

## Quality properties of yoghurt produced from cow milk and soymilk

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### Abstract

*The effect of base materials (whole cow milk, powdered milk and soymilk) on the physicochemical, microbial and organoleptic properties of yoghurt were determined in a nested procedure of completely randomized experimental design. The results showed that significantly ( $P < 0.001$ ) higher titratable acidity and total fats values of 2.09% and 3.07% were recorded on whole cow milk yoghurt (WCMY) and lower values of 1.46% and 2.07% recorded on soymilk yoghurt (SMY), respectively. The total solids of 13.40% obtained on SMY was significantly different ( $P < 0.001$ ) from 16.00% and 15.74% obtained on WCMY and powdered milk yoghurt (PMY), respectively. The total protein of PMY (3.48%) was the highest and significantly different from the 3.03% obtained on WCMY, which was also different from the 2.96% obtained on SMY. No significant difference was recorded on total microbial load due to base material. The Ca values of WCMY (1.704 to 2.086 g/l) were higher than those (1.101 to 1.282 g/l) of PMY, which were higher than those (0.512 to 0.564 g/l) of SMY ( $P < 0.05$ ). The concentration of Cu in SMY produced with 2.5 g/l inoculant was significantly the highest. The taste of PMY rated pleasant (3.4) was significantly ( $P < 0.001$ ) higher than those of WCMY rated fair (2.5) and SMY rated indifferent (2.0). Also the overall acceptability rating of 3.5 (between fair and pleasant) for PMY was significantly ( $P < 0.001$ ) higher than ratings for WCMY and SMY (2.5 and 2.1, respectively). It was concluded that qualitative and acceptable yoghurt could be produced from the three base materials.*

**Keywords:** Quality properties of yoghurt, cow milk and soymilk

### Introduction

Yoghurt, a cultured dairy product obtained by souring of milk using a pure culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (FAO, 1990) can be manufactured from liquid cow milk, powdered milk and vegetable milk (soymilk) as base material. Earlier works to improve the keeping quality of milk have studied the local production, quality and characteristics of 'nono', a locally consumed fermented sour milk (Eka and Ohaba, 1977;

Akinyanju, 1989; Jensen, 1992, Ibeawuchi and Dalyop, 1995; Zaria *et al.*, 1998), which is widespread in the sub-humid and semi-arid areas of Nigeria.

Dairy farmers in Nigeria face the problems of ready outlet for their liquid milk product, especially during the rainy seasons, when milk is most abundant and low income during the dry seasons when milk is scarce. Thus, producers have to rely on products with greater storage stability, such as yoghurt.

Soy milk, an alternative source of quality protein, is commonly characterized as having beany off-flavour, this can be improved by lactic acid fermentation of yoghurt-like product such as soy milk yoghurt (Lee *et al.*, 1990).

The spread and level of demand of dairy products in Nigeria, as well as cost of importing the products, demand that efforts be made to produce the dairy products locally. Information on processing techniques and quality properties of yoghurt in Nigeria has been very scanty. The current research was designed to provide information on the physicochemical, microbial and organoleptic properties of yoghurt produced from different base materials (whole cow milk, powdered milk and soy milk).

## Materials and Methods

### *Sources of Milks Used in the Study*

Whole cow milk obtained from a peri-urban dairy herd of Bunaji breed of cattle at outskirts of Bauchi metropolis was used for the study. Partially skimmed milk powder (Damo brand) was obtained from the Central Market, Bauchi. The milk powder was reconstituted by mixing 1.0 kg with 3 litres of water (at 25° to 30°C) until a smooth paste was obtained, followed by 5 litres of hot water (at 85°C) with continuous mixing (Tamime and Robinson, 1989; Kordylas, 1991; Muhammad and Abubakar, 2001). Soy milk was extracted (Nelson *et al.*, 1976; Metwalli *et al.*, 1982a; Iwe and Agu, 1993) from soybean (*Glycine max* (L.) Merr) variety obtained from the Railway market in the outskirts of Bauchi metropolis. The percentage composition (moisture, protein, fat and ash) of the whole cow milk (WCM), reconstituted powdered milk (PM) and soy milk (SM) were determined according to the methods of AOAC (1990) and Egan *et al.* (1981). The carbohydrate contents are calculated as a difference in the percentages.

### *Yoghurt Processing*

Samples of WCM, PM and SM were processed into whole cow milk yoghurt (WCMY),

reconstituted powdered milk yoghurt (PMY) and soy milk yoghurt (SMY), respectively according to the methods of Nelson *et al.* (1976), Tamime and Robinson (1989), FAO (1990) and Muhammad and Abubakar (2001). The three base materials were inoculated with dried lactic culture (MC-380 DVS by Chr Hansen's Laboratory, Inc) of *L. bulgaricus* and *S. thermophilus* at 2.5, 5.0 and 10.0 g/l inoculation concentrations. The inoculation was done after pasteurization at 65°C for 30 minutes and cooled to inoculation temperatures of 25°C and 45°C. After coagulation the yoghurt samples were homogenized using a blender (Phillips, Type HR 2815i), with addition of 30 g/l sugar (sucrose), 50 ml/l pineapple flavour, 0.5% thickner solution and 120 mg/kg benzoic acid. The samples were labeled and packaged into 200 ml plastic containers and stored at 6 to 10°C.

### *Physicochemical and Microbial Analysis*

The yoghurt samples were analyzed for titratable acidity (% lactic acid) as described by AOAC (1990) and O'Connor (1995), total solids, total protein, total fats (Werner-Schmid method) according to the procedures of Egan *et al.* (1981) and ash (AOAC, 1990). The mineral composition of the ash was determined using Atomic Absorption Spectrophotometre (AGP model 210). The pH of the samples were measured using Cyberscan 20<sup>PH</sup> pH-meter.

The total microbial loads of the stored yoghurt samples were enumerated as described by Matalon and Sandine (1986) and Singleton (1999). Inoculated plates were incubated for 48 hours at 38°C and the results were recorded as colony forming units (cfu/l) of yoghurt.

### *Organoleptic Assessment*

Yoghurt samples were randomized and randomly numbered panel of 5 trained judges evaluated the 21 days old yoghurt on a scale ranking of 1 = poor, 2 = just acceptable (indifferent), 3 = fair, 4 = pleasant, 5 = good, 6 = very good and 7 = excellent, for taste, aroma, colour, texture and overall acceptability (Williams, 1982). All samples were served in plastic cups and were

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allowed to reach the temperature of 10°C before evaluation.

### Experimental Design and Statistical Analysis

The experiment was conducted in a nested design with two inoculation temperatures (25°C and 45°C) nested within three inoculation concentrations (2.5, 5.0 and 10.0 g/l) in each of the three base materials (WCM, PM and SM) to form an experimental unit. Each experimental unit with its two replications (Gomez and Gomez, 1984) were stored for 21 days.

The data obtained from the physicochemical, microbial and organoleptic assessments were subjected to analysis of variance (Gomez and Gomez, 1984; Muktar, 2003) in a completely randomized design. Means are differentiated using standard error (SE) and least significant difference (LSD).

## Results and Discussion

### Composition of Milk

The percentage composition of whole cow milk (WCM), reconstituted powdered milk (PM) and soymilk (SM) used to prepare the yoghurt in the

study are shown in Table 1). The moisture contents of PM (87.42%) and SM (90.40%) were higher than the 86.90% recorded on WCM, which could be attributed to processing method of the former two. Possibly the dilution levels were on the higher side. Metwalli *et al.* (1982b) recorded mean moisture contents of 91.01% and 91.36% for soymilk obtained using two different processing methods. Chang and Stone (1990) reported moisture contents of 90.27%, 91.34%, 92.23%, 93.02% and 93.60% for soymilk extracted using 1:6, 1:7, 1:8, 1:9 and 1:10 soybean: water extraction ratios, respectively. Skimmed milk powder was reconstituted with 90.5% (Tamime and Robinson, 1989) and 90.82% moisture for the production of non-fat and low-fat yoghurt (Trachoo and Mistry, 1998), respectively. The 86.90% moisture content of WCM obtained in the current study compares favourably with 87.55%, 87.15% and 87.59% reported by Ibeawuchi and Dalyop (1995) for bulk milk samples collected at three different locations in Plateau State, Nigeria. Water forms the bulk of milk and holds other components either in solutions or in suspension.

**Table 1:** Percentage Composition of the Milks Used to Prepare the Yoghurt

Component	WCM	PM	SM
Moisture	86.90	87.42	90.40
Fat	4.40	3.39	2.00
Protein	3.10	3.42	3.01
Milk sugar/carbohydrate <sup>1</sup>	4.90	4.95	3.93
Ash	0.70	0.82	0.66

<sup>1</sup>Calculated as difference

The highest fat content (4.40%) was obtained for WCM while the lowest was for SM. The PM had the highest percentage protein (3.42%), milk sugar (4.95%) and ash (0.82%), while SM had the lowest values of 3.01%, 3.93% and 0.66%, respectively. The fat content of WCM (4.40%) obtained was the same as the 4.40% quoted by Ensminger (1971) but slightly lower than the 4.77% reported by Akinsoyinu (1981), Ibeawuchi and Umoh (1990) and Ibeawuchi and Dalyop (1995) for Bunaji,

Bunaji-Friesian and Friesian cattle, respectively. The 3.39% milk fat obtained on the PM was higher than 1.34% recorded on skimmed milk retentate powder processed with no heat treatment by El-Samragy *et al.* (1993). The fat content of soymilk obtained (2.00%) compares with the 2.5% and 2.4% for soymilk obtained using two different processing methods (Metwalli *et al.*, 1982b). Iwe and Agu (1993)

**Table 2:** Effect of Base Material on the Physicochemical and Microbial Properties of Yoghurt

Properties	Base Material					
	WCMY	PMY	SMY	SE±	LS	LSD
TA	2.09	2.03	1.46	0.041	***	0.136
pH	4.55	4.70	5.11	0.025	***	0.084
TS	16.00	15.74	13.40	0.154	***	0.507
TF	3.07	1.90	2.07	0.021	***	0.070
TP	3.03	3.48	2.96	0.036	***	0.118
Ash (%)	0.74	1.03	0.73	0.006	***	0.0228
TML	65.84	65.24	65.17	3.010	ns	

LS = Level of significance (\*\*\*) -  $P < 0.001$ ; ns = not significant; TA = Titratable acidity (% lactic acid), TS = Total solids (%); TF = Total fat (%); TP = Total protein (%); TML = Total microbial load ( $\times 10^6$  cfu/ml)

reported a mean fat content of 2.3% for soymilk extracted from steam treated soybean.

The protein level of WCM (3.10%) and SM (3.01%) obtained in the current study confirmed values reported by other authors (Metwalli *et al.*, 1982a; Escueta *et al.*, 1985; Iwe and Agu, 1993). Tamime and Robinson (1989) reported protein content of 3.60% for reconstituted skimmed milk powder, which is slightly higher than the 3.40% obtained in this study. The difference could be attributed to possible difference in reconstitution techniques. The act of concentrating milk through partial removal of fat increases percentage protein. The carbohydrate and ash contents of WCM (4.90% and 0.70%) and PM (4.95% and 0.82%) were higher than those of SM (3.93% and 0.66%), possibly due to high solids-not-fat (SNF) content of bovine milks. The carbohydrate and ash values compare favourably with the 4.93%, 0.83% and 2.5%, 0.66% for WCM and SM respectively reported by Metwalli *et al.* (1982a). Trachoo and Mistry (1998) reported ash content of 0.81% for skimmed milk powder. Ash content is the least affected component of milk during processing.

*Physicochemical and Microbial Properties*

The effects of base material on the physicochemical and microbial properties of yoghurt are shown in Table 2. The titratable

acidity values differed significantly ( $P < 0.001$ ) among the three base materials with the highest value being recorded on WCMY (2.09%) and the lowest value recorded on SMY (1.46%). The pH value of SMY (5.1) was the highest and differed significantly ( $P < 0.001$ ) from the pH 4.7 obtained on PMY and pH 4.55 on WCMY. The high titratable acidity and low pH of WCMY and PMY recorded may be due to the possible presence of high percentage of D(-) lactic acid, following high inoculation concentration, high incubation temperature and prolonged period of storage as opined by Tamime and Robinson (1989). The low rate of acid development in SMY can be related to, among other reasons, the absence of lactose sugar and the lower level and different composition of amino acids in SMY compared to that of WCMY and PMY. Generally, lysine, asparagine, tyrosine, methionine and leucine contents in soymilk are less than those in whole cow milk (Metwalli *et al.*, 1982b; Lee *et al.*, 1990).

The total solids of 13.40% obtained on SMY was significantly different ( $P < 0.001$ ) from 16.00% and 15.74% obtained on WCMY and PMY, respectively, which were statistically similar. WCMY showed the highest (3.07%) total fat which differed significantly ( $P < 0.001$ ) from that

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obtained on SMY (2.07%) and PMY (1.90%). The total protein of PMY (3.45%) was the highest and significantly different ( $P < 0.001$ ) from the 3.03% obtained on WCMY which was also different ( $P < 0.001$ ) from the 2.96% obtained on SMY. The recorded higher total solids, total protein and total fats corroborated the low pH values and higher titratable acid percentages recorded on WCMY and PMY against SMY.

The ash content of PMY (1.03%) was higher than those of WCMY (0.74%) and SMY (0.73%) because partial removal of fat during skimming concentrated the total solids, thus the mineral compounds of the milk. No significant difference

was recorded on total microbial load due to the base materials because both bacteria and yeast found suitable growth medium in both milk-based and soymilk-based yoghurt.

Table 3 shows the effects of base materials and concentration of inoculant on mineral composition of yoghurt. The values of calcium for WCMY (1.704 to 2.086 g/l) were higher than those (1.101 to 1.282 g/l) of PMY, which in turn were higher than those (0.512 to 0.564 g/l) of SMY ( $P < 0.05$ ). The higher concentration of Ca in WCMY and PMY compared with SMY was expected as whole cow milk is a major source of dietary calcium (Berner and Lofgren, 1991). The WCMY inocu-

**Table 3:** Effect of Base Material and Concentration of Inoculant on Mineral Contents (g/l) of Yoghurt

Base material	WCMY						PMY			SMY		
	2.5	5.0	10.0	2.5	5.0	10.00	2.5	5.0	10.0	SE±	LS	LSD
Calcium	2.086	1.786	1.704	1.101	1.282	1.279	0.539	0.564	0.512	0.043	*	0.142
Sodium	4.523	5.097	5.878	6.416	5.554	5.280	3.852	3.184	3.236	0.100	***	0.330
Potassium	9.447	8.825	8.521	9.098	9.522	8.772	10.824	10.644	10.135	0.098	ns	
Magnesium	0.504	0.494	0.449	0.518	0.572	0.543	0.974	1.028	1.014	0.013	*	0.043
Copper	0.008	0.009	0.011	0.021	0.019	0.021	0.025	0.018	0.014	0.001	*	0.003
Zinc	0.229	0.257	0.271	0.215	0.202	0.222	0.214	0.217	0.232	0.003	ns	
Iron	0.157	0.168	0.063	0.158	0.164	0.182	0.151	0.167	0.192	0.005	***	0.016
Manganese	0.069	0.040	0.038	0.043	0.044	0.053	0.104	0.116	0.114	0.002	***	0.008

<sup>1</sup>IC = Inoculation concentration  
 LS = Level of significance (\* -  $P < 0.05$ , \*\*\* -  $P < 0.001$ )  
 ns = not significant

lated with low concentration of inoculum (2.5 g/l) had the highest calcium concentration of 2.086 g/l which is higher than the reported values of 1.12 g/l (Harper and Hall, 1981) and 1.17 g/l (Lucey and Fox, 1993) in whole cow milk. Deeth and Tamime (1981) reported calcium values of 1.45, 1.50 and 1.76 g/l for full fat, low fat and fruit yoghurt respectively.

The sodium content of PMY produced with 2.5 g/l (6.416 g/l) was the highest, followed by that of WCMY produced with 10.0 g/l (5.878 g/l) while the sodium content of SMY at the three inoculation concentration levels (3.184 to 3.852 g/l) were the lowest ( $P < 0.001$ ). Potassium and zinc were not affected by either base materials

or concentration of inoculant. The higher sodium and potassium values may be attributed to some of the utensils (calabashes and metal pots) used during handling and processing of milk, which were previously used in cooking that involves addition of table salt (NaCl) and potash as suggested by Webb *et al.* (1980). Oloafe (1988) reported potassium and sodium contents of 9.34 and 0.22 g/kg, respectively in dehulled soybean, compared to a range of 10.14 to 10.82 g/l for potassium and 3.18 to 3.85 g/l for sodium recorded on SMY at the three inoculation concentrations in the current study.

The magnesium contents of SMY (0.974 to 1.028 g/l) were significantly higher than those of

WCMY (0.449 to 0.504 g/l) and PMY (0.518 to 0.572 g/l) at the three inoculation concentrations. The concentration of copper was statistically similar among all the treatments except with SMY (0.025 g/l) produced with 2.5 g/l which was significantly ( $P < 0.05$ ) the highest. The iron concentrations of 0.192 g/l and 0.182 g/l recorded on SMY and PMY produced with 10.0 g/l inoculant respectively, were significantly ( $P < 0.001$ ) the highest. The manganese contents of SMY (0.104 to 0.116 g/l) were higher ( $P < 0.001$ ) than those of WCMY (0.038 to 0.069 g/l) and PMY (0.043 to 0.053 g/l) which were statistically similar. The magnesium content of SMY was higher, because magnesium and potassium are the predominant minerals of pulses, such as pigeon pea whose potassium and magnesium contents compare favourably with that of soybean (Oshodi *et al.*, 1993) and ranged from 1.2 to 1.8 mg/kg DM in raw seed and 1.5 to 2.1 mg/kg DM in autoclaved seeds.

The concentration of minor mineral elements recorded in this study (copper, zinc, iron and manganese) were either similar or slightly higher than literature values (Webb *et al.*, 1980) for whole cow milk. SMY had higher concentration of iron and zinc than PMY and WCMY. Iron is normally deficient in dairy products (Rice and

McMahon, 1998). Much attention has been given to copper content of milk because of its catalytic effect on the development of oxidized flavour in milk and milk products. Copper is a normal component of milk, present in amount of about 0.002 to 0.02 g/l which increases during processing and storage in metal containers (Webb *et al.*, 1980).

*Organoleptic Properties*

The effects of base materials on the organoleptic properties of yoghurt are shown in Table 4. The taste of PMY rated pleasant (3.4) was significantly ( $P < 0.001$ ) higher than those of WCMY rated fair (2.5) and SMY rated indifferent (2.0). The ratings for aroma (3.7) and colour (4.1) of PMY rated between fair and good, were significantly more acceptable than those of WCMY (3.8 and 3.1) and SMY (2.0 and 2.5) rated between fair (3.0) and indifferent (2.0). The texture ratings of WCMY (2.6) and SMY (2.5) which were rated fair were significantly ( $P < 0.001$ ) lower than those of PMY (3.9) rated good. The aroma, colour and texture of PMY were rated significantly higher than those of WCMY and SMY. The overall acceptability rating of 3.5 (between fair and pleasant) for PMY was significantly ( $P < 0.001$ ) higher than ratings for WCMY and SMY (2.5 and 2.1 respectively).

**Table 4:** Effects of Base Material on the Organoleptic Properties of Yoghurt

Properties	Base Material			SE±	LS	LSD
	WCMY	PMY	SMY			
Taste	2.5	3.4	2.0	0.141	***	0.46
Aroma	2.8	3.7	2.0	0.133	***	0.44
Colour	3.1	4.1	2.5	0.130	***	0.43
Texture	2.6	3.9	2.5	0.136	***	0.45
Overall acceptability	2.5	3.5	2.1	0.124	***	0.40

LS = Level of significance (\*\*\*) -  $P < 0.001$

Total protein plays an important role in the formation of yoghurt coagulum. Hence, the consistency and texture of yoghurt are directly proportional to the level of protein, which relates to mouthfeel and therefore contributes to taste. The high protein content may be the cause of preference shown by the respondents to the taste and aroma of PMY. The WCMY with higher fat content produced more creamy yoghurt than PMY and SMY which contain low level of fat (Tamime and Robinson, 1989). The lower taste rating of SMY may not be unconnected with the off-flavour associated with soymilk. Matsuura et al. (1989) reported an increase in objectionable after taste of soymilk with increased levels of isoflavone compounds deidzein and genistein in soymilk. Chang and Stone (1990) implicated partial degradation of lipids to the development of undesirable flavour of soymilk.

The aroma, colour and texture of PMY were rated higher than those of WCMY and SMY and might have contributed to the higher overall acceptability rating of the PMY.

A result indicating higher acceptance rating for frozen yoghurt produced with 100% of the milk SNF replaced with whey protein concentrate and fermented whey protein concentrate was reported by Opdahl and Baer (1991) showing the effect of protein content on overall acceptability of yoghurt.

### **Conclusion**

The PMY with high protein content and titratable acidity was most preferred by the respondents, although WCMY and SMY were also found acceptable showing that yoghurt with acceptable qualities can be produced from the three base materials. During the rainy season when whole cow milk is most abundant WCMY should be produced while in the dry season PMY should be produced. More studies to improve the quality and acceptability of SMY is recommended.

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