

*pH analysis of pure Type 1 water may not yield accurate results due to lack of elements and conductivity in the water.

**The texture of beans cooked in the ground salt treatment was deemed satisfactory according to Ugandan preferences at the time of puncture force test, demonstrated by the same value for both of the cooking times. This texture was used as a comparative threshold for other treatments.

Table 2. Chi-squared value, corrected for ties, (χ^2 , 3 d.f.) and rank mean scores for treatments ($n=48$). Values along rows with the same superscript are not significantly different at $p \geq 0.004167$ (Bonferroni like adjustment).

Characteristic	χ^2	Treatment			
		Control	Table Salt	Ground Salt	Ash Filtrate
Smell	18.13 ($p < 0.001$)	77.13 ^a	107.00 ^{ab}	117.98 ^b	83.90 ^a
Colour	12.04 ($p = 0.007$)	79.09 ^a	106.03 ^{ab}	111.18 ^b	89.70 ^{ab}
Flavour	27.55 ($p < 0.001$)	70.61 ^a	116.30 ^b	116.83 ^b	82.25 ^a
Texture (hardness)	33.60 ($p < 0.001$)	58.91 ^a	107.35 ^b	119.28 ^b	100.46 ^b
Texture (softness)	29.38 ($p < 0.001$)	61.65 ^a	106.68 ^b	116.45 ^b	101.23 ^b
Bitterness	12.10 ($p = 0.007$)	88.09 ^{ab}	102.52 ^{ab}	115.18 ^a	80.21 ^b
Overall	31.41 ($p < 0.001$)	68.80 ^a	112.44 ^b	122.74 ^b	82.02 ^a

despite similar temperature, a statistically significant difference among means was found for the time to boil but only between the control (9.78 \pm 0.06^a min) and ground salt treatments (8.37 \pm 0.27^b minutes). A significant difference among means was found for cooking time necessary to obtain a puncture force of 150 g. The addition of ground salt significantly ($p \leq 0.01$) decreased time by up to 18% and ash filtrate by up to 13%, compared to either the control or table salt treatments. The required cooking time to acceptable texture increased for all treatments except ground salt, which felt palatable and not at all chalky when the puncture force test was passed. A significant ($p \leq 0.05$) difference among treatment means was found for cooking time to acceptable texture. The ground salt and ash filtrate treatments decreased cooking time to eating soft significantly ($p \leq 0.01$), compared to the control, by 30.3 and 20.3 min or 27 and 18%, respectively.

Sensory properties of beans cooked with water only, table salt, ground salt, and ash filtrate

A non-parametric chi-square analysis showed treatment

effects on all sensory characteristics (Table 2). Higher values demonstrate a greater preference for the treatment. There is a distinct preferential pattern for beans cooked with the ground salt across all parameters, followed by beans from the table salt, then beans from the ash filtrate, and least preferred were those cooked in the plain distilled water (control) (Figure 2). The only anomaly in the rankings was that beans cooked in the ash filtrate scored lowest for bitterness.

Several two-factor ANOVAs were used to identify possible interactions between study site, treatment, and three demographic factors (age, gender, and education level). The results revealed a significant ($p < 0.05$) main effect of both treatment and study site on overall sensory preference, suggesting cultural taste variation on a small geographic scale. There was also a significant interaction between the two factors, with specific differences evident at the Arok site, where the table salt treatment was not well accepted (Figure 3). Otherwise, the general trend of taste preferences supported Kruskal-Wallis results for overall preference scores. Further, independent variables investigated with cooking treatment through two-factor ANOVA included factors of gender, age, and education level. There was no main effect of gender, age, or

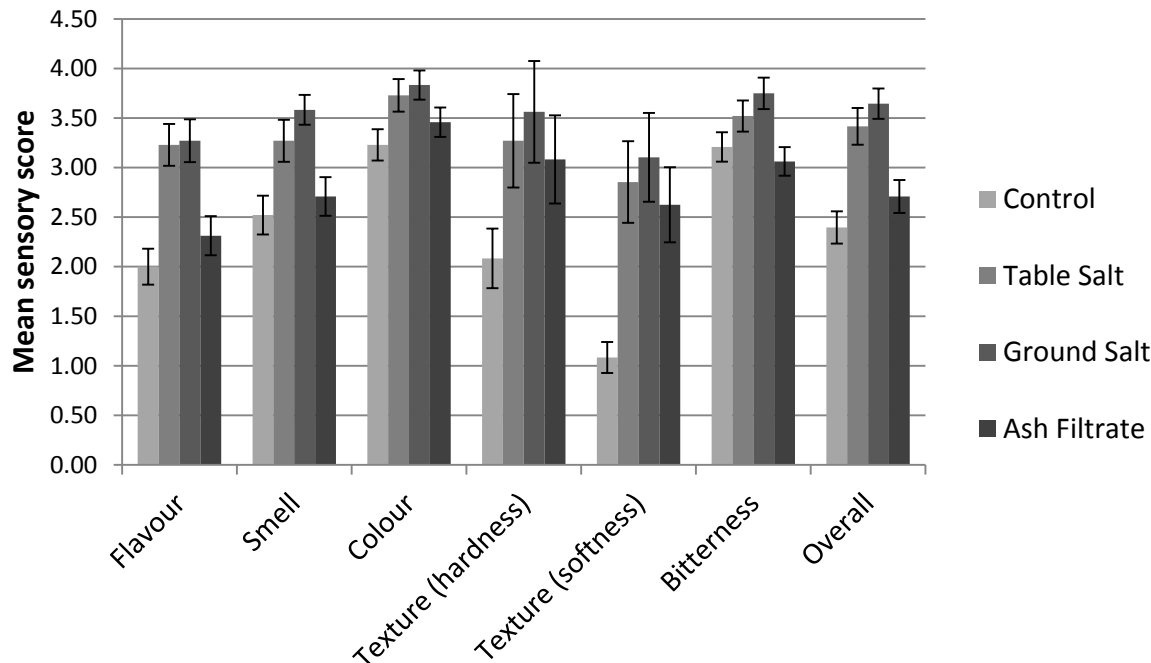


Figure 2. Mean (\pm standard error) scores of sensory preference by parameter for treatments.

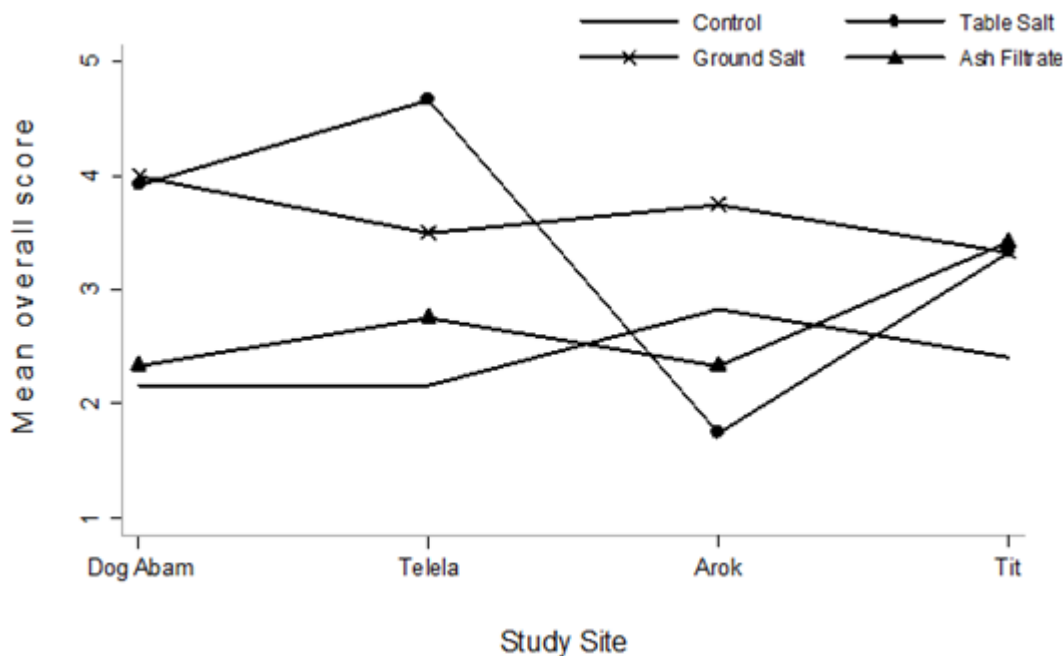


Figure 3. Interaction terms between study site and treatment type on respondents' overall sensory scores.

education level; however, the treatment type was a significant ($p < 0.05$) main effect in each test. There were no interactions between treatment and gender, age, or education level.

Participant responses to cooking times and sensory characteristics

Statistical findings supported interview responses, where

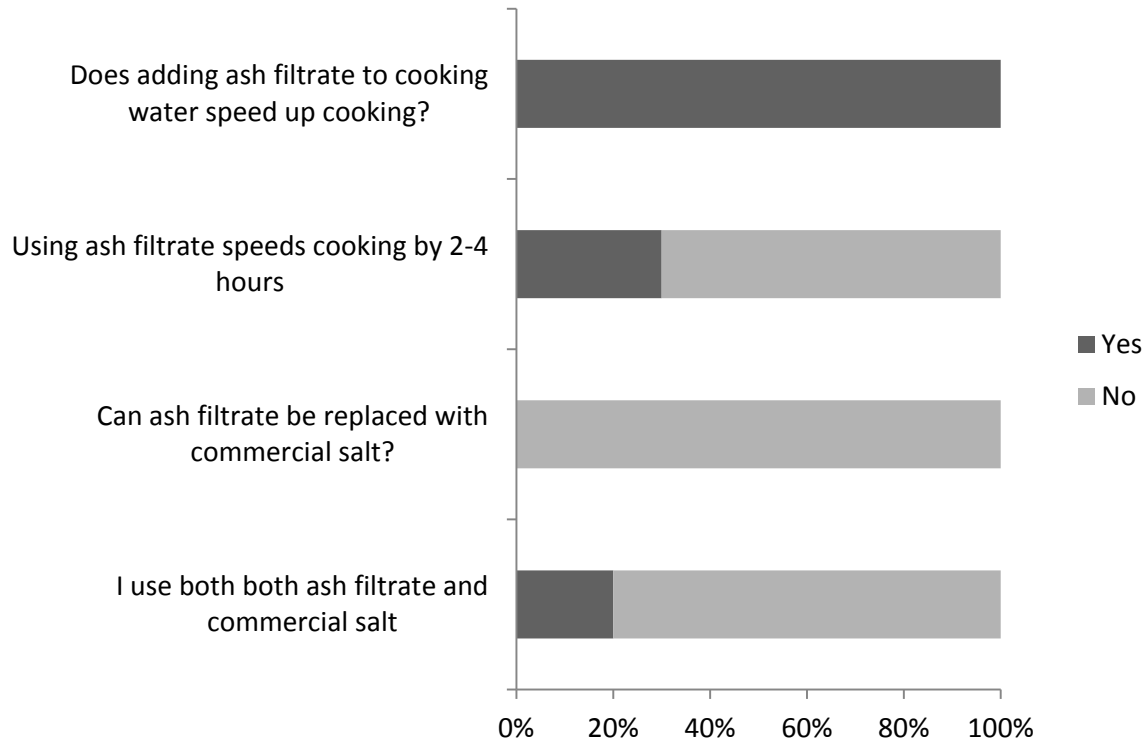


Figure 4. Percent response of cooking time related interview responses (n=20). Every bar totals 100%, with “Yes” and “No” responses viewed as proportions of the bar.

all women stated that ash filtrate decreased cooking time and that the difference could be 2-4 h faster depending on the amount being cooked and the size of the fire (Figure 4). Note that in Figure 4, every bar totals 100%, with “yes” and “no” responses viewed as proportions of the bar. Other responses about actual time savings were less definitive but still suggested considerable time savings; “There is a big difference between food cooked with *kado atwona* [ash filtrate]...it is much faster”. Several respondents did say that ground salt could be used instead of ash filtrate, both for decreasing cooking time and to make the taste culturally acceptable. All interviewees further specified that substituting table salt for the ash filtrate was not possible because it wouldn’t have the same effect on cooking time. However, several women said that they use both ash filtrate to speed cooking and table salt after cooking to improve flavour.

During the interviews, 85% of women stated that they preferred beans cooked with ash filtrate for improved taste, smell, or both, which did not correspond to the statistical findings of the blind taste tests. Two women answered that they did not prefer to use it but that it was necessary, “For me, it is the culture that makes me use it but I don’t like it”. There was one nonresponse. Several respondents said that they add table salt and other ingredients (e.g., peanuts) to the beans after they are cooked with filtrate, to further improve flavour.

Ash filtrate decreased cooking time as compared to

either the control or table salt treatments, validating the anecdotal belief. Additionally, ground salt was found to decrease cooking time even more than the ash filtrate. Based on this finding that both traditional treatments sped up the cooking process, it is probable that they share similar properties and/or mechanisms of pectin degradation, confirming previous findings (Mamiro et al., 2011). Indeed, both treatments were highly alkaline (pH 9.6 (ground salt) and 10.5 (ash filtrate)) compared to either the control or table salt treatments (pH 7.7-8.2, respectively), and both contained high levels of elemental concentration, particularly sodium (ground salt) and potassium (ash filtrate) (Bergeson, 2014). The slightly basic pH of the table salt treatment is likely due to additional impurities in the salt (Varriano-Marston and de Omana, 1979). High concentrations of sodium and potassium, and an alkaline pH have all been shown to be important in the reduction of cooking time of legumes (Varriano-Marston and de Omana, 1979).

As the temperature at boiling was not found to be significantly different among treatments in this study, it could not be the cause of differing cooking times. The addition of a solute (e.g., salt) to a pure solvent (e.g., water) is known to elevate boiling temperature due to vapor pressure differential between the pure solvent and the solution (Andrews, 1976). This colligative property depends on the number of particles present in the solution. The lack of observed difference in boiling

temperature in this study is likely because a small amount of solute was added, which did not contribute sufficient particles to change the temperature at a scale observable with our thermometers.

Another interesting anomaly, with respect to many other studies, was that the table salt treatment did not decrease bean cooking time as compared to the control, and actually took longer than the control to become texturally acceptable (Table 2). The use of NaCl has consistently been shown to increase the rate of softening and therefore decrease cooking time for hard- to- cook beans (Silva et al., 1981; Van Buren, 1986; de León et al., 1992). de León et al. (1992) found continually significant decreases in cooking time obtained with increasing ratios of monovalent to divalent ion concentration (increased Na^+ , predominantly). By the methodology explained in de León et al. (1992), the ratio of monovalent to divalent ions in the plain (control) oven-dried beans (80 g) in this study was 4.2; the sum of monovalent ions (K^+ and Na^+) was 964 mg (919 mg K^+ + 45 mg Na^+) and the sum of divalent ions (Ca^{2+} and Mg^{2+}) was 228 (104 mg Ca^{2+} + 124 mg Mg^{2+}). The ratio of 4.2 in this study (Bergeson, 2014) was lower than the 4.6 ratio of the dried beans used in de León et al. (1992). The addition of 2 g of table salt, 2 g of ground salt, and 15 ml of ash filtrate treatment additives to 1 L of water and 80 g of dried beans would alter the ratio to 7.4, 4.9, and 5.1, respectively (Bergeson, 2014). In contrast to previous findings, the addition of table salt and increased monovalent to divalent ratio in this study did not decrease cooking time compared to the control. This may be due to differences in chemical composition of the commercial salts used in each study as refining processes are likely to differ between companies and countries of origin. The commercial salt used in this study could contain amounts of additional divalent ions not present in the solutions employed by de León et al. (1992). The different outcome may also be due to differences in methodology. de León et al. (1992) reported soaking the dry beans prior to cooking, but in this study beans were cooked from the dried state.

A major benefit to the shortened cooking time is the lessened pressure on fuel wood supplies. Deforestation continues to be a problem in Uganda, where the vast majority of the rural population uses wood or wood products (e.g., charcoal) for all domestic energy needs. It has been estimated that the average rural western Ugandan family will use approximately 8.4 kg of fuel wood per day for cooking meals (Wallmo, 1996), translating into slightly more than 3000 kg per year. Given that beans and legumes are also the most commonly cooked foods at that study site as well (Wallmo, 1996) and that they typically require the longest cooking time on the fire, it is reasonable to assume similar fuel wood requirements in rural Northern Uganda.

Experience gained by the cooking of beans for the sensory study portion of this research and multiple

observations of meal preparation provided basic data on the length of time needed to cook beans on both charcoal stoves and over a fire. When the ash filtrate was added, a medium-sized (approximately 1.5 L) pot of beans required about two and a half hours to cook on a charcoal stove in a sheltered environment. While charcoal is becoming somewhat more prevalent in certain areas due to its benefits (e.g., long lasting nature, steady heat provision, and decreased emissions when cooking inside a building), many families cannot afford it. Fuel wood remains the dominant resource for cooking and other domestic requirements (van Gemert et al., 2013). Through observation and discussion, the same-sized pot of beans cooked with ash filtrate would take approximately four hours on a fire stove in a sheltered area. By extrapolating the findings of the controlled time trials where ash filtrate resulted in an 18% time difference, we could hypothesize that using the filtrate is saving women approximately one hour (63.2 min) when cooking over a fire. This translates into a sizable difference in the amount of fuel wood necessary to cook beans either in plain water or with the ash filtrate.

The beneficial aspect of traditional additives in decreasing cooking time must be weighed against probable drawbacks. The high alkalinity of both treatments has been shown to negatively impact the bioavailability of some minerals (Mamiro et al., 2011), decrease fibre content (Wanjekeche et al., 2003), and have deleterious effects on various vitamins (Kaputo, 1996) and amino acids (Minka et al., 1999). In contrast, the high concentration of certain elements in the ground salt and ash filtrate may not only counteract the decreased bioavailability, but also be contributing levels of other elements that could be exceeding daily recommended intakes (Bergeson, 2014). Further, several interviewees stated that they also added table salt after cooking in addition to the use of ash filtrate in order to improve flavour. This introduces additional sodium to the consumed product. The amount will vary depending on preference, but based on observation it could range from one half (~3 g) to one (~6 g) teaspoon (730 mg to 1461 mg sodium, respectively, Bergeson, 2014) in a pot with 4-6 servings of 240 g cooked beans. A diet high in sodium (greater than 1600 mg/day for adults) is known to contribute to hypertension, which subsequently raises health concerns such as cardiovascular disease, stroke, and edema (SACN, 2003). Lastly, protein content and availability has been shown to react differently with various types of salt; ground salt may slightly increase protein content (Onwuka and Okala, 2003; Wanjekeche et al., 2003), while table salt has a negative effect on protein efficiency ratio and protein content (de León et al., 1992; Onwuka and Okala, 2003).

Sensory evaluation across study sites yielded surprising results given anecdotal beliefs and interview responses. Beans cooked in ash filtrate were not well scored and almost exclusively the second to last

preferred of all treatments. The sole parameter which rated beans cooked with ash filtrate over that of the control was improved texture (Table 2), probably due to the effect of alkalinity on breakdown of legume cell properties (Ankrah and Dovlo, 1978; Varriano-Marston and de Omana, 1979; Uzogara et al., 1990; Onwuka and Okala, 2003). However, the high alkalinity of the ash filtrate treatment was likely the reason why beans cooked with the ash filtrate scored lowest for bitterness. Also unexpected was the preference for the ground salt treatment as prior research results indicated that it contributed to an unpleasant colour (Wanjekeche et al., 2003) and flavour (Onayemi et al., 1986; Onwuka and Okala, 2003). Addition of ground salt can cause beans to turn a darker, less appealing colour which has resulted in low acceptability (Onayemi et al., 1986; Wanjekeche et al., 2003). The same results were not found in this study, perhaps because black beans were used and the colour variability was less apparent than with the lighter coloured beans used previously. The flavour however, was clearly preferred in the ground salt treatment and the table salt treatment. Both of these treatments contain higher sodium content than the other treatments, suggesting that this is an important contributor to sensory acceptability.

In comparison of study sites, the ash filtrate treatment was not the most preferred treatment at three of the four sites, although rated equal to the ground and table salt treatments by respondents only at Tit village (Figure 3). All other sites rated beans cooked with ash filtrate very poorly, and only slightly better than those cooked in distilled water. Participants at the Dog Abam site preferred beans cooked in both salt treatments by a large margin over those cooked in the control and ash filtrate treatments, suggesting a greater affinity for sodium. Respondents from Telela showed a strong preference for beans cooked in table salt. This village is located closest to a large town (Lira) and it may be that availability of table salt is easier, thus developing a preference for its use, or that traditional customs are somewhat less relied upon, thus lessening the preference for ground salt and ash filtrate. In contrast, respondents from the Arok study site greatly disliked the table salt treatment compared to participants from all other sites (Figure 3). The reason for this was not apparent, other than local preferences, as this study site was located not far from Dog Abam and no observable differences in these study sites were identified during data collection. However, the difference may be due to factors not identified in this study. Participants from Tit showed preference for any cooking additive over the control, which may be a function of the villages' history. This village was the last of the four study sites to resettle after living at an Internally Displaced Persons (IDP) camp for many years. Scarcity of either table salt or traditional additives during those years may have subsequently made the availability of any additive welcome.

The results of statistical tests showed that both site and treatment were important in understanding differences in preferences, as was the interaction between them. It was anticipated that treatment would affect sensory evaluation, but it is interesting that site (location) also affected preference. This suggests important cultural connections within small populations, which makes sense as women within these communities often share cooking duties and materials, such as ash. These women and their families may develop similar preferences for food. An important lesson from this finding is that there are different and complex traditions (e.g., cooking methods and/or amount of ash filtrate added) to consider among even small communities, that influence individuals' preferential tastes for food. It would be inaccurate to treat these communities as homogenous by assuming similar taste preferences throughout.

None of the demographic factors were found to be of statistical significance in contributing to observed differences among treatments. However, when interpreting these findings in a real life context, it must be noted that gender is important, as women perform a vast majority of domestic duties and as such, are responsible for how meals are prepared (Madge, 1994). The perceived benefits of using ash filtrate include improved taste and smell of food, as well as decreased cooking time for hard-to-cook foods. The distinct flavour imparted by the filtrate has resulted in it being used ubiquitously by households, and subsequently becoming a culturally obligatory practice. The practical benefit of decreased cooking time reduces daily workload for women, by reducing the number of hours of meal preparation and the time spent on associated activities (e.g., collection of fuel wood). The results of the blind taste tests in this study may be used to identify preferences between study sites and form a basis from which to initiate an individualized conversation with women from each community.

Several factors which may have influenced the dislike for beans cooked with ash filtrate in this study need to be considered. While every attempt was made to replicate common cooking practices, women in this region are used to preparing their own food and so have personal preferences that cannot be duplicated in every case (e.g., such as amount of filtrate to add and how long to cook the beans). Those interviewed indicated that the over-addition of filtrate creates very bitter tasting beans, and as the filtrate treatment scored poorly for bitterness (Table 2) it may be that the amount used was not in accordance with all household preferences. However, low scores across most parameters for the beans cooked in ash filtrate treatment suggest a general dislike. Also, refrigeration is very rarely used in this area and while refrigerated samples were warmed to ambient temperature before testing, this may have impacted taste. Lastly, cooked beans are always served with a sauce made from the remains of cooking water and addition of

peanuts, salt, and/or other additives. The retention of this sediment likely provides a large portion of the flavour and so the taste differences between drained bean samples would be very subtle. In a region with very limited exposure to novel foods or cooking practices, participants may have had difficulty in differentiating specific sensory parameters in an atypically cooked food such as plain dry beans.

Conclusion

To date, it does not appear that a study using traditional salt(s) as a comparable soaking medium has been conducted. Given the reduction of cooking times with traditional additives in this study, it may be that their use would reduce soaking time equally, if not faster, than table salt. Further investigation is needed. Adding table salt to the soaking water hastens the process even further, thus reducing the opportunity for bacterial growth.

Legumes cooked with ash filtrate, while identified as being culturally preferred, did not rank well with legumes cooked with ground salt and table salt in blind testing. Given the contradictory findings among study sites, as well as between this research and other studies, sensory evaluations pertaining to specific populations or areas should always be conducted to identify area-relevant preferences.

Conflict of interests

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

The authors would like to thank Geoffrey Odongo, the communities and the households who provided logistical, informational support to, and ash samples for this study. This study was funded by Northern Uganda Development Foundation and University of Northern British Columbia.

REFERENCES

- Andrews FC (1976). Colligative properties of simple solutions. *Science* 194:567-571.
- Ankrah EK, Dovlo FE (1978). The properties of trona and its effect on the cooking time of cowpeas. *J. Sci. Food Agric.* 29:950-952.
- Bergeson TL (2014). Use of filtrate from crop residue ash for cooking in rural households in Northern Uganda. Master's Thesis, University of Northern British Columbia.
- Chambers R (1997). *Whose reality counts? Putting the first last*. Rugby: Intermediate Technology Publications.
- de León LF, Elias LG, Bressani R (1992). Effect of salt solutions on the cooking time, nutritional and sensory characteristics of common beans (*Phaseolus vulgaris*). *Food Res. Int.* 25:131-136.
- Van Gemert F, Chavannes N, Nabadda N, Luzige S, Kirenga B, Eggermont C, de Jong C, van der Molen T (2013). Impact of chronic respiratory symptoms in a rural area of sub-Saharan Africa: an in-depth qualitative study in the Masindi district of Uganda. *Prim. Care Respir. J.* 22:300-305.
- Devereux S, Hoddinot J (1993). *Fieldwork in developing countries*. Boulder: Lynne Rienner Publications.
- Gotelli NJ, Ellison AM (2004). *A Primer of Ecological Statistics*. Sinauer Associates, Inc.: Sunderland, MA.
- Kaputo MT (1996). The role of ashes and sodium bicarbonate in a simulated meat product from chikanda tuber (*Satyria siva*). *Food Chem.* 55:115-119.
- Le Roux B (1998). Community-owned development amongst marginalized San communities of the Kalahari, as adopted by a san community development organization. Working Paper in Early Childhood Development No. 22. The Hague: Bernard van Leer Foundation.
- Madge C (1994). Collected food and domestic knowledge in The Gambia, West Africa. *Geogr. J.* 160:280-294.
- Makanjuola AA, Beetlestone JG (1975). Some chemical and mineralogical notes on kaun (trona). *Niger. J. Min. Geol.* 10:31-41.
- Mamiro P, Nyagaya M, Kimani P, Mamiro D, Jumbe T, Macha J, Chove B (2011). Similarities in functional attributes and nutritional effects of magadi soda and bean debris-ash used in cooking African traditional dishes. *Afr. J. Biotechnol.* 10:1181-1185.
- Mikkelsen B (1995). *Methods for development work and research*. Thousand Oaks: Sage Publications.
- Minka SR, Mbofung CMF, Gandon C, Bruneteau M (1999). The effect of cooking with *kanwa* alkaline salt on the chemical composition of black beans (*Phaseolus vulgaris*). *Food Chem.* 64:145-148.
- Norman G (2010). Likert scales, levels of measurement and the "laws" of statistics. *Adv. Health Sci. Educ.* 15:625-632.
- Onayemi O, Osibogun OA, Obembe O (1986). Effect of different storage and cooking methods on some biochemical, nutritional and sensory characteristics of Cowpea (*Vigna unguiculata* L. Walp). *J. Food Sci.* 51:153-160.
- Onwuka UN, Okala O (2003). Effects of selected salts on the cooking time, protein content and sensory properties of African yam beans and cowpeas. *Food Serv. Technol.* 3:3-7.
- Pratt B, Loizos P (1992). *Choosing research methods: data collection for development workers*. Oxford: Oxfam.
- Reyes-Moreno C, Paredes-Lopez O (1993). Hard-to-cook phenomenon in common beans – a review. *Crit. Rev. Food Sci.* 33:227-286.
- SACN (Scientific Advisory Committee on Nutrition) (2003). *Salt and Health*. The Stationary Office: London, England. Available at: http://www.sacn.gov.uk/pdfs/sacn_salt_final.pdf.
- Sammy J, Opio C (2005). Problems and prospects for conservation and indigenous community development in rural Botswana. *Dev. South. Afr.* 22 (1):67-85.
- Siegel A, Fawcett B (1976). *Food Legume Processing and Utilization (with special emphasis on application in developing countries)*. International Development Research Center: Ottawa, Canada.
- Silva CAB, Bates RP, Deng JC (1981). Influence of soaking and cooking upon the softening and eating quality of black beans (*Phaseolus vulgaris*). *J. Food Sci.* 46:1716-1720.
- Stake ER (1995). *The art of case study research*. Thousand Oaks: Sage Publications.
- Uzogara SG, Morton ID, Daniel JW (1990). Influence of various salts in the cooking water on pectin losses and cooked texture of cowpeas (*Vigna unguiculata*). *J. Food Biochem.* 14:283-291.
- Van Buren JP (1986). Snap bean texture softening and pectin solubilization caused by the presence of salt during cooking. *J. Food Sci.* 51:131-134.
- Varriano-Marston E, de Omana E (1979). Effects of sodium salt solutions on the chemical composition and morphology of black beans (*Phaseolus vulgaris*). *J. Food Sci.* 44:531-536.
- Wallmo K (1996). A comparison of traditional and improved cookstoves in western Uganda. M.Sc., Forestry, University of Florida, Gainesville, Florida.
- Wanjikeche E, Wakasa V, Mureithi JG (2003). Effect of germination, alkaline and acid soaking and boiling on the nutritional value of mature and immature *Mucuna* (*Mucuna pruriens*) beans. *Trop. Subtrop. Agroecosystems.* 1:183-192.



African Journal of Food Science

Related Journals Published by Academic Journals

- *African Journal of Microbiology Research*
- *African Journal of Plant Science*
- *International Journal of Genetics and Molecular Biology*
- *Journal of Cell and Animal Biology*

academicJournals