



Effect of soybean fortification on fermentation characteristics and consumer acceptability of *Hausa koko*, a Ghanaian fermented porridge

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Original submitted in 19th January 2010. Published online at www.biosciences.elewa.org on April 8, 2010.

ABSTRACT

Objective: To assess the effect of soybean fortification on microbial growth and consumer acceptability of *Hausa koko*.

Methodology and results: *Hausa koko* was prepared from a mixture of soaked millet grains and pre-soaked, blanched and dehulled soybeans added at 0 to 50 % replacement levels. pH, titratable acidity and microbial counts were determined before and after the fermentation period using standard methods. The effect of the added soybean on acceptability was evaluated on a nine point hedonic scale by an untrained panel that is familiar with *Hausa koko*. Data were subjected to Analysis of Variance and Tukey testing for the separation of means ($p < 0.05$). There was a general increase in acidity with increasing percentage of soybean in the mixture. Lactic acid bacteria growth was accelerated with the addition of soybean from 10^6 to 10^9 cfu/ g after 12h of fermentation. Taste, odor and overall acceptability were significantly and negatively affected above 40% soybean content. Colour significantly improved upon addition of soybeans whereas texture was not noticeably affected.

Conclusions and application of findings: *Hausa koko* can be fortified with soybean up to 40% replacement level to improve the protein quality. The fortification with soybeans up to 40% yielded a product most acceptable to consumers. This will make a significant contribution towards the alleviation of protein–energy malnutrition in communities of developing countries where *Hausa koko* or similar products are consumed.

Key words: Fortification, *Hausa koko*, fermentation, acceptability

INTRODUCTION

Throughout Africa, fermentation is a traditional part of cereal, cassava and dairy processing. A diversity of fermented products, which include porridges, beverages (alcoholic and non-alcoholic), breads and pancakes, fermented meat, fish, vegetables, dairy products and condiments, are produced in developing countries (Campbell-Platt, 1994; Steinkrans, 1996). Examples of these foods

are *ogi* and *mawè* in Benin, *kenkey* and *koko* in Ghana and *injera* in Ethiopia.

In Ghana, porridges produced from cereals (particularly maize and millet) are known as *koko*. An example of these porridges is *Hausa koko* that is produced from pearl millet (*Pennisetum glaucum*). *Hausa koko* is sold early in the morning in a ready-to-eat form in front of the producer's home or on the street and is frequently



eaten by the population for breakfast. Most cereal porridges similar to *Hausa koko* are often used for the complementary feeding of infants and young children in Africa. However, compared to the required composition of complementary food (Dewey & Brown, 2003; Lufter & Dewey, 2003), the traditional gruels are characterized by low energy and nutrient density (Lorri & Svanberg, 1994; Trèche & Mboime, 1999).

The traditional processing of these foods therefore needs to be changed or modified to improve their nutritional status. Fortification of popularly consumed staple foods, such as cereals, with legumes is being exploited in many developing countries. In this process, the protein quality of staple foods is improved through a mutual complementation of their limiting amino acids (Annan *et al.*, 2005). Cereal-legume mixtures make a very significant contribution towards the alleviation of protein-energy malnutrition (Baningo *et al.*, 1974; Plahar *et al.*, 1983, 1997), and soybean is one of the commonly used legumes

during cereal-legume fortifications. Soybean has in recent times become popular in the West African sub-region where it is being cultivated at a steadily increasing rate (Annan & Plahar, 1995). Soy-cereal wining foods at 20% replacement levels of the soybean have been produced on a pilot scale in Ghana and are very popular among middle-income mothers (Annan & Plahar 1995; Plahar *et al.*, 1997). The wining blends are also being promoted in farming communities where they are helping to reduce protein-energy malnutrition (Plahar *et al.*, 1995).

The addition of boiled whole soybeans to soaked maize grains before milling and fermentation of the Ghanaian maize dough was found to be the most appropriate and cost effective technique for household, small-scale and medium-scale operations (Plahar *et al.*, 1997). This paper reports on the effect of soybean fortification on the microbiology and sensory qualities of *Hausa koko* for different fortification levels.

MATERIALS AND METHODS

Cereals and legume grains: The local variety of pearl millet (*Pennisetum glaucum*) and *Salintuya* variety of soybeans were both purchased from a local retail outlet in Navrongo market, Ghana. They were cleaned and stored at ambient temperature ($29\pm 1^\circ\text{C}$) until they were used.

Preparation of Hausa koko samples: *Traditional unfortified Hausa koko:* About 5kg duplicate batches of cleaned whole millet grains were soaked in 8 liters of water at ambient temperature ($28-30^\circ\text{C}$) for 12 hours. The steep water was decanted and the millet grains wet milled in a plate attrition mill (Hunt no. 2A & Co., Kent, UK). Water (about 6 liters) was added to the milled dough, kneaded and sieved to remove the chaff. The filtrate was allowed to settle (ferment) for 12 hours. The supernatant was then separated from the decanted paste. The supernatant was heated to boiling point and the decanted paste added while stirring, and cooked for about 3 minutes to form porridge.

Soy-fortified Hausa koko: Soy-fortified *Hausa koko* was prepared in duplicates by replacing portions of millet grains with separately weighed raw soybeans at 10, 20, 30, 40, and 50 % replacement levels. The soybeans were soaked water for 2 hours and boiled for 20

minutes to inactivate trypsin inhibitor activity and reduce the beany flavor (Plahar *et al.*, 1997). The boiled beans were hand dehulled by rubbing in cold water. For fortification, the dehulled soybeans were mixed with the decanted soaked millet grains and milled together (Fig. 1).

Determination of pH and acidity during fermentation: pH and titratable acidity (expressed as lactic acid) were determined in 10% (w/v) slurries of the unfermented milled dough (0 hours) and fermented pastes (12 hours). Ten-milliliter aliquots of filtrate were titrated against 0.1 N NaOH standard solution to determine acidity, while the pH was determined using a pH meter (Crison Basic model 20) calibrated with standard buffer (pH 7.0 and 4.0). Acidity was expressed as lactic acid based on the conversion of 1 ml of 0.1 N NaOH being equivalent to 9.008×10^{-3} g lactic acid.

Enumeration of microorganisms: Ten grams of unfermented dough and fermented pastes were homogenized in 90ml buffered peptone water (Merck, 64271 Darmstadt, Germany) using a stomacher (BagMixer, Buch & Holm, France) for 30 seconds. Ten-fold dilutions were made and used to carry out the pour plate techniques for the enumeration of lactic acid



bacteria and yeasts. Lactic acid bacteria were enumerated in deMan, Rogosa and Sharpe (MRS) agar (Merck) incubated at 35°C, in an oxygen-free CO₂ atmosphere (Anaerocult® A; Merck) for 48 hours. Yeasts were enumerated on malt extract agar (Merck) supplemented with 100 mg/l chloramphenicol (chloramphenicol selective supplement; oxoid) and 50 mg/l chlortetracycline (Sigma Chemical Co., St. Louis, MO, USA) incubated at 25°C for 7 days.

Sensory evaluation: The final products (*Hausa koko*) containing soybeans at 0, 10, 20, 30, 40 and 50 %

replacement levels were served to 20 untrained judges, who are familiar with *Hausa koko*, to evaluate the sensory qualities (taste, odor, colour, texture, and overall acceptability) using a nine-point hedonic scale (1 and 9 representing extremely dislike and extremely like, respectively).

Data analysis: Data were subjected to analysis of variance and Tukey test was used for the separation of means ($p < 0.05$).

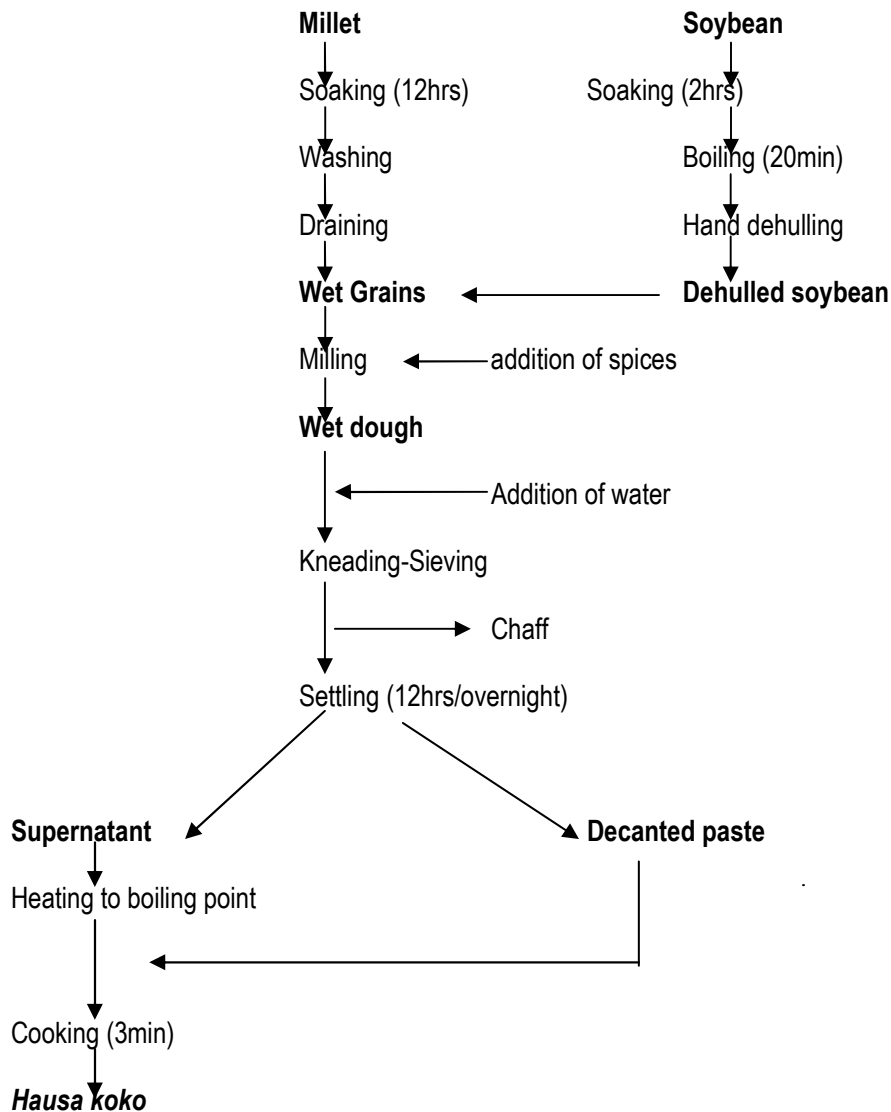


Figure 1: Modified process for preparing soy-fortified *Hausa koko*.

RESULTS AND DISCUSSION

There was a general increase in total acids expressed as lactic acid with increasing percentage of soybean fortification (table 1). This trend could be attributed to a buffering effect because of the higher content of amino acids contributed by the soybeans (Nche *et al.*, 1994; Plahar *et al.*, 1983, 1997). It has also been determined that the type of soy flour used during fortifications can affect the amount of acid produced. Ampadu (1989) reported that full-fat soy flour produced the highest amount of titratable acids, followed by defatted soy flour and extruded soy flour. This shows that free fatty acids from soybeans could contribute to total acids during soy-cereal fortifications and possibly explains the increasing acidity observed during the fermentation with

increasing soybean fortification levels, even at 0 hours when no fermentation had begun.

Microbial counts reached 10^8 cfu/g for unfortified samples and 10^9 cfu/g for soy-fortified samples after 12h of fermentation. Yeast counts reached 10^6 cfu/g for both soy-fortified and unfortified samples. Lactic acid bacteria growth in sour dough has been found to be enhanced by the presence of amino acids (Gobetti *et al.*, 1994). The increased protein content of fermented fortified samples resulting from the addition of soybeans could contribute to the increased growth of lactic acid bacteria in these samples.

Table 1: Microbiological characteristics of unfortified and soy fortified Hausa koko.

Fermentation characteristics	Fermentation time (hours)	Levels of soybean fortification (%) by replacement					
		0	10	20	30	40	50
pH	0	5.61±0.08	5.50±0.14	5.25±0.17	5.11±0.25	5.00±0.15	5.34±0.13
	12	4.00±0.03	4.23±0.09	4.05±0.21	4.05±0.29	4.15±0.15	4.25±0.20
Titratable acidity	0	0.11±0.09	0.18±0.13	0.21±0.06	0.23±0.11	0.25±0.15	0.26±0.17
	12	0.43±0.04 (3.3±0.13) ×10 ⁶	0.49±0.08 (4.2±0.04)×1 0 ⁶	0.76±0.10 (4.7±0.12) ×10 ⁶	0.89±0.15 (5.6±0.05) ×10 ⁶	1.01±0.10 (1.4±0.08) ×10 ⁷	1.24±0.21 (2.6±0.10) ×10 ⁷
LAB cfu/g	0	(4.2±0.40) ×10 ⁸	(6.3±0.25)×1 0 ⁸	(8.1±0.34) ×10 ⁸	(1.6±0.40) ×10 ⁹	(5.0±0.32) ×10 ⁹	(7.3±0.2 5)10 ⁹
	12	(2.1±0.28) ×10 ⁵	(5.0±0.15)×1 0 ⁴	(1.5±0.15) ×10 ⁴	(1.6±0.3 3)10 ⁴	(4.2±0.26) ×10 ⁴	(2.3±0.20) ×10 ⁴
Yeasts cfu/g	0	(1.3±0.40) ×10 ⁶	(1.8±0.37)×1 0 ⁶	(1.6±0.26) ×10 ⁶	(2.1±0.31) ×10 ⁶	(2.6±0.24) ×10 ⁶	(1.4±0.18) ×10 ⁶
	12						

Values are means of duplicate determinations from two independent trials; LAB = Lactic Acid Bacteria; ± = Standard deviations

Table 2: Effect of soybean on the sensory qualities of Hausa koko*

%Soybean	Taste	Odor	Colour	Texture	Overall Acceptability
0	3.0±1.29 ^a	4.9±1.07 ^a	2.4±1.43 ^a	6.1±2.27 ^a	6.2±1.03 ^a
10	4.6±1.43 ^a	4.8±1.75 ^a	3.9±1.59 ^b	5.1±2.51 ^a	5.8±1.03 ^a
20	4.0±2.45 ^a	4.0±1.26 ^a	3.9±1.73 ^b	5.2±2.74 ^a	5.8±1.23 ^a
30	3.8±2.25 ^a	4.1±1.59 ^a	4.6±2.41 ^b	5.1±2.28 ^a	6.4±1.08 ^a
40	6.6±1.17 ^b	6.5±1.08 ^b	5.0±2.26 ^b	5.0±2.75 ^a	6.2±1.32 ^a
50	2.5±1.43 ^c	2.8±1.87 ^a	6.6±1.71 ^c	5.6±2.01 ^a	4.4±0.54 ^b

*Means followed by the same letter in a column are not significantly different ($p > 0.05$)

There was no significant difference between the unfortified and the soy-fortified *Hausa koko* at 10, 20, and 30 % soybean replacement levels for taste and odor qualities (table 2). Both taste and odor aspects were determined to be most acceptable at 40% soybean replacement. There was however, a sharp decrease in overall acceptability above 40% soybean fortification level. There was a general increase in likeness for the colour with increasing percentage of soybeans. The mean scores for texture were not significantly affected regardless of soybean content.

CONCLUSION

Soybean fortification affected the fermentation characteristics and sensory attributes of Ghanaian *Hausa koko*. The fortification with soybeans accelerated the growth of microorganisms and the subsequent production of total lactic acid during the fermentation step in *Hausa koko* processing, which allowed the production of *koko* with acceptable flavor. However, the flavor (taste and odor) is significantly and negatively affected above 40% soybean fortification

REFERENCES

- Ampadu EW, 1989. The chemical and functional properties of cereal- legume blends. BSc. Project Report, Department of Nutrition and Food Science, University of Ghana, Legon, Ghana.
- Annan NT. and Plahar WA, 1995. Development and quality evaluation of a soy-fortified Ghanaian weaning food. *Food and Nutrition Bulletin* 16:263-269.
- Banigo EOI, de Man JM, Duitschaever CL, 1974. Utilization of high-lysine corn for the manufacture of Ogi, using a new improved processing system. *Cereal Chemistry* 51: 559-573.
- Campbell-Platt G, 1994. Fermented foods: a world perspective. *Food Research International* 27:253.
- Cerefer, 2003, European Commission, Annual Report of the European INCO- DEV Project (5th FP), Contract No. ICA4-CT2002-100471: Meeting consumer requirements for cereal based fermented foodstuffs with improved nutritional and sanitary quality and shelf- life in Africa, Oct. 2002-2003. Report available at <http://www.mpl.ird.fr/cerefer/>.
- Dewey KG. and Brown KH, 2003. Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Food and Nutrition Bulletin* 24:5-28.
- Gobetti M, Corsetti A, Rossi J, 1994. The sourdough microflora. Interaction between lactic acid bacteria and yeast: metabolism of amino acids. *World Journal of Microbiology and Biotechnology* 10:275-279.
- Lorri W. and Svanberg U, 1994. An overview of the use of fermented foods for child feeding in Tanzania. *Ecology of Food and Nutrition* 34:65-81.
- Lutter CK. and Dewey KG, 2003. Nutrient composition for fortified complementary foods: proposed nutrient composition for fortified complementary foods. *Journal of Nutrition* 133: 3011
- Nche PF, Odamtten GT, Nout MJR, Bombouts FM, 1994. Dry milling and accelerated fermentation of maize for industrial production of 'Kenkey', a Ghanaian maize food. *Journal of Cereal Science* 20: 291-298.
- Nuot MJR. and Motarjemi Y, 1997. Assessment of fermentation as a household technology for improving food safety: a joint FAO/WHO workshop. *Food Control* 8:221-226.

The sharp decrease in the mean scores of odor and taste above 40% could be due to the characteristic beany flavor of soybeans, which is not desired in *Hausa koko*. The carry-over of the beany flavor could be due to the presence of soybean fats (because the soybeans used in this study were not defatted) as these soybean fats are usually found to contain the flavoring compounds. The general increase in mean scores for colour with increase in soybean proportion could be due to the creamy appearance of the final product, which is desired in porridges.

level. *Hausa koko* can therefore be fortified with soybeans up to 40% replacement level to improve nutritional quality and consumer acceptability.

ACKNOWLEDGEMENTS: This study was carried out at the University for Development Studies (UDS)/Danish International Development Assistance (DANIDA) food microbiology laboratory, Navrongo, Ghana.



- Oyewole OB, 1997. Lactic fermented foods in Africa and their benefits. *Food Control* 8:289-297.
- Plahar WA, Leung HK, Coon CN, 1983. Effects of dehydration and soy- fortification on physico-chemical, nutritional and sensory properties of Ghanaian fermented maize meal. *Journal of Food Science* 48: 1225-1259.
- Plahar WA, Nti CA, Allotey L, Ocloo GK, 1995. Soybean production, processing and utilization in Ghana. Case study at Manchie/ Korleman, Asutsuare Accra. IDRC/ IITA Soybean Utilisation Project, Phase III, International Institute of Tropical Agriculture, Ibadan, Nigeria.
- Plahar WA, Nti CA, Annan NT, 1997. Effects of soy-fortification method on the fermentation characteristics and nutritional quality of fermented maize meal. *Plant Foods for Human Nutrition* 51: 365-380.
- Steinkraus KH, 1996. *Handbook of Indigenous Fermented Foods*, Second edition. Marcel Dekker, New York.
- Talamond P, Gallon G, Trèche S, 1998. Rapid and sensitive liquid chromatography method using a conductivity detector for the determination of phytic acid in food. *Journal of Chromatography A* 805:143-147.
- Trèche S, and Mbome IL, 1999. Viscosity, energy density and osmolality of gruel for infants prepared from locally produced commercial flours in some developing countries. *International Journal of Food Science and Nutrition* 50:117-125.

