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Effect of Different Blends of Cow -Soy Milk on Yield, Nutritional and Organoleptic Characteristics of West Africa Soft Cheese (*Wagashie*)

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Abstract

The aim of this study was to assess the effect of blending different proportions of cow-soy milk on the fresh curd yield and physico-chemical characteristics of West Africa soft cheese (WASC). The average fresh curd yields of WASC were significantly different ($p < 0.05$) and ranged between 174.6 – 210.1g/l of milk. Generally, the yield of curd decreased with increasing proportion of soy milk. The average moisture contents of the WASC were between 48.10 ± 6.1 and 68.80 ± 4.5. The moisture values of the products increased with increasing percentage of soy milk and vice versa. The average crude protein (CP) contents of WASC were in the range of 11.12 ± 1.1 % and16.37 ± 0.3%. The CP values of products T3 and T4 were significantly ($p < 0.05$) higher than products T1, T2 and T5. The crude fat content of all the WASC products were significantly different and varied between 5.88 ± 1.1% and 28.34 ± 0.5%. The inclusion of25%, 50% and 75% soymilk reduced fat content WASC by 23.0%, 57.8%, and 60.6% respectively. The total ash contents of WASC products were significantly similar ($p > 0.05$). The predominant essential macro-minerals present in the products ere calcium (1312.5 – 1318.7 mg/kg), phosphorus (1034.0 – 1040.6mg/kg), sodium (901.0 – 907.0 mg/kg) and potassium (247.8 – 252.0 mg/kg. The colour, flavour, taste and overall acceptability of WASC products were significantly affected by the proportions of cow-soy milk used to manufacture the milk products.

Keywords*:* *Curd yield, formulated milk, nutritional composition, organoleptic, West Africa soft cheese*

INTRODUCTION

The West Africa soft cheese (WASC) commonly known as *wagashie* is one of the local dairy products that have high market demand in Northern parts of Ghana. The West Africa cheese is typically unripened and soft cheese made by coagulation of cow milk using rennet enzymes from the plant known as Sodom apple (Belewu and Aina, 2000; Chikpah *et al*., 2014). Cheese making is a process of concentrating solid constituents in milk. Therefore, the WASC product is an excellent source of nutrients such as proteins, fats, and minerals for adults and children. Some poor women in rural communities of Northern region and Northern part of Volta region of Ghana engage in the processing and sale of WASC products as their source of income (Personal communication).

Like other countries, cow milk is the major milk used for WASC making in Ghana. The milk is mainly supplied by the Fulani herdsmen in the rural communities. There is however, limited supply of cow milk for curd making which may be attributed to small volumes of milk production per animal and the small number of lactating cows. Furthermore, the unwillingness to accept Fulani herdsmen in some rural communities in Ghana is expected to have negative impact on cow milk supply. Therefore, there is the need to search for alternative sources of cheap but readily available, and high nutritional quality milk to supplement the limited supply of cow milk. Soy milk is reported to have great potentials to supplement cow milk (Merritt and Jenks, 2004). The soybean is readily available for milk production and contain high quality protein and essential amino acids (Derbyshire *et al*., 1976); essential minerals and vitamins (O'Conner, 1993). Soymilk was reported to contain phytochemicals that have anti-tumor activity and prevent cancer (Steinmetz and Potter, 1991); prevent high blood pressure and cardiovascular diseases (Messina and Messina, 2003). In Ghana, soymilk is been used for soy curd manufacturing (Chikpah *et al*., 2015). However, its full potentials are still underutilized. Therefore, the aim of this research was to determine the effect of blending different proportions of cow milk with soymilk on the curd yield, nutritional composition and organoleptic characteristics of West Africa soft cheese known as "*wagashie*".

MATERIALS AND METHODS

Cow milk collection and milk pretreatment

Fresh whole cow milk was purchased from the farm of a herdsman in the Gbung community in the East Gonja District of the Northern region in May, 2015. The milk was collected into an ice box containing ice and quickly transported to the Food Technology laboratory of the Faculty of Agriculture, University for Development Studies. The milk was then pasteurized at 70 ^{o}C for 15 minutes before use.

Soybeans and milk extraction

Soybeans used for the soy milk extraction was purchased from the Tamale Central market in the Northern Region of Ghana in May, 2015. The soybeans were cleaned of all foreign materials before the milk extraction. Each batch of soymilk extraction was done using 3 kg of soybeans as described by Chikpah *et al*. (2015) with few modifications. In this study, the distilled water added to the blended soybeans was reduced to 9 litres instead of 12 litres as reported by Chikpah *et al*. (2015). Approximately, seven (7) litres of soymilk was extracted from the three kilograms of soybeans.

Preparation of milk coagulant

Sodom apple *(Calotropis procera*) extract was used as the milk clotting agent. The fresh leaves and stems of *C. procera* plant were harvested from plants growing on the Nyankpala campus of the Faculty of Agriculture, University for Development Studies in May, 2015. The plant extracts were prepared based on the procedure described by Chikpah *et al*. (2014) with few modifications. In this experiment, different proportions of the plant leaves (50 grams) and stems (100 grams) were used. The less proportion of leaves used as compared to the stems was to reduce the green coloration and bitterness of the plant material on the West Africa soft cheese products.

Formulation of cow and soy milk mixtures and manufacturing of soft cheese products

Five (5) different blends of cow and soymilk: 100:0, 75:25, 50:50, 25:75 and 0:100 cow: soy milk (vol/vol) were formulated and were used to manufacture West Africa soft cheese (WASC) products: T1, T2, T3, T4 and T5 respectively as shown in Table 1. The appropriate quantities of each milk type were measured into separate 3 litre clean-plastic containers and stirred thoroughly using a clean wooden spoon for proper mixing. Each of the formulated milk samples was used for the preparation of WASC products according to the method described by Chikpah *et al.* (2014) with modification: In this study, immediately after the curd was separated from the whey, excess whey was drained from the raw curd by applying a weight of approximately 2 kg for 30 minutes.

Table 1: West Africa soft cheese (WASC) and the proportions of soy and cow milk used

WASC Product	Proportions of raw milk used	
	Cow milk (% vol)	Soy milk (%vol)
T1 (control)	100	0
T2	75	25
T3	50	50
T4	25	75
T5	0	100

T1, T2, T3, T4 and T5 represent WASC products made from 100:0, 75:25, 50:50, 25:75 and 0:100 cow: soy milk (vol/vol) respectively.

Data collection

The parameters that were determined included: fresh curd yield, nutritional composition and organoleptic characteristics of West Africa soft cheese. All measurements were done in triplicates.

Measurement of fresh curd yield

The fresh yield (weight) of the final curd after removal of excess whey was determined by the used of an electronic balance (Sartorius, TE 612). The average weight of the curds produced from the three different preparations of WASC was calculated and used as the mean yield of curd for each treatment. The yield of WASC was recorded as fresh weight of curd (g) per litre of milk.

Nutritional analysis

Proximate Analysis

The moisture, crude protein, fat and total ash of the WASC products were determined according to the procedure described by AOAC (1990).

Mineral analysis

Macro – minerals including calcium, potassium, magnesium, sodium, and chlorine, and micro-minerals such as iron, manganese, copper, zinc, and molybdenum concentrations in WASC samples were determined.

All the WASC samples were oven dried at 60 ^{o}C until constant weight was obtained. The dried samples were grinded separately using a laboratory mortar and pestle and one gram of each sample was taken and subjected to wet digestion method as described by Richards (1968). The analysis for calcium, potassium and sodium were done through flame photometer (JENWAY, PFP7 Flame photometer) while magnesium, zinc, copper, iron, manganese and molybdenum were analysed using an atomic absorption spectrophotometer (Perkinelmer, Analyst 400) according to the procedure described by AOAC (1990). Phosphorus concentration was determined using Spectrophotometer (JENWAY, 730 Spectrophotomer) in accordance with the method described by Kitsonand Mellon (1944).

Chloride concentration in samples was determined by the silver nitrate method of Mohr's Titration described by Sawyer *et al.* (1994). Briefly, 1 mL of each of the digested sample was measured separated into different 100mL beakers and was made alkaline by adding calcium carbonate about 0.08g to each. Then 1 drop of potassium chromate solution was added as indicator. It was then titrated against silver nitrate drop-wise until end point (precipitate of brick red color) was reached. Blank titration (without WASC sample) was carried out by the same procedure described above until end point was determined. The chloride concentration was then calculated as follows:

$$Cl^{-} = \frac{(V1-V2)*1000}{\text{Volume of sample}}$$

Where
V1 = Volume of silver nitrate used to titrate sample
V2 = Volume of silver nitrate used titrate for blank

Organoleptic properties assessment

The flavour, colour, texture, taste, and the overall acceptability of the West Africa soft cheese (WASC) products were evaluated. A total of 21 panellists consisting of unequal numbers of males and females of different ages (above 20 years) were randomly selected from the Department of Food Processing Technology and Family & Consumer Sciences in the Faculty of Agriculture, University for Development Studies, Ghana to evaluate the organoleptic characteristics of the WASC products. The selected panelists were educated on the product formulation and 15 panelists were finally selected and trained to carry out the organoleptic assessments. Sample of raw WASC products were used for colour and texture assessment while processed (fried) WASC samples were used for assessing the taste, flavor and overall acceptability of the products. The WASC samples were cut into small sizes (about 15 g each), wrapped in small pieces of aluminum foils and placed on clean small white plates coded with random 2 –digit numbers. Printed questionnaires were then given to the panelists and asked to assess the various WASC samples according to the five –point hedonic scale used by Sugri and Johnson (2009) as shown in Table 2.

Table 2: Five -point hedonic scale used to assess the organoleptic properties of the WASC samples

Scale	5	4	3	2	1
Taste	Extremely good	Very good	good	Slightly good	Poor /dislike
Flavour	Extremely strong	Very strong	Strong	Slightly strong	Off- flavour
Colour	Very green	Green	Pale green	Slightly green	Almost white
Texture	Very hard	Hard	Slightly hard	Soft	Very soft
Overall acceptability	Excellent	Very good	Good	Fair	Dislike/Poor

Sugri and Johnson (2009)

Statistical analysis

Statistical analysis was carried out using Minitab statistical software (version 17, free edition). The effect of blending different proportions of cow and soymilks on the curd yield, nutritional composition and organoleptic properties of WASC were tested using the general liner model (GML) method of analysis of variance (ANOVA), and the separation of treatment means was done using the Tukey's pairwise comparisons at 95 % confidence level.

RESULT AND DISCUSSION

Fresh yield of West Africa soft cheese (WASC) products

The yield of WASC products: T1, T2, T3, T4 and T5 were significantly ($p < 0.05$) affected by the proportions of cow and soymilk used for the product manufacturing. The WASC product

T1 (control) had the highest yield (210.1g/l) while product T5 recorded the lowest yield (174.6 g/l) as indicated in figure1. The average curd yields of products: T1, T2 and T3 were significantly similar ($p > 0.05$) but different from products T4 and T5. Generally, the yield of WASC decreased with increasing proportion of soy milk. The variations in the yield of fresh curd can be attributed to differences in milk composition since the composition of milk particular fat and protein contents affects cheese yield (Banks *et al.*, 1981; Fox *et al.*, 2000). This study confirmed the findings of Igyor *et al.* (2006) that cheese yield declined as there was increased in soymilk supplementation but disagreed with that of Fashakin and Unokiwedi (1992) that yield remained relative constant with levels of melon milk substitution. The average yields of WASC products recorded were within the ranges reported by Chikpah *et al.* (2014, 2015).

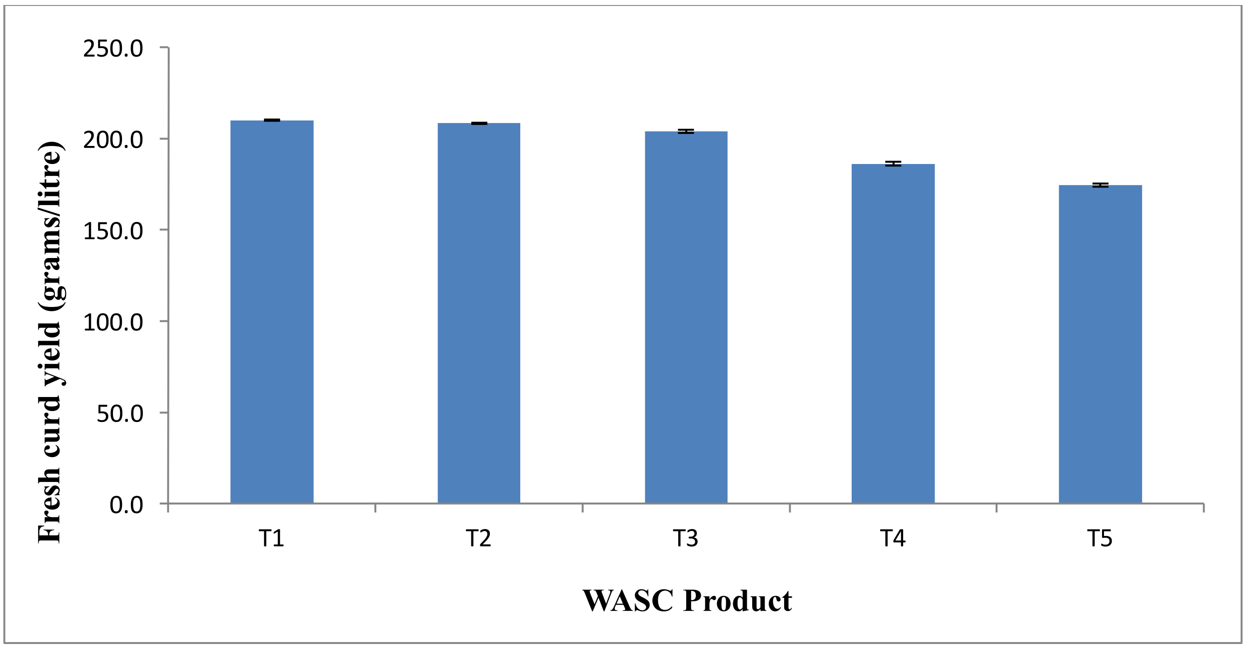

Figure 1: Average yield of WASC. Values are means of three replicates. Error bars represent standard errors of differences of means.

Proximate composition of West Africa soft cheese products (*wagashie*)

The moisture content, crude protein, total ash and fat content of the WASC samples are shown in Table 3. The moisture contents of WASC samples were in the ranged of 48.10 ± 6.08 % and 68.80 ± 4.53 %. The blending of cow-soymilk significantly ($p < 0.05$) influenced the moisture content of WASC products. The moisture content of products: T2, T3, T4 and T5 were significantly similar ($p > 0.05$) but were higher than the moisture content of product T1. Generally, the moisture content of WASC products increased with increasing percentage of soymilk. The addition of 25%, 50%, and 75% soymilk into cow milk caused an increase of about 25.7%, 28.5%, and 30.8% in the moisture content of products T2, T3, T4 and T5 respectively (Table 3). The relatively high moisture contents of WASC may be attributed to the high percentage of water contained in the soymilk. The moisture content of WASC products were lower than the values recorded in fresh cheese 700 g/kg (70 .0%) but similar to that of soft cheese (520 g/kg) which represent 52.0 % moisture (Sieber*et al.*, 2001).

The crude protein (CP) contents of WASC products were significantly different ($p < 0.05$) and the values ranged between 11.12 ± 1.07 % and 16.37 ± 0.31%. Products T3 and T4 had significantly higher CP content followed by products T1 while T2 and T5 recorded the least average CP values as shown in Table 3. The differences in the percentage CP of WASC products may be attributed to differences in chemical composition of the formulated raw milk samples. The Crude protein contents of the WASC products determined were higher than the protein values of fresh cheese (110g/kg, ~11 % protein) but lower than soft, semi –hard, hard and extra hard ripened cheese (Sieber*et al*., 2001). These differences may be attributed to variations in the milk composition and manufacturing processes.

Similarly, the average fat contents of all the WASC samples varied significantly ($p< 0.05$) and were in the ranges of 5.88 ± 1.11 % and 28.34 ± 0.46 %. The percentage fat was significantly higher in product T1 (control) and drastically reduced by 23.0%, 57.8%, and 60.6 % when 25%, 50%, and 75 % soy milk were added to cow milk respectively. This indicates that the average fat content of WASC samples decreased with increasing proportion of soymilk in cow milk and vice versa. The percentage fat recorded in the WASC products T1 and T2 were higher whereas T3, T4, and T5 were lower than the fat values of cheese (20 %) reported by Mustafa *et al*. (2013). With the exception of WASC product T5, all the other WASC products had higher fat values than that of fresh cheese (80g/kg) which represent 8.0% fat reported by Sieber*et al*. (2001). However, products: T2, T3, T4, and T5 had lower fat values as compared to the fat content (220g/kg = 22 % fat) of soft ripened cheese (Sieber*et al*., 2001). The differences in the fat content of the WASC products and fat values cheese reported by other author may be attributed to differences in milk chemical composition and cheese manufacturing procedures.

The proportion of soy and cow milk used for WASC production did not significantly ($p > 0.05$) affect the total ash content of the WASC products. The average ash contents in the products were between 2.43 ± 1.17 and 4.72 ± 0.39 %. The ash values were slightly high in products: T2 (4.72 %), T5 (4.24 %) and T1 (4.00 %) but a little lower in products T3 (3.19 %) and T4 (2.34 %). The ash values of the WASC products were similar to the average ash content (4.45 %) measured in other cheese (Mustafa *et al*., 2013).

Table 3: Proximate composition of West Africa soft cheese (WASC) products

WASC Product	**Nutritional composition (%)**			
	Moisture	**Protein**	**Fat**	**Ash**
T1	48.10 ± 6.1^{a}	14.32 ± 0.6^{b}	28.34 ± 0.5^{e}	4.00 ± 0.7
T2	61.40 ± 3.7^{b}	11.38 ± 0.1^{a}	21.83 ± 0.7^{d}	4.72 ± 0.4
T3	61.80 ± 5.1^{b}	16.37 ± 0.3^{c}	13.67 ± 1.9^{c}	3.19 ± 0.3
T4	62.90 ± 0.4^{b}	15.15 ± 1.3^{bc}	11.17 ± 0.2^{b}	2.43 ± 1.2
T5	68.80 ± 4.5^{b}	11.12 ± 1.1^{a}	5.88 ± 1.1^{a}	4.24 ± 1.1
SED	4.41	0.66	1.05	0.81
P- value	0.039	0.002	0.001	0.166

Mean value = mean ± standard deviation and are means of data from three replicate analysis.
SED = Standard error of differences of means; Means in each column with no superscript in common are significantly different ($p < 0.05$).

Table 4a: Average macro minerals concentrations in West African soft cheese products

Minerals	Concentration (mg/kg) in WASC samples						
	T1	T2	T3	T4	T5	Mean ± SD	P-value
Phosphorus	1038.0	1039.1	1034.0	1039.5	1040.6	1038.2 ± 2.5	0.991
Calcium	1313.4	1312.5	1316.2	1314.4	1318.7	1315 ± 2.4	1.000
Potassium	247.8	249.0	248.5	250.0	252.0	249.5 ± 1.6	0.994
Sodium	901.0	907.0	906.0	905.0	903.0	904.4 ±2.4	0.993
Magnesium	15.0	23.0	16.7	18.0	20.3	18.6 ± 3.1	0.879
Chloride	49.0	47.0	54.0	52.0	49.0	50.2 ± 2.8	0.903

Values are averages three replicate. SD = Standard deviation.

Table 4b: Average micro minerals concentrations in West African soft cheese products

Mineral	Concentration (mg/kg) in WASC samples						
	T1	T2	T3	T4	T5	Mean ± SD	P-value
Iron	35.9	36.3	36.7	35.4	36.0	36.1 ± 0.48	0.945
Manganese	3.0	3.1	3.1	3.2	3.3	3.1 ± 0.11	0.978
Zinc	ND	ND	ND	ND	ND	-	-
Molybdenum	22.0	23.0	28.0	28.0	27.0	25.6 ± 2.9	0.080
Copper	ND	ND	ND	ND	ND	-	-

ND = Not detected.

Organoleptic properties of West African soft cheese (WASC) products

The average scores of the following organoleptic properties: colour, flavour, taste, and overall acceptability of WASC products are shown in Table 5. The colour, taste, flavour and overall acceptability of the WASC were significantly ($p< 0.05$) influenced by the proportions of cow and soy milk. The colour of productsT1 (control) and T2 were slightly green whereas Products T3, T4 and T5 were almost white according to the hedonic scale described in Table 2. Generally, the colour of WASC changed from slightly green to almost white as the proportion of soy milk increase. Therefore, the slightly green nature of products T1 and T2 may be attributed to the high proportions of cow milk as reported by Nozière*et al.* (2006).

The flavour of products T1 and T2 were strong while that of T3, T4 and T5 were slightly strong. It was observed that increasing the proportion of soy milk had reducing effect on the flavour of WASC product. The differences in flavour of WASC products may be as a result of the variations in the fat contents of the products since fats in food products have significant influence on product flavour Saxby (1996). The flavour of products T3, T4, and T5 were similar to the flavour of soy curd reported by Chikpah *et al*. (2015).

The taste of WASC products scored between slightly good and good. Product T1, T2, T3 and T4 were significantly the same ($p > 0.05$) but were different from product T5. This implies that the addition of 25, 50 and 75 % soymilk to cow milk had no significant influence on the taste of WASC products. The textures of the WASC ranged between soft and slightly hard.

However, the overall acceptability of the WASC products were significantly affected ($p < 0.05$) by the proportions of cow and soy milks used. Generally, product T1, T2, T3, and T4 had outstanding organoleptic properties than product T5 which was prepared using solely soy milk.

Table 5: Organoleptic characteristics of West African soft cheese (*wagashie*)

Product	Organoleptic properties				
	Colour	Texture	Taste	Flavour	Overall acceptability
T1	2.0^{a}	2.8	2.9^{a}	2.7^{a}	3.2^{a}
T2	2.0^{a}	2.3	2.9^{a}	2.6^{ab}	2.9^{a}
T3	1.4^{b}	2.5	2.9^{a}	2.3^{abc}	3.1^{a}
T4	1.2^{b}	2.5	2.6^{a}	2.2^{bc}	2.9^{a}
T5	1.1^{b}	2.3	2.0^{b}	1.9^{c}	2.2^{b}
SED	0.21	0.22	0.25	0.23	0.25
P- value	0.001	0.112	0.001	0.004	0.003

Mean value = mean ± standard deviation and are means of data from three replicate analysis.
SED = Standard error of differences; Means in each column with no superscript in common are significantly different ($p < 0.05$).

Conclusion and recommendation

The blending of cow soymilk influenced the fresh curd yield, nutritional composition and organoleptic properties of the West Africa soft cheese (WASC). Fresh curd yield reduced significantly when 75 % and 100 % soymilk were used. However, 25% and 50% soymilk inclusion gave similar curd yield compared to the control (100 % cow milk). The moisture of the WASC products increased while fat reduced with increasing proportions of soymilk in cow milk. Product T3 and T4 had higher crude protein contents. The following macro minerals: calcium, phosphorus, sodium and potassium were predominant in the WASC products. With the exception of colour, the organoleptic properties of WASC products T2, T3, and T4 were significantly similar to the control product (T1) Therefore it is conclusive that 25%, 50% and 75 % soymilk could be used to supplement cow milk without much negative effect on yield and physico-chemical characteristics on West Africa soft cheese (Wagashie) and hence help to address the problem of limited cow milk supply for cheese making in Ghana. However, improved methods should be used for soymilk extraction in order to reduce the water content of the milk.

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