Advance Journal of Food Science and Technology 5(6): 665-670, 2013
DOI:10.19026/ajfst.5.3146
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: December 15, 2012 Accepted: February 01, 2013 Published: June 05, 2013

Research Article

Effect of Partial Substitution of Fresh Cow Milk with Bambaranut Milk on Nutritional Characteristics and Yield of Soft ('Unripe') Cheese-'Warankashi'

S.U. Okorie and I.I. Adedokun
Department of Food Science and Technology, Imo State University, Owerri, Imo State, Nigeria

Abstract: Nutrition characteristics and percentage yield of cheese 'warankashi' with partial substitution of bambaranut milk was studied. Extracted bambaranut milk was blended with fresh raw cow milk using varying proportions of 5:95; 10:90; 15:85; 20:80; 30:70; 40:60 and 50:5050%, cheese analogue of 100% bambaranut and a control of whole cow milk cheese was produced. Samples of cheese from different mix and control were examined for nutritional characteristics and percentage cheese yield. Data obtained from each examination was statistically analyzed. The result on percentage yield of cheese showed an increase from 28.05% control sample (100% cow milk cheese) as level of bambaranut milk increases in the cheese mix to 40.22% of cheese with 50% added bambaranut. Cheese analogue recorded highest (52.86%) yield. Increase in proportion of added bambaranut milk (5-50%) in cheese making caused significant ($p<0.05$) changes in proximate content, the values ranged from 7.86% protein; 0.58% ash; 1.05% crude fiber; 13.17% carbohydrate to maximum values of 14.69% protein; 2.51% ash; 3.51% crude fiber; and 28.7% carbohydrate. Crude fat declined from 13.59% control sample of 100% cow milk cheese to 8.62% of 100% cheese analogue. The mineral content of cheese samples showed a maximum values of 44.79 mg/kg calcium, 2.37 mg/kg potassium and declined as there was increase bambaranut milk substitution in the cheese samples, while 8.11 mg/kg iron, 3.01 mg/kg zinc, 9.40 mg/kg phosphorous and manganese of 1.52 mg/kg highest value in each cases among the samples. The results showed the potential of bambaranut as alternative source of milk analogue in cheese with improved nutritional values and percentage yield.

Keywords: Analogue, bambaranut-milk, cheese, nutritional, warankashi, yield

INTRODUCTION

Milk has been recognized as an important food for infant and growing children (Obizoba and Anyika, 1995), because milk is an excellent source of nutrients such as vitamins, amino acids, fats, minerals, proteins and sugar, making it an excellent medium for microbial proliferation (Akinyele *et al*., 1999). In developing countries, the cost of dairy milk and their products e.g., 'nono', cheese etc. are beyond the reach of common man. The high cost of milk in developing countries has led to the development of alternative source of milk from plant materials (Singh and Bains, 1988). An inexpensive substitute in the form of a milk and cheese analogue or beverage made from locally available plant foods, high in protein, with satisfactory quality milk could play an important role to reduce protein malnutrition. In many tropical regions of sub-saharan Africa (except East Africa), the production of milk and milk products are limited, scarce and expensive (Fashakin and Unokiwedi, 1992). A remedy could be sought through extending fresh cow milk with vegetable milk from legume in the production of a traditional cheese-like product 'Warankashi. This could offer very cheap sources of vegetable milk, which can be used as substitutes for whole milk in the production of cheese curds.

Fashakin and Unokiwedi (1992) succeeded by using extracted soymilk blended with fresh milk in cheese production. Substitution of animal proteins with plant proteins affects the yield, microbial count and acceptability of extended 'Warankashi' (Aworh and Akinniyi, 1989). Metwalli *et al*. (1982) work on effect of soymilk on rennet coagulation property, organoleptic and chemical properties of cheese made from mixtures of soymilk and whole milk showed significant differences between 'Warankashi' and 'Soy-warankashi', while Aworh and Akinniyi, (1989) reported no significant difference in overall acceptability.

Bambara groundnut is the third most important grain after groundnut and cowpea. In separate reports by Ezue (1977) and Atiku (2000), it was noted that in Nigeria bambara groundnut is widely produced in Borno, Anambra, Plateau, Taraba, Sokoto, Bauchi, Benue, Kano, Yobe, Adamawa and Gombe states. Goli (1997) reported that Bambara groundnut contains about 63% carbohydrate, 19% protein and 6.5% oil and is

Corresponding Author: I.I. Adedokun, Department of Food Science and Technology, Imo State University, Owerri, Imo State, Nigeria

consumed in different forms. Akanni *et al*. (2000), Atiku *et al*. (2004) and Linnemann (1988) stated that the seed of bambara groundnut can be used for baby food, human consumption, industrial products and for animal feed. Linnemann (1990) reported that bambara groundnut flour has been used in making bread in Zambia and Brough *et al*. (1993) noted that the milk prepared from bambara groundnut gave a flavour preferred to that of milk from cowpea, pigeon pea and soybean. Despite this economic importance, no commercial production and industrial use of this crop have taken place in Nigeria. According to Akanni *et al*. (2000), research is concentrated only on the agronomic aspect, while post-harvest technology of the crop aspects has been neglected. Among the sources of vegetable milk, soybean has received very high research is attention and more research still being designed to improve the quality of soymilk (Sun-Young *et al*., 2000). Little reseacrh attention has been given to bambaranut as source of vegetable milk despite its high nutritional values and annual yield in Nigeria and other sub-saharan Africa.

This present research work aimed toward exploiting the potentials of Bambaranut milk in cheese making and investigating the effect substitution on nutritional characteristics and yield of cheese.

MATERIALS AND METHODS

Materials collection and preparation: Sodom apple leaves and fresh cow milk was obtained from a nomadic Fulani settlement located within Ago-Are town in Atisbo Local Government Area of Oyo State, Nigeria. The fresh cow milk was collected from the animal aseptically and packaged in a sterile white plastic container and placed in a cooler containing ice crystal to prevent post harvest contamination and increase in storage temperature during long transportation. Bambara groundnut ('Nav Red' variety) was purchased from Ama-Hausa market in Owerri metropolis, Imo State, Nigeria.

Preparation of bambaranut-milk: The method described by Igyor *et al*. (2006) for production milk substitute was modified in the extraction of bambaranut milk. The nuts of bambaranut 'Nav Red' variety was manually sorted cleaned with portable water and soaked in (4:1 w/v) portable water for 24 h, while water used in soaking was changed at every 6 hours interval during the soaking duration. The seed coat of the nuts was dehulled after 24 h of soaking by rubbing the seed within the palm and sieved the husk out of the water and wet milled using hammer mill. Cheese muslin cloth was used in the extraction of milk from the bambaranut mash. The extract liquor was filtered three times to obtain clearer milk and stored in a sterile white container for further use.

Production of Cheese -'Warankashi': The procedure described by Igyor *et al.* (2006) was modified in the production of cheese-'Warankashi'. Cheese samples with added bambarant milk were formulated by partial substitution of cow milk with bambaranut-milk at

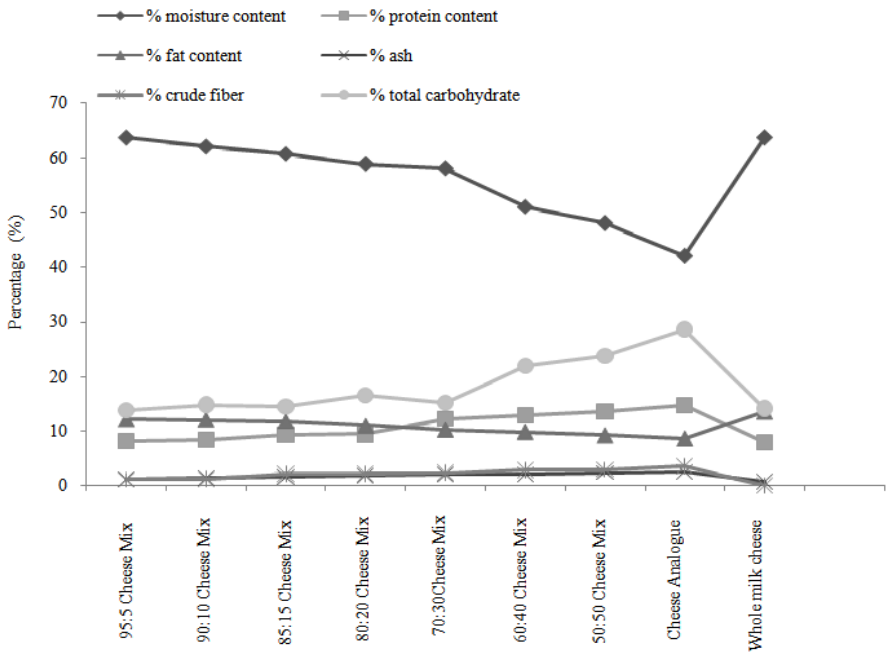

Fig. 1: Proximate composition of cheese with added bambaranut milk

varying proportion range from 0, 5, 10, 15, 20, 30, 40 and 50%, respectively (v/v) which was also in accordance with methods described by Aworh *et al*. (1987) and hundred percent (100%) cow milk Warankashi was produced as reference sample. The blends and control samples were fermented with 4% juice extract of Sodom apple leaves (enzyme). The extracted juice of Sodom apple was added into each formulated blends and the control at ratio 1:9 (v/v of juice and blend or milk mix) respectively. Each mixture was mixed thoroughly and heated slowly at the rate of 1ºC/min in a water bath (Gallemkamp, UK) with a shaker (Citenco Ltd Herts, UK) maitained at 50rpm until a temperature of 70^0C was reached. After heating for about 20 min and adjusting the pH of the mixture to 6.5, a yellowish grey liquid-whey and transparent scum-curd was precipitated. The mixture was filtered to remove the scum and floating dirt. The curd was cooked further for five (5mins) minutes, strained with several layers of cheese muslin cloth and returned to the whey liquid. The curd from each blend was finally molded and cut into rectangular shapes ($1\times2\times2.5$ cm^3). The illustration of the process flow chart is shown in Fig. 1 aseptically packaged, stored frozen for further analytical works.

Determination of percentage yield: This was determined by method described by Igyor *et al*. (2006). The yield of 'Warankashi' from cow milk-bamabara blends/mix and whole cow milk was determined by calculation as follows:

$$\text{Yield of Warankashi (\%)} = X_2/X_1 \times 100/1$$

where,

X_1 = Vvolume (mL) of Bambaranut-cow milk or whole cow milk used

X_2 = Weight (g) of 'Warankashi' (either from blends or whole cow milk) produced. (Assume 1gm =1 mL)

Proximate and mineral analysis: The standard method of the A.O.A.C. (2000) was used for the analysis of percentage protein, crude fat, ash content, crude fiber, moisture content. Total carbohydrate was determined by the differences: % Carbohydrate = 100-[% protein+% fat+% Ash+% Crude fiber]. The methods described by Onwuka (2005) was used in the determination mineral elements such as Ca, Fe, K, Zn, P and Mn using Flame photometer and atomic absorption spectrophotometer.

Statistical analysis: The data obtained from different analyses were subjected to various statistical analyses which include simple descriptive mean and standard deviation, Analyses of variance (ANOVA) and Duncan's multiple range tests was used to separate the means using SPSS 17.0 Software Inc. USA.

RESULTS AND DISCUSSION

Proximate composition of cheese produced with added bambaranut milk: The proximate composition of cheese produced with added Bambaranut milk Table 1 (which also described in Fig. 1) showed significant difference ($p<0.05$) in all the parameters evaluated. This significant difference observed may be associated to added bambaranut milk at varying proportions with raw whole milk during cheese making. The moisture content was highest (63.80%) in control sample (100% raw milk cheese) followed by 63.78% of cheese with 5% added bambaranut milk. The significant effect of added Bambaranut milk on moisture content of cheese showed effect from 10% bambaranut milk substitution and declined to 48.12% moisture of sample with 50% added bambaranut milk. This result showed the effects of increasing addition of bambaranut milk on the moisture content of cheese. The cheese analogue of 100% bambaranut milk had the least (42.11%) moisture content. The result obtained is similar to those earlier reported by Aworh and Akinniyi (1989) and Fashakin and Unokiwedi (1992), who reported 61.13% and 60.8% respectively. However, Egan *et al.* (1981) and Frazier and Westhoff (1988) had stressed that the moisture content is a measure of the water content and accounts for the texture of the cheese. Smith (1990) stated that one of the main differences between processed cheese and processed spread

Table 1: Proximate composition of 'Wara' a local cheese produced with added bambaranut milk

Cheese blend cow- bambara	*M.C%	*Protein%	*Fat%	*Ash%	*Crude fiber%	*CHO%
95%-5% Mix	63.78±0.01a	8.12±0.03e	12.14±0.06b	1.09±0.01c	1.05±0.01e	13.82±0.04e
90%-10%Mix	62.16±0.04b	8.34±0.04e	12.09±0.01b	1.39±0.01c	1.18±0.01e	14.84±0.01e
85%-15%Mix	60.80±0.03c	9.14±0.03d	11.81±0.01cd	1.55±0.02bc	2.11±0.01d	14.59±0.02e
80%-20%Mix	58.94±0.04d	9.34±0.04d	11.10±0.02c	1.85±0.01b	2.17±0.01cd	16.60±0.08d
70%-30%Mix	58.13±0.04d	12.15±0.04c	10.25±0.04d	1.93±0.01b	2.29±0.01c	15.25±0.05e
60%-40%Mix	51.10±0.02e	12.90±0.03c	9.85±0.01e	2.05±0.01ab	2.81±0.01b	21.92±0.04c
50%-50%Mix	48.12±0.04f	13.61±0.01b	9.21±0.04e	2.35±0.02a	2.90±0.01b	23.81±0.05b
0%-100%Mix	42.11±0.04g	14.69±0.01a	8.62±0.03f	2.51±0.01a	3.50±0.01a	28.57±0.06a
100% (control)	63.80±0.02a	7.86±0.04f	13.59±0.01a	0.58±0.01d	ND	14.17±0.05e

Mean of samples with different superscript letter are significantly different ()

*:Mean of triplicate values; ±: standard deviation M.C moisture content; CHO total carbohydrate; ND- Not Detected

Table 2: Percentage yield and mineral content of cheese produced with added bambaranut milk

Cheese blends cow- bambara	Yield (%)	Ca (mg/kg)	Fe (mg/kg)	K (mg/kg)	Zn (mg/kg)	P (mg/kg)	Mn (mg/kg)
95%-5% Mix	28.56	43.89	1.85	2.37	0.68	2.21	1.23
90%-10%Mix	29.42	43.0	1.98	2.13	1.18	3.22	1.27
85%-15%Mix	30.58	30.58	2.68	1.86	1.52	3.28	1.30
80%-20%Mix	33.60	30.11	3.60	1.80	2.32	4.18	1.37
70%-30%Mix	37.12	20.07	5.45	1.17	2.36	7.55	1.40
60%-40%Mix	40.22	17.03	5.90	1.14	2.81	7.73	1.40
50%-50%Mix	41.11	17.0	6.08	1.10	2.88	7.80	1.43
0%-100%Mix	52.86	8.80	8.11	0.86	3.01	9.40	1.52
100% (control)	28.05	44.79	0.98	2.13	0.68	2.18	1.30

product and analogue is the level of moisture content in the product, which affects its rheological factor. Furthermore, the result agreed with the finding of Uaboi-Egbenni *et al*. (2010). The trends observed on protein content of cheese showed increment as affected by increasing proportions of bambarnut milk.

The protein content (14.69%) of the cheese analogue sample was significantly different ($p<0.05$) from cheese samples with added bambaranut milk (5-50%) and the control whose protein increase from 8.12-13.6% respectively. The cheese analogue sample of 100% bambaranut milk showed the highest (14.69%) protein while the control sample of 100% cow milk was the least (7.86%). The indication from these results implied that the addition of bambarabut milk from 5% proportion will significantly ($p<0.05$) increase the protein content of the cheese. The protein values discovered in this study were higher than those reported by earlier researchers on cheese and these values are 5.33% (Frazier and Westhoff, 1988) and 12.86% (Uaboi-Egbenni *et al*., 2010), but lower than the findings of Fashakin and Unokiwedi (1992) who reported 44.5% protein of cheese with added melon milk. This variation in high protein content of the samples in this study may be attributed to potential influences of vegetable source of protein in cheese (served as a cheaper source when compared to 100% whole milk cheese) whose its consumption will help eliminate protein deficiencies that have become the bane of poor nations, Nigeria inclusive.

On the contrary, the trend observed in fat content of cheese samples was found differed from that of protein, the control sample had the highest (13.59%) fat content. Cheese samples with added bambaranut milk (5-50%) declined in fat contents from 12.14-9.21 respectively. Cheese analogue sample of 100% bambaranut milk showed least (8.62%) fat content. However, this variation was found significant ($p<0.05$) and the result may be associated partly to the varying proportions of bambaranut milk used in the production and partly due to the level and nature of fat in Bambaranut used. Akande *et al*. (2009) recorded a range of 7.15-8.31% fat for raw and roasted bambaranut. The value of fat found in this study was closely related to 13.4% fat recorded by Uaboi-Egbenni *et al*. (2010). Significantly, fat is important as a source of energy in human body (Onyeka, 2008). The ash content in foodstuffs is a measure of mineral element in food. The ash content of cheese samples varied significantly ($p<0.05$) and increased among the cheese samples with increasing proportion of added bambaranut milk. The control sample had 0.58% the least while cheese with added bambaranut milk increased from 1.09-2.35% of ash content (5% and 50% proportions of added Bambara nut milk respectively). The cheese analogue of 100% bambaranut showed the highest value of 2.51% of ash. Uaboi-Egbenni *et al*. (2010) reported 0.6% ash content for fermented cheese sample. Similar sequence was observed on the crude fiber of cheese samples, the value increased from 1.05% to 2.90%, the cheese analogue had 3.51% the highest values. Total carbohydrate determined by difference ranged from13.82-23.81% among the samples with added bambaranut, cheese analogue had 28.57% and these values were higher (14.17%) than the control sample. Similar observation was reported by Fasakin and Unokiwedi (1992) during the chemical analysis of cheese from milk and melon milk. The investigation on proximate composition in this study has showed the potential influence of added bambaranut milk as cheap source in improving the nutritional value of cheese 'Warankashi.

Percentage yield and mineral content of cheese produced with added bambaranut milk: The percentage yield and mineral content of cheese with added bambaranut milk was presented in Table 2. The observation from the result showed an increased in percentage yield of cheese samples from 28.05% of control sample of 100% cow milk to 41.11% of cheese produced with 50:50 proportion of cow-bambara mix, cheese analogue of 100% bambaranut recorded the highest (58.86%) yield. The indication from this observation shows the influence of added bambaranut milk on the percentage yield of cheese. This result was not in line with the findings of Igyor *et al*. (2006) who reported decline in percentage of cheese as there was increase in soymilk supplementation in cheese (30.50-

15.50% for 100% cow cheese and cheese with 75% soymilk supplementation). Fashakin and Unokiwedi (1992) reported that yield remained relative constant with levels of soy substitution. Observation from percentage yield may be dependent on the level of available protein for curdling by enzyme. This result was further supported by the amount of protein discovered in cheese samples (Table 1). Again, Fox (1993) stated that principles of cheese making involves the removal of water from milk with a consequent six- to tenfold concentration of the protein, fat, minerals and vitamins by the formation of a protein coagulum that then shrinks to expel 'Whey'.

The mineral content of cheese examined showed the limits of 8.8-44.79 mg/Kg calcium and 0.86-2.37 mg/Kg potassium, both mineral elements declined as there was increase in added bambaranut milk in cheese. On the contrary to this observation, iron, zinc and phosphorous content increases with a range of 0.98-8.11, 0.68-3.01, and 2.18-9.40 mg/Kg, respectively. The manganese was found in traces at the range of 1.23-1.52 mg/Kg. The changes in minerals content may be as a result of using two different raw materials of different origin (plant and animal origins) at varying proportions of substitution. However**,** Onyeka (2008) reported that mineral elements are inorganic matters that play important roles in human nutrition and their inadequacy may result to nutritional disorder.

CONCLUSION

The technology of processed cheese making, including analogues, has evolved dramatically over the past century. It was to some extent an art, where manufacturers tended to blend different cheeses using various materials, milk analogue from vegetable origin and spice extracts to modify or impact certain characteristics of the cheese and this based largely on experience. Cheese making in West Africa especially in Nigeria is largely dictated by tradition. The indication from this research study further showed the possibility of using milk analogue from vegetable source such as bambaranut in cheese production. The percentage yield, nutritional value and mineral content discovered on cheese samples will improve the nutritional well-being of the populace from Nigeria and other developing countries.

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