Trop. Anim. Prod. Invest. 11 (1): 13-16 (2008)
ISSN: 1115-2540
http://animalsci.agric.ui.edu.ng/TAPI/index.php/tapijournal/index

ORIGINAL RESEARCH ARTICLE

Influence of milk powder on physical and chemical properties of yoghurt made from fresh zebu milk

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ABSTRACT

Yoghurt is a nutritious and palatable human food derived from the milk of dairy animals. Quality of yoghurt made from fresh milk is enhanced when solids content of milk is increased. This can be achieved by addition of milk powder to fresh milk for yoghurt production. In this study, milk powder was stirred into fresh milk at 0, 20, 40, 60, 80 and 100 g/L to improve the physico-chemical properties of the yoghurt. Time of curd formation in yoghurt varied from 6–10 hours. Addition of milk powder shortened coagulation time by 2-4 hours. The pH of yoghurt at 3 days of refrigerated storage varied significantly (p<0.05) among the treatments from 4.00–4.40. Yoghurt without milk powder had the highest value and yoghurt with 100 g/L milk powder had the least value. The chemical composition of yoghurt varied significantly (p<0.05) with addition of milk powder. Protein content of yoghurt increased from 3.18 – 4.24%; fat content increased from 4.43 – 5.85%; and total solids increased from 14.50 – 17.52% as level of milk powder in yoghurt milk increased. Sensory scores of yoghurt improved significantly (p<0.05) with incorporation of milk powder into fresh milk prior to fermentation. On a hedonic scale of 1-9, acceptability of the yoghurts were judged as 5.92, 6.80, 6.92, 7.44, 7.66 and 7.71 for 0, 20, 40, 60, 80, and 100 g/L of milk powder inclusion. It may be concluded therefore that, incorporation of milk powder into fresh milk prior to incubation shortened time of curd formation and improved nutritional and sensory qualities of yoghurt made from fresh zebu milk.

Keywords: Chemical composition, Fresh milk, Milk powder, Sensory quality, Yoghurt

INTRODUCTION

Milk is a complete food with significant amounts of essential nutrients required by children and adults for growth, development and wellbeing (Haug, 2007). However, milk is highly perishable and prone to microbial spoilage due to its high moisture and nutrient profile. Yoghurt provides an opportunity to extend the shelf-life of milk and preserve its nutrients for human consumption due to its acidic properties. Yoghurt is a delicious and health-promoting food obtained through the fermentation of milk essentially by two lactic acid bacteria: *Streptococcus thermophilus* and *Lactobacillus bulgaricus* (Schmidt *et al*., 2001). Yoghurt has high nutritional and therapeutic properties that promote health in the human body. It is rich in carbohydrate, protein, fat, vitamins, calcium and phosphorus. The nutritive value of yoghurt is higher than that of milk from which it is derived due to the concentration of milk nutrients during its production (Remeuf *et al*., 2003). Regular consumption of yoghurt reduces blood cholesterol level, cancer effects, improves anti-microbial activity and increases immunity in the human body (Desobry-Banon *et al.*, 1999). Yoghurt is more digestible than fresh milk and people with lactose intolerance can consume yoghurt because the lactose in yoghurt is pre-digested to lactic acid during fermentation (Kolars *et al*., 1984). The quality and consistency of yoghurt is affected by the total solids content of the milk from which it is produced (Omer, 2003). Total solids of milk intended for yoghurt production is usually increased by evaporating the milk or adding milk powder. This study was therefore conducted to assess the physico-chemical properties of yoghurt made from fresh milk with different levels of milk powder addition.

MATERIALS AND METHODS

The experiment was conducted at the Dairy Science Laboratory of the Department of Animal Science, University of Ibadan, Ibadan, Nigeria.

Milk collection

Raw milk was collected from Fulani herdsmen at Gaa Apaara in Oyo-East Local Government Area of Oyo State. The milk was collected in four plastic bottles (4L each), ice-packed and transported immediately to the laboratory where the experiment was conducted.

Table 1. Chemical composition of fresh milk and milk powder used in making yoghurt

Component (%)	Fresh milk	Milk powder
Total solids	13.11± 1.30	96.30±3.45
Protein	3.20 ±0.14	26.20±1.86
Fat	4.65±0.62	27.80±1.90
Ash	0.74±0.01	6.70±0.98
Sugar	4.52±0.56	35.60±2.10

Starter culture

A freeze-dried commercial starter culture (Yogourmet, Lyo-San Inc., Canada) containing a mixture of *Streptococcus thermophillus, Lactobacillus bulgaricus* and *Lactobacillus acidophilus* was used to inoculate the milk before incubation. The inoculums was prepared by dissolving 2 kg of milk powder in 6 L of warm water and inoculating it with 100 g of freeze-dried culture at 45 °C for 6 h until a gel was formed. The obtained gel was stirred and used as inoculum for the preparation of yoghurt.

Yoghurt preparation

Raw milk was clarified manually using a muslin cloth. The milk was then heated to 60 °C and homogenized using a high speed mixer (Qlink®, China). The milk was pasteurized by heating in a water bath to a temperature of 75 °C for 20 minutes under continuous stirring. A sample of the fresh milk was taken for analysis. Sugar (sucrose) was stirred into the fresh milk at 100g/L. Thereafter, the milk was divided into six parts and milk powder was added at 0, 20, 40, 60, 80 and 100 g/L of milk to form the experimental treatments. Each treatment was cooled to 45ºC and inoculated with the starter culture at 20 g/L. Each treatment was further divided into four plastic cups (500 mL each, with lids) and placed inside an incubator at 43 °C. Gel formation and pH were assessed for each treatment at 4, 6, 8 and 10 hours of incubation. After incubation, yoghurt samples were cooled and refrigerated at 4 °C for further analysis.

pH of yoghurt samples

The pH of fresh milk and yoghurt samples was determined at 25 °C using an electronic pH meter (PHS-3C, TBT, China). The pH meter was calibrated with buffer standards of pH 4 and 10 prior to use and samples were assessed after gel was formed.

Chemical analysis

Total solid in raw milk and yoghurt was determined by drying in an oven at 105 °C to constant weight. Protein was determined by Kjeldahl method (N x 6.38), ash was determined using a muffled furnace and fat by a modified Rose Gottlieb method following the general procedures of AOAC (1995). The sugar fraction of the samples was determined as the difference between the total solids and other milk solids (protein, fat and ash).

Sensory evaluation

All the samples were evaluated for sensory characteristics and overall acceptability by a 16-man panel drawn from the Department of Animal Science, University of Ibadan. Yoghurt samples were identified by three-digit random numbers and presented to the panel in a random manner. A nine-point hedonic scale ranging from 9 (highest score) to 1 (lowest score) was used (Iwe, 2002). Sensory characteristics evaluated included colour, aroma, taste and mouth feel. Overall acceptability of yoghurt was determined as the average score for sensory characteristics.

Statistical analysis

The experimental design adopted for the study was the completely randomized design (CRD). Data obtained were subjected to analysis of variance using procedures of SAS (1995). Means were separated using Duncan's multiple range test of the same package.

Results and Discussion

The chemical composition of fresh milk and milk powder used for making yoghurt is presented in Table 1. As expected, the total solids, protein, fat and other components are higher in milk powder than fresh milk due to the concentration of these components by the removal of water during manufacture of milk powder.

Table 2. Coagulation time and pH of yoghurt with different levels of milk powder addition

	Milk powder (g/L fresh milk)						
Parameter	0	20	40	60	80	100	SEM
Coagulation time (hours)	10.00	8.00	8.00	8.00	8.00	6.00	-
pH (at coagulation)	4.48	4.48	4.46	4.45	4.42	4.40	0.22
pH (3 days with refrigeration)	4.40^a	4.20^b	4.18^b	4.16^b	4.14^b	4.00^c	0.20

abc: means with different superscripts within the row are significantly different (P < 0.05)

Table 3. Chemical composition of yoghurt with different levels of milk powder addition

	Milk powder (g/L fresh milk)						
Parameter (%)	0	20	40	60	80	100	SEM
Total solids	14.50[e]	14.90[e]	15.40[d]	16.20[c]	16.99[b]	17.52[a]	0.78
Protein	3.18[b]	3.40[b]	3.61[ab]	3.82[a]	4.00[a]	4.24[a]	0.10
Fat	4.43[c]	4.60[c]	4.73[c]	5.20[b]	5.62[a]	5.85[a]	0.15
Ash	0.76	0.75	0.75	0.76	0.77	0.80	0.06
Sugar	6.13[b]	6.15[b]	6.31[ab]	6.42[ab]	6.60[a]	6.63[a]	0.27

abcde: means with different superscripts within the row are significantly different (P < 0.05)

The addition of milk powder to fresh milk is expected to concentrate solids components of the yoghurt formed. The time of curd formation in milk and pH of yoghurt formed from milk with different levels of milk powder addition is shown in Table 2. Addition of milk powder to fresh milk influenced the time of curd formation in the yoghurt. Formation of yoghurt curds was faster when milk powder was added to fresh milk. The time gained varied from 2-4 hours as level of milk powder addition increased. Fresh milk containing 100 g/L of added milk powder had the fastest rate of curd formation, and fresh milk without milk powder the least.

The pH of yoghurt after coagulation was similar for all treatments; however, at 3 days of refrigerated storage, pH of yoghurts varied significantly with addition of milk powder. The pH of yoghurts varied from 4.00 – 4.40 at 3 days storage. Yoghurt with no milk powder had the highest value and yoghurt with 100 g/L of milk powder had the least. This shows that addition of milk powder to yoghurt milk enhanced fermentation and increased the rate of acid formation in the yoghurt. The chemical composition of yoghurts with different levels of milk powder addition is given in Table 3. Total solids in yoghurt varied significantly (P< 0.05) with addition of milk powder, and increased in proportion with level milk powder added to fresh milk prior to incubation. The protein, fat and sugar fractions also increased with increasing levels of milk powder addition to fresh milk. This can be attributed to the concentration of these components in milk powder.

The total solids in these yoghurts varied from 14.50 – 17.52% while protein varied from 3.18 – 4.24%. Fat content in the yoghurts varied from 4.43 – 5.85% and sugar from 6.13 - 6.63%. These values are comparable to 11.5–19.2% total solids, 3.0 – 4.7% protein, 2.4 – 6.8% fat and 5.4 – 6.6% sugar reported for yoghurt by Musaiger *et al*. (1998). The sensory scores for yoghurts with different levels of added milk powder are shown in Table 4. There were significant differences (P<0.05) in sensory scores (colour, aroma, taste and mouth feel) of yoghurt with different levels of added milk powder. Panelists preferred the colour of yoghurts with added milk powder to yoghurt without milk powder. This may be due to the whiter colour of yoghurts with added milk powder compared to the off-white colour of yoghurt without milk powder addition.

Aroma and taste of the yoghurts also improved with addition of milk powder to the fresh milk used for yoghurt production. The higher fat and sugar content in the yoghurt with addition of milk powder may have contributed to the development of flavour compounds such as acetaldehyde, diacetyl, acetoin and other volatile free fatty acids, which enhanced the aroma and taste of the yoghurt (Baranowska, 2006). Addition of milk powder to fresh milk also improved the texture (or mouth feel) and acceptability of the yoghurt. This is related to the total solids content of yoghurt which increased with addition of milk powder. The sensory properties of yoghurt are known to be influenced by the total solids content of the milk from which yoghurt is made (Sodini *et al*., 2004).

Table 4. Sensory scores of yoghurt with different levels of added milk powder

	Milk powder (g/L fresh milk)						
Parameter	**0**	**20**	**40**	**60**	**80**	**100**	**SEM**
Colour	6.31[b]	7.50[a]	7.06[ab]	7.63[a]	7.81[a]	7.85[a]	0.08
Aroma	6.19[c]	6.81[b]	6.88[b]	6.94[b]	7.44[a]	7.50[a]	0.09
Taste	5.63[c]	6.63[b]	6.80[b]	7.44[a]	7.75[a]	7.77[a]	0.10
Mouth feel	5.56[d]	6.25[c]	6.94[b]	7.75[a]	7.63[a]	7.68[a]	0.07
Overall acceptability	5.92[c]	6.80[b]	6.92[b]	7.44[a]	7.66[a]	7.71[a]	0.07

abcd: means with different superscripts within the row are significantly different (P < 0.05)

CONCLUSIONS

The results showed that the addition of milk powder to fresh milk prior to incubation had positive influence on physico-chemical properties of yoghurt. Coagulation time was shortened, lactic acid formation was enhanced, total solids content and nutrient composition improved and sensory properties of yoghurt were enhanced with addition of milk powder to fresh milk during yoghurt production. Since the highest quality of yoghurt was produced at the highest inclusion level, it is recommended that a minimum of 100 g/L of milk powder be added to fresh milk to produce quality yoghurt from zebu milk.

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