Evaluating the feasibility of adding value to goat's milk by producing yoghurt using low cost technology method for rural Namibia

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Abstract

Physico-chemical , bacteriological, nutritional and sensory characteristics of goat's and cow's milk and corresponding low cost processed yoghurt samples were assessed for the purpose of feeding children of weaning age and for income generation by the rural poor. Goat milk sample was rated superior in terms of nutritional quality with reference to calcium, magnesium. Potassium, chloride and vitamins A, D, thiamin, riboflavin, nicotinic acid, B6 and B12. It was also superior in some essential amino acids such as histidine, methionine, phenylalanine ad threonine. Total solids, protein, ash, specific gravity and calorific value were higher for goat milk, which was however lower in sodium, citrates and vitamin C. Both goat milk and cow milk had practically similar contents of zinc, iron, phosphorous and linolenic acid. Goat milk was lower in some essential amino acids namely isoleucine, tryptophan and valine including essential fatty acids a-linoleic aicd. The higher dry matter content of goat milk was reflected in higher viscosity and superior texture of its yoghurt samples. Althogh goat milk yoghurt was preferred over cow milk yoghurt, in appearance and palatability, the differences were small. Similarly, although cow milk yoghurt had better smell and taste, the differences were also small. The study indicated that it is posible to process good quality yoghurt from goat milk using low cost technology

Introduction.

According tot statistics, the average income levels of household in Namibian rural families arevery low. It is estimated that these families earn N$ 25—300 a month of which 60-70% is spent on food alone and that 57% of all households in rural areas rank below the poverty line (Van Rooy, et al., 1994). Yet studies have estimated that Namibia has about one million goats. These are Boer goats or indigenous goats of a genotype similar to the Bantu goats of Zimbabwe and Botswana (Mason, 1981). These goats are concentrated in the north of the country ad the communal areas of the central and southern Namibia. Similar studies have shown that 78% of all rural households own goats at the average of 11-14 goats per household (Hukulinen, 1992).

Goats play an important role in income generation and nutrition provision (Devendra, 1992). They serve as a means of capital storage or may be sold to aid cash flow (Morand-Fehr, 1993), providing a degree of financial stability to women, children and the elderly, particularly where men are forced to find employment away from home (Acharya, 1992). Goats are very adaptable and are capable of utilising a wide range of plants, which make them easy to keep (French, 1970).

The purpose of this study was to evaluate the possibility of adding value to goat milk by producing yoghurt using low cost technology method in an attempt to alleviate poverty and the problems of malnutrition and other related nutritional disorders among women, the elderly and children in rural Namibia.

Background

In hot conditions or in hot environment milk deteriorates rapidly. However, once processed into fermented milk products like yoghurt or cultured sour milk, its useful life may be extended without refrigeration up to one week (Kosikowski and Mistry, 1987). Goat milk fat and proteins have higher nutritional value than cow milk and are digested more easily (MacDonald and Low, 1988). Fermented milks are more nutritious and healthier than fresh milk (Mann, 1977; Kilara and Shahani, 1987). It is claimed that consumption of fermented milk resultsin a lower serum cholesterol level (Mann and Spoerry, 1974; Richardson, 1978; Grunewals, 1992; Pulusani and Rao, 1983). It has also been shown that the lactobacilli which are the organisms responsible for the souring of such milk, are useful for dgiestion (Sandine, 1992; Gervie, 1984; Friend and Shahani, 1984). Daily consumption of 200 mL of goat milk, either fresh or processed can provide up to 50% of protein, calcium and vitamin D requirements of a 2 year old child (Cooper, 1996; Juarez and Ramos, 1986).

Glass and Hendrik (1976) and Platt (1964) demonstrated that fermented milk products are a good source of the B vitamins including cobalamine (B12) and that initial amounts may be increase during fermentation process. It has also been shown that lactase deficient pateints tolerate fermented dairy products including yoghurt, without symptoms of lactose intolerance (Jay, 1986; Gallagher, 1979).

Traditional fermented milk processed as Amaas of Southern Africa, Maziwa-lala or Maziwa mgando of Tanzania and Mala, Kenya prodce flavour compounds such as Diacetyl and Acetaldehyde which are very refreshing when consumed in the fermented milk products (Golberg, 1945; Nout, 1985). Diacetyl reductase enzyme becomes responsible for the loss of the flavour after a long storage (Oberman, 1985).

Historically, agricultural research in Southern Africa has not been focused on small holder system. It is the aim of the current Namibian Government to create systems which boost small holder income through productive activities, self reliance and increase efficiency. Food security and Nutrition Assessment Report of Namibia (FSNAR, 1995).

Objectives

- To evaluate the processing of goat milk into yoghurt using low cost technology method for small holder income generation and nutrition.

- To determine and compare the nutritional value of goat milk and cow milk and yoghurt samples in relation to their suitability for feeding children under the age of five.

- To evaluate consumer acceptability of goat milk yoghurt in comparison to cow milk yoghurt.

Materials

Collection of milk samples

Fresh goat milk samples were obtained from Boer goats in the Teaching farm of the Tsumis College of Agriculture in Nanmibia. Thirty six samples were collected over a period of three months art the interval of once a week for twelve weeks. The goats were hand-milked twice a week and the milk was accumulated and cooled to 4-5° C for collection at the end of the week. They were collected into sterile 500mL milk sample bottles. Fresh cows milk samples were obtained from Friesian cows by machine milking at Neudamm Agricultural College of the Ministry of Agriculture, Water and Rural Development in Namibia.

Starter cultures, food colours, flavours, sugar and other ingredients including packaging materials, lables, processing pot, stove, gas, stirrer, thermometer, plastic water bath and ice cubes were obtained or purchased from Namibia Dairies Ltd.; African Packaging and African Marketing, Bioscientific, Medlab ands Shoprite Super Market.

Methodology

Nutrition and proximate analyses

The thirty six milk samples were analysed for total solids, fats, proteins, ash, pH, titratable acidity, specific gravity, calorific values, major, minerals, vitamins, essential amino acids and fatty acids according to AOAC methods, chapter 33 (1990) and Pearson's Composition and analysis of Foods (1991).

Rural Technology method of yoghurt making

The following procedure is used:
Fresh milk is filtered (cream separation - optional) and poured into a pot ready for sterilisation. Sugar equal to 6% of the weight of the milk and food colour at the rate of 20 -30 mL per 100kg of milk (optional) are added, mixed and sterilised at 95° C for 30 minutes. The fermentation vessel is prepared, cleaned, filled with the milk and cooled to temperatures of 40 - 45 ° C in a bath of cold water. A 2% starter culture (S. thermophilus and L. bulgaricus) and a 20 - 30 mL of food flavour per 100kg of the milk (optional) are added, mixed and incubated for a period of 3 - 4 hours in order to coagulate. Finally, the yoghurt is cooled overnight in a birth of cold water to less than 10° C. Packaging 9in plastic cups with lids or pouches) and distribution are done on the following morning (O'Mahony, 1985 and Fellows, 1997).

Processing of experimental Yoghurts

Fresh goat's and cow milk samples were separately processed into yoghurt using the normal procedure as illustrated below (Kosikowski and Mistry, 1997; Kessler, 1981) and subjected to sensory evaluation in terms of its aroma, flavour, texture and palatability. In addition, the dry matter, viscosity, bacteriological quality and pH were determined according to Pearson (1991) and AOAC standards (1990).

Fresh milk
↓
Preheated to 45 ° C
↓
And Filtered
↓
20 mL food colour/100 lt of milk and 6% sugar were added and mixed
↓
Batch Pasterurised to 95° C and held for 30 min.
↓
Cooled to Inoculation temperature of 45° C in closed vessel and in a bath of cold water.
↓
2% starter culture and 20 mL food flavour/ 100 lt of milk were added and mixed.
↓
Incubated at 45 ° C for 3 hrs to coagulate.
↓
After coagulation, stored in a bath of cold water for overnight.
↓
Product ready for analysis/tasting

Fig 1: Flow Diagram for experimental yoghurt

Sensory Evaluate

Sensory Attributes are important aspects of yoghurt quality. Sensory attributes such as appearance, aroma, flavour, texture, consistency and palatability have been identified as important determinants of overall quality of yoghurt especially that of goat milk. A nine-member trained panel of judges consisting of students and university lecturers familiar with the quality attributes of goat milk and cow milk yoghurt was constituted. The panelists were asked to rate the samples for appearance, flavour, texture, aroma and palatability (AOAC, 1990). The ratings were scored off from a Hedonic scale ranging from 9 ("like extremely") to 1 ("dislike extremely") with 5 representing neither like nor dislike (Larmond, 1977).

Statistical analysis

The results obtained were subjected to analysis of variance (Anova). Mean comparisons were carried out between the two yoghurts by Turkey's Multiple Range Test and by Statistical Programs from for Social Sciences (SPSS, 1992).

Results and Discussions

All results are presented in Tables 1-9. Proximate composition results (Table 1) showed that goats milk had a superior composition than cow milk. Milk produced from goat had higher total solids content which reflected in goat milk being higher in protein, lacotese, fat, ash, energy contents, as well as in specific gravity than cow milk. Goat milk was also higher in microbial content than cow milk (Table 1). This was attributed to the difference in milking technique whereby the goats were milked by hand whereas the cows were milked more hygienically by machine. Goat milk had a lower pH of 6.3 compared to 6.7 for cow's corresponding with the lactic acid content of the milk in each case (Table 1). Although both pH values were high, the implication was that the lowere pH of goat milk rendered it more stable than cow milk at room temperature for short periods of time after milking.

The mineral compositions of goat and cow milk are given in Table 2. The citrate content of the milk is also given in the same table. Citrate plays a role in flavour of milk and milk products. These results

Table 1. Comparison of mean physico-chemical properties (per 100 g) of goat and cow milk.

Property	Goat milk	Cow milk
Crude protein content (g)	3.7	3.2
Crude fat content (g)	4.5	3.5
Lactose content (g)	4.8	4.7
Total solids content (g)	13.83	12.12
Ash (g)	0.83	0.72
Specific gravity	1.035	1.030
Lactic acid (%)	0.18	0.15
pH	6.3	6.7
Calorific value (kJ)	295.0	289.0
Total vialbe counts (cfu*/g)	5.6×10^8	1.8×10^7
Yeast and moulds (count/g)	2.3×10^2	1.6×10^2

*cfu/g = colony forming units per gram
These results carry a SD of 0.1-0.3 and about $1 \times 10^{2-3}$ for the micro-organisms.

Table 2. Comparison of mean mineral contents (mg/100) of goat milk and cow milk.

Mineral	Goat milk	Cow milk
Sodium (Na)	37.6	57.8
Potassium (K)	193.1	153.0
Calcium (Ca)	137.9	123.0
Magnesuim (Mg)	21.5	11.0
Phosphorus (P0	95.4	95.0
Chloride (Cl)	193.9	98.7
Zinc (Zn)	0.56	0.53
Iron (Fe)	0.022	0.021
Citrate	151.0	201.0

The results carry a SD of 2.0 - 3.- for Na, Ca, Mg, P, and Cl; 0.01-0.02 for Zn and Fe and 5.0 for Citrate.

Table 3. Comparison of mean vitamin contents of goat and cow milk.

Vitamins	Goat Milk	Cow Milk
Vit A	2063.00	1563.00
Vit D	24.00	19.00
Thiamin	0.52	0.45
Riboflavin	1.82	1.76
Nicotinic Acid	1.85	0.93
Vit B_6	0.061	0.55
Biotin	0.040	0.033
Folic acid	0.0026	0.0029
Vit B_{12}	0.006	0.0044
Ascorbic acid (Vit C)	15.3	21.2

Vit A international units/lt; all other; mg/litre.
These results carry a SD of: Vit A 15-17; Vit C and D of 1-2; 0.01-0.03 for Riboflavin and Nicotinic acid and 0.001-0.003 for the B group vitamins.

show that goat milk was superior to cow milk in its content of minerals such as calcium, magnesium, potassium and chloride, but was poorer in its content of sodium and citrate. The two milks had practically the same contents of phosphorus, zinc and iron. Thus the higher ash content (Table 1) of goat milk was also reflected in goat milk having a higher concentration of certain minerals than cow milk as given in Table 2. Thus on average, goat milk was found to be a better source of minerals than cow milk.

The vitamin content of goat and cow milk was quite variable (Table 3), but goat milk proved to be superior to cow milk in its content of vitamins A, vitamin D, thiamin, riboflavin, nicotinic acid, vitamin B_6 and vitamin B_{12}. Goat milk was however poorer than cow milk in vitamin C and floc acid. The two milks also varied in their content of essential amino acids (Table 4). Goat casein had higher levels of histidine, leucine, methionine, phenylalanine threonine, but was lower in isoleucine, tryptophane, and valine than cow milk. Their content of lysine wa practically the same. In terms of b-Lactoglobulin, goat milk was richer only in valine whereas cow milk b-Lactoglobulin was superior in all others i.e. histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine and tryptophane. In total, considering both the casein and b-Lactoglobulin essential amino acids, goat milk was superior in content of histidine, methionine, phenylalanine and threinine than cow milk, while cow milk was superior in content of isoleucine, leucine, and valine. The tow milks had practically similar levels of linoleic acid although cow milk was slightly superior in its content of a-linoleic acid than goat milk (Table 5). Thus on average, goat milk and cow milk are nutritionally good sources of essential amino acids and essential fatty acids.

The viscosity, dry matter and p (Table 6) of the yoghurts made from goat and cow milk were influenced by the composition of the milk. Higher total solids content in goat milk (Table 1) resulted in yoghurt from goat milk having a higher viscosity and dry matter content than cow milk yoghurt (Table 6). Similarly higher lactose content in goat milk (table 1) resulted in more acid goat milk yoghurt than cow milk yoghurt under the same treatment (Table 6). The higher viscosity of goat milk yoghurt also resulted in a better consistency than the consistency than the consistency of the yoghurt made from cow milk. Nutritionally, goat milk yoghurt had an advantage over cow milk yoghurt due to its higher nutrient density.

The sensory properties (Table 7) of yoghurts were also variable. Goat milk yoghurt was preferred to cow milk yoghurt in appearance, texture and palatability while yoghurt from cow milk was preferred in aroma and flavour. The preferences for cow milk yoghurt was attributed to the higher content of citrates (table 2) in cow

Table 4. Mean comparison of essential amino acids in goat and cow milk.

Amino acids (%)	Goat milk		Cow milk	
	Casein	β-Lactoglobulin	Casein	β-Lactoglobulin
Histidine	5.0	2	3.0	2
Isoleucine	4.3	9	6.3	10
Leucine	9.9	20	9.6	22
Lysine	8.2	15	8.1	15
Methionine	3.5	4	3.0	4
Phenylalanine	6.0	4	5.2	4
Threonine	5.7	8	4.6	8
Tryptophane	1.3	2	1.5	2
Valine	5.7	10	7.4	9

These results carry a SD of 0.1 -0.3 for casein and 0.5 for β-Lactoglobulin.

Table 5. Mean comparison of essential amino acids in goat and cow milk.

Fatty acid	Goat Milk	Cow milk
Linolei acid	2.3	2.5
α-Linolenic acid	0.85	0.97

These carry a SD of 0.2 for Linoleic acid and 0.03 for Linoleic acid.

Table6. Mean comparison of essential amino acids in goat and cow milk.

Yoghurt	Viscosity (Pa.s)	D/Matter (%)	pH
Goat milk	80.7	24.61	3.9
Cow milk	67.8	19.47	4.0

These carry a SD of 4.0 for viscosity; 3 -5 for dry matter and 0.2-0.3 for pH. 1 Pa.a= 1Kg ms^{-1}

Table7. Comparison of mean sensory evaluation scores of goat and cow milk yoghurt.

Yoghurt sample	Appearance	Smell	Taste	Texture	Palatability
Goat milk	7.2	7.0	6.7	6.9	7.1
Cow milk	6.8	7.3	6.8	7.0	

These carry a SD of 0.3 - 0.4.
9= Like very much . 8= like much. 7=Like moderately. 6=Like little. 5= Neither like nor dislike. 4= Dislike little.
3=Dislike moderately. 2= Dislike much. 1= Dislike very much.

Table8. Mean values of Bacteriological anaylses of goat and cow milk yoghurt as per South Africa Bureau of Standards (SABS) requirements.

Identity	Test Done	Results
Goat milk yoghurt	Total counts at 37° C	1 x 10^6 cfu/g
	E coli/Coliforms	Negative
	Staphylococcus aureus	Negative
	Salmonella spp	Negative
	Clostridium spp	Negative
Cow milk yoghurt	All as above	1 x 10^6 cfu/g
	All as above	Negative

milk than in goat milk, while the higher total solids in goat milk had favourable influence on yoghurt appearance, texture and palatability. The differences were however small for preferences in various sensory properties as indicated by the mean sensory scores in Table 7. These scores show that the yoghurts were on average for each sensory characteristics only 'moderately liked' by the panelists, the exception being the texture. Goat milk yoghurt texture was much superior to cow milk yoghurt. It was 'moderately liked' while the texture of cow milk yoghurt was only 'little liked'. This emphasizes more on the advantages on yoghurt quality of high total solids in milk as observed in goat milk.

The becteriological quality of the two yoghurts made from goat and cow milk (Table 8) showed a mean total count of 1 x 106 cfu g^{-1}. Specific counts for Escherichia coli, Spreptococcus aureus, Salmonella spp and Clostridium spp were negative. The pasteurisation process used in preparation of the milk and low pH of yoghurt had effectively destroyed the micro-organisms previously recorded in fresh goat and cow milk and yoghurts respectively. The total counts observed in the yoghurts originated only from the culture used to ferment the yoghurt. The yoghurts were thus considered to be safe microbiologically.

The cost analysis (Table 9) for the production of goat milk yoghurt indicated that the process can be profitable for the rural people.

Conclusion

The findings of this research demonstrate that it is possible to make good quality fermented milk products such as yoghurt, free from harmful microorganisms and acceptable for consumption and for market in the rural set up if quality control mechanisms using Hazard Aalysis Critical Control Point (HACCP) concepts for hygiene and technology are properly transferred (Mortimore and Wallace, 1998).

The findings also indicate that goat milk and yoghurt show some superiority over cow milk in terms of proximate analyses, including vitamins, minerals, essentials amino acids and fatty acids contents and this could be the reason for feeding the infants with goat milk in traditional rural areas of Namibia and elsewhere. However, the difference between goat and cow milk and yoghurt is small and one can easily be substituted for the other except where there is a problem of allergy due to utilisation of cows milk protein-lactabumin, goat milk will be good substitute. For lactose intolerance and allergy associated with it, fermented milk products such as yoghurt will be of benfit in alleviating the miseries since the lactose is converted to lactic acid during yoghurt making.

Table 9. Cost Analysis for Production of One Cup of Yoghurt using low cost processing technique

A. Expenditure	N$
1. Milk - N$2.00 per lt x 500 lt	= 1000.00
2. Sugar (6%) - 6 x 500/100 x N$ 4	= 120.00
3. Cups - 2000	= 620.00
4. Lids -2000	= 200.00
5. Logo - N$ 120 (permanent)	= 10.00
6. Essesnce - 150 mL x 3.00/30 mL	=*15.00
7. Food Colour 150 x 3.00/30 mL	= 15.00
8. Starter culture - 2% x 500/100 x 7.00	= 70.00
9. Processing equipment*3715/10 yrs	= 371.50
10. Ice cubes - 10 pkts @ 3.00	= 30.00
Total Cost N$	**= 2451.50**
B. Gross Profit	
500 lt yoghurt = 2000 cups of 250 mL	
One cup yoghurt = N$ 3.25 Thus 2000 x 3.00	= 6500.00
Therefore N$ 6,500 - 2451.50	= 4048.50
Profit per cup = N$ 4048.50/2000 cups	= N$ 2.00
Note that: 175 mL cup of yoghurt in Windhoek Supermarkets costs N$ = 2.85: (7N$ = US$)	
Note that: The analysis assumes that the processing facilities are going to be financed by Rural Development Financing Agents which are in Namibia for purchasing of pots, thermometers, coolers, agitators, scooping facility and packaging facility shown below: *	
C. Financial Commitment	**N$**
2000 yoghurt cups	= 620.00
200 lids	= 200.00
2000 labels	= 123.00
Logo scanning	= 120.00
Boiling table and burner	= 1840.00
Sterilising pot, S/steel	= 1200.00
Food Colour 150 mL x 3.00/30	= 15.00
Food flavour 150 mL x 3.00.30	= 15.00
Thermometers 1 x 150.00	= 150.00
Stirrer 1 x 25.00	= 25.00
Plastic water bath	= 530.00
Totals N$	**= 4838.00**
*** Fixed assets (10yrs)**	**= 3115.00**
Consumables	**= 1123.00**
Totals N$	**= 4838.00**

Note
That the production can be scaled down proportionately to fit in with the household's capacity and ability to process and market the products. Also it will depend on the availability of goat milk. However, in the absence of goat milk, cow milk can be used as a substitute. After all, most milk comes from the cows and the technology is the same.

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