Research Article

Analysis of Proximate Compositions and Physiochemical Properties of Some Yoghurt Samples from Maseru, Lesotho

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Abstract

A total of nine commercially available yoghurt samples were purchased from Maseru, the Kingdom of Lesotho and were analysed for their proximate compositions such as protein, fat, crude fibre, ash, moisture and carbohydrate. Additionally, physiochemical properties such as percentages of total solids, solids non-fat (SNF) and gross energy content of all nine samples were also analysed. The percentages of protein content, fat content, crude fibre, ash content, moisture content and the carbohydrate content of samples were found to be 1.95-2.70, 1.49-3.50, 0.00-0.08, 0.28-0.95, 76.08-80.07 and 13.65-19.20%, respectively. The total solids and the SNF of the samples were found to be 19.93-23.56 and 6.85-21.68%, respectively. The gross energy content of samples was found to be 85.00-104.75 Kcal/100g. Our study showed that the compositions of all samples were significantly different ($p<0.05$).

1. Introduction

The bacterial cultures such as *Streptococcus thermophilus, Lactobacillus delbrueckii ssp. bulgaricus* etc. are used as starter cultures [1, 2] to produce yoghurts from milk. The traditional cultures such as *Lactobacillus helveticus, Lactobacillus delbrueckii spp. lactis* etc. are still used in some countries, [3]. One of the advantages of these traditional cultures is that they grow even at low pH and their growth is not affected by acidity [1, 4, 5]. The disaccharide lactose present in the milk is converted into lactic acid by fermentation by these starter cultures. Lactic acid lowers the pH value and the milk protein casein present in the milk is coagulated and yoghurt is produced. Additionally, the low pH value serves as a method of preservation since at low pH value, the growth of pathogenic bacteria will be inhibited [4, 5].

The microorganisms which improve intestinal microbial balance and enhance health of the host are called probiotics [6]. Yoghurts are probiotic carriers and they have mildly sour taste with smooth texture, aroma and pleasant flavor. It has been reported that yoghurts are rich nutritional sources such as fat, high biological value protein, calcium, zinc, potassium, magnesium, phosphorus, riboflavin (vitamin B_2), thiamine (vitamin B_1), vitamin B_6, vitamin B_{12}, niacin, folate etc. [3, 6-8]. It has also been reported that yoghurts are good sources of proteins of high quality [3], nutritionally richer than milk, readily digestible [6, 8], suitable for lactose-intolerant infants, [9] and have many other health benefits [10]. The aim of the present study was to analyse the proximate compositions and physicochemical properties of nine commercially available yoghurt samples from three manufacturers purchased from a local market in Maseru, Lesotho. The results thus obtained are communicated in this article.

2. Materials and Methods

2.1 Determination of protein content

The crude proteins were determined by the macro Kjeldahl method as described in literature [8]. Briefly, 2g of the sample was introduced into a Kjeldahl digestion flask together with 10g of copper sulphate and sodium sulphate in the ratio of 5:1. 25 mL of concentrated sulphuric acid was added to the digestion flask and the digestion was carried at about 1500°C in the fume cupboard until frothing ceased. A clear and light blue coloration was observed. The digest was cooled and diluted up to the mark with distilled water in 100 mL volumetric flask. 10 mL of the diluted mixture was poured into the distillation apparatus and 18 mL of 40% of sodium hydroxide was added. 25 mL of 2% boric acid was added into the receiving conical flask and two drops of bromocresol green and methyl red mixed indicator was added. The distillation was continued until boric acid solution turned from pink to yellowish green. After the distillation, the solution in the conical flask was titrated against 0.1N hydrochloric acid until the end point was reached. A blank was taken using the same procedure using only with distilled water. The protein was calculated as:

$$\% \text{ crude protein} = \% \text{ nitrogen} \times 6.38$$

$$\% \text{ nitrogen} = \frac{(ml\ standard\ acid - ml\ blank) \times N\ of\ acid \times 1.4007}{sample\ in\ grams}$$

2.2 Determination of crude fat content

The fat content was determined as described in literature [11]. Briefly, 5g of sample was mixed with 0.88mL of ammonia solution and 10 mL of 95% ethanol and mixed well. 25 mL of diethyl ether was added to the mixture and shaken vigorously for 1 minute. This was then followed by addition of 25 mL of petroleum ether and shaken vigorously to mix well. The mixture was then left to stand for an hour to allow aqueous and organic phase to separate. The fat extract (organic phase) was

collected and the solvent was removed by distillation. The fat in the flask was dried in the oven at 100°C for 30 minutes and the solvent was removed completely. The flasks were then cooled in a desiccator and were weighed for their mass of fat. The percentage fat was calculated by the following formula.

$$\% \text{ fat} = \frac{weight\ of\ extracted\ fat\ (g)}{weight\ of\ sample\ used\ (g)} \times 100$$

2.3 Determination of crude fibre

The crude fibre was determined according to the procedure reported in literature [5]. It was determined as the fraction remaining after digestion with standard sulphuric acid and sodium hydroxide. Briefly, 2g of the sample was hydrolysed in a beaker containing 299 mL of 1.25% of sulphuric acid and then boiled for 30 minutes. The mixture was filtered under vacuum and the residue was washed with hot distilled water for 3 times and then boiled again for 30 minutes with 200 mL of 1.25% of sodium hydroxide and filtered again. The digested sample was washed with hydrochloric acid to neutralize sodium hydroxide and then with hot distilled water for 3 times. The residue was taken into a crucible, dried at 100°C for 2 hours in an oven, the sample was cooled in a desiccator and then weighed. The sample in the crucible was incinerated at 500°C for 5 hours until all carbonaceous matter were burnt. Finally, the crucible containing the ash was cooled in the desiccator and weighed.

The percentage crude fibre was calculated by the following formula.

$$\% \text{ crude fibre} = \frac{loss\ in\ weighed\ (g)after\ ignition}{weight\ of\ the\ original\ sample\ (g)} \times 100$$

$$= \frac{W_1 - W_2}{W} \times 100$$

where: W_1= weight of digested sample and crucible before ash; W_2=weight of crucible and ash; W=weight of sample used.

2.4 Ash content determination

The ash content was determined by direct heating method as described in literature [12]. Briefly, 2g of each one of the yoghurt samples was weighed in dried glass crucibles separately. The samples were then incinerated to ash in a muffle furnace for 3 hours at 550°C. The crucibles were then removed, cooled in desiccator and the weight of the ash was determined. The percentage ash content was calculated by the following formula.

$$\% \text{ ash} = (Z\text{-}X/Y\text{-}X) \times 100$$

where; X=weight of empty crucible; Y=weight of crucible + sample; Z=weight of crucible + ash

2.5 Determination of moisture content

The percentage of moisture content was determined by oven method as described in literature [12]. Briefly, 2g of yoghurt samples was dried in the oven for 24 hours at 100°C. The percentage moisture content was calculated by the following formula.

$$\% \text{ moisture} = W_1 - \frac{W_2 \times 100}{W_1}$$

where, W_1=initial weight of sample; W_2=weight of the dried sample.

2.6 Determination of carbohydrates content

Carbohydrates were determined using a mathematical function below as described in literature [12].

CHO=100 - % (ash + protein + fat + crude fibre + moisture)

2.7 Determination of total solids

The total solids were obtained from moisture content analysis as described in literature [13]. The weight of the residue obtained from moisture content was determined and expressed as percentage total solids by the relation:

% total solids=(100 - %moisture)

2.8 Determination of total solids-non-fat

Total solids-non-fat (SNF) was determined by taking the difference between % total solids and % fat content as described in literature [12].

%solids-non-fat=%total solids - %fat content.

2.9 Determination of gross energy

Total energy value was determined by Atwater method as described in literature [14]. This method involves multiplying % carbohydrate content by 4%, protein content by 4% and fat content by 9%. The energy was measured in kilo-calories/100g (Kcal/100g).

energy value=$(\%CP \times 4) + (\%CFT \times 9) + (\%CHO \times 4)$ where; %CP=percentage crude protein; %CFT=percentage crude fat; %CF=percentage crude fibre; %CHO=percentage carbohydrate

2.10 Statistical analysis

Statistical analysis was done in triplicates and the results were expressed as means of three values. One-way analysis of variance (ANOVA) was used to compare means at the significant level $p<0.05$. All analysis was performed by Microsoft Excel software.

3. Results and Discussion

A total of nine commercially available yoghurt samples were purchased from a local market in Maseru, the kingdom of Lesotho. The samples labelled as Y_{1A}, Y_{1B} and Y_{1C} were from manufacturer 1, the samples labelled as Y_{2A}, Y_{2B} and Y_{2C} were from manufacturer 2 and the samples labelled as Y_{3A}, Y_{3B} and Y_{3C} were from manufacturer 3. All nine samples were analysed for their proximate compositions such as protein, fat, crude fibre, ash, moisture and carbohydrate. Additionally, physiochemical properties such as percentages of total solids, solids non-fat (SNF) and gross energy content of all nine samples were also analysed. The results are summarised in Tables 1 and 2.

The result of the proximate compositions of the all nine yoghurt samples are summarised in in Table 1. The protein content of samples Y_{1A}, Y_{1B} and Y_{1C} were found to be 2.39, 2.33 and 2.13% respectively; for Y_{2A}, Y_{2B} and Y_{2C} it has been found to be 1.95, 2.07 and 2.70% respectively; and for Y_{3A}, Y_{3B} and Y_{3C} it has been found to be 2.35, 2.27 and 1.95% respectively. This result showed that Y_{2C} has highest protein content of 2.70% while Y_{2A} and Y_{3C} have lowest protein content of 1.95%. According to Codex standards, the yoghurt sample should contain not less than 2.70% protein content. Our study showed that the protein content of all samples were found to be slightly lower than 2.70%, except Y_{2C} in which case it is 2.70%. However, our literature search showed that the percentage of protein content of yoghurts samples have previously been reported in the range of 1.29-3.52% from other studies [5].

The fat content of Y_{1A}, Y_{1B} and Y_{1C} were found to be 1.61, 1.49 and 1.55% respectively; for Y_{2A}, Y_{2B} and Y_{2C} it was found to 2.24, 2.08 and 2.10% respectively and for Y_{3A}, Y_{3B} and Y_{3C} it was found to be 3.41, 3.50 and 3.34% respectively. The result showed that Y_{3A}, Y_{3B} and Y_{3C} have higher fat content compared to Y_{1A}, Y_{1B}, Y_{1C}, Y_{2A}, Y_{2B} and Y_{2C} samples. Y_{3B} showed highest fat content of 3.50% while Y_{1B} showed lowest fat content of 1.49%.

It has been reported that the percentage of fat content plays a vital role in yoghurts since it improves texture, appearance, flavour and taste of yoghurts [8]. According to [15], yoghurt samples with more than 3.25% of fat content should be labelled yoghurt; yoghurt with fat content in the range of 0.5-2.0% should be labelled as Low-Fat yoghurt and yoghurt with less than 0.5% fat content should be labelled Non-Fat yoghurt. According to [16], yoghurt should have less than 15% of fat content. The results from our studies showed that the fat

content of the above nine samples are comply with these standards.

The crude fibre content of samples Y_{1A}, Y_{1B} and Y_{1C} were found to be 0.03, 0.05 and 0.07%; for Y_{2A}, Y_{2B} and Y_{2C} it was found to be 0.08, 0.07 and 0.01% respectively. However, Y_{3A}, Y_{3B} and Y_{3C} did not exhibit any fibre content. Yoghurt Y_{2A} exhibited highest fibre content of 0.08%. The literature value of percentage of crude fibre content of the samples is 0.21-0.51% [12]. However, the percentage crude fibre content of all nine samples were found to be much lower than literature values. Fibre content improves textural properties and structure, reduce lipid retention and reduce caloric content by acting as acting as a bulking agent [17].

The percentage of ash content of Y_{1A}, Y_{1B} and Y_{1C} were found to be 0.28, 0.31 and 0.31% respectively; for Y_{2A}, Y_{2B} and Y_{2C} it was found to be 0.45, 0.46 and 0.45% respectively and for Y_{3A}, Y_{3B} and Y_{3C} it was found to be 0.94, 0.93 and 0.95% respectively. The content of ash in the samples is the indication of the mineral content which promote bone formation and mineralization [18]. Samples Y_{3A}, Y_{3B} and Y_{3C} exhibited highest mineral contents compared to other samples.

The moisture content of Y_{1A}, Y_{1B} and Y_{1C} were found to be 79.16, 79.74 and 80.07% respectively; for Y_{2A}, Y_{2B} and Y_{2C} it was found to be 76.08, 76.98 and 76.44% respectively and for Y_{3A}, Y_{3B} and Y_{3C} it was found to be 79.64, 79.65 and 79.63% respectively. Y_{1C} exhibited highest moisture content of 80.07% while Y_{2A} showed lowest moisture content of 76.08%. Our results are in good agreement with previously reported values of 78.62 to 82.41% [12]. The moisture content of yoghurt should be less than 84%. The presence of higher moisture content affect the texture and mouth feel.

The carbohydrate content of Y_{1A}, Y_{1B} and Y_{1C} were found to be 16.53, 16.08 and 15.86% respectively; for Y_{2A}, Y_{2B} and Y_{2C} it was found to be 19.20, 18.35 and 18.30% respectively and for Y_{3A}, Y_{3B} and Y_{3C} it was found to be 13.66, 13.65 and 14.12%, respectively. Y_{2A} showed highest carbohydrate content of 19.20% while Y_{3B} showed lowest carbohydrate content of 13.65%. The disaccharide, lactose found in yoghurts has been hydrolysed by the enzyme lactase (β-galactosidase) and produced simple sugars, glucose and galactose. These simple sugar are easily absorbed by the body and therefore yoghurt is ideal for people with lactose maldigestion [3]. According to [19] yoghurt should contain carbohydrate content of 13.7 - 17.7%. Our study showed that all nine samples are in good agreement with this standard.

The result of physiochemical properties of various yoghurt samples are summarised in Table 2. The total solids of Y_{1A}, Y_{1B} and Y_{1C} were found to be 20.84, 20.26 and 19.93% respectively; for Y_{2A}, Y_{2B} and Y_{2C} it was found to be 23.92, 23.02 and 23.56%, respectively and for Y_{3A}, Y_{3B} and Y_{3C} it was found to be 20.36, 20.35 and 20.37%, respectively. Although, all samples have comparable total solids, Y_{2A}, Y_{2B} and Y_{2C} have higher total solids. Y_{2C} showed highest total solids of 23.56% while Y_{1C} showed lowest total solid of 19.93%. The total solid contents for fruit yoghurt has been reported as15.0-22.8% [20] and it has also been reported as 18.4 - 21.41% [12]. Our findings showed that all samples are in close agreement with these values. The total solids concentration level of 24% and above would severely inhibit the growth of *Lactobacillus bulgaricus* [20]. On the other hand, the low percentage of total solids in yoghurt could lead to malfunction of starter culture [12]. Yoghurt containing less than 20% total solid was evaluated as thin and tasteless [1].

Samples	Protein (%)	Fat (%)	Crude fibre (%)	Ash (%)	Moisture (%)	Carbohydrate (%)
Y_{1A}	$2.39^a \pm 0.08$	$1.61^a \pm 0.01$	$0.03^a \pm 0.00$	$0.28^a \pm 0.01$	$79.16^a \pm 0.12$	$16.53^a \pm 0.07$
Y_{1B}	$2.33^{ab} \pm 0.08$	$1.49^b \pm 0.03$	$0.05^b \pm 0.01$	$0.31^a \pm 0.05$	$79.74^b \pm 0.12$	$16.08^b \pm 0.16$
Y_{1C}	$2.13^c \pm 0.08$	$1.55^{ab} \pm 0.04$	$0.07^c \pm 0.01$	$0.31^a \pm 0.07$	$80.07^c \pm 0.02$	$15.86^b \pm 0.08$
Y_{2A}	$1.95^d \pm 0.07$	$2.24^d \pm 0.04$	$0.08^{bcd} \pm 0.03$	$0.45^b \pm 0.00$	$76.08^d \pm 1.02$	$19.20^c \pm 0.99$
Y_{2B}	$2.07^{bcd} \pm 0.18$	$2.08^e \pm 0.08$	$0.07^d \pm 0.00$	$0.46^b \pm 0.01$	$76.98^d \pm 0.08$	$18.35^c \pm 0.16$
Y_{2C}	$2.70^e \pm 0.07$	$2.10^{de} \pm 0.09$	$0.01^e \pm 0.00$	$0.45^b \pm 0.01$	$76.44^d \pm 1.15$	$18.30^c \pm 0.99$
Y_{3A}	$2.35^{acde} \pm 0.37$	$3.41^f \pm 0.01$	-	$0.94^{cd} \pm 0.01$	$79.64^b \pm 0.06$	$13.66^d \pm 0.40$
Y_{3B}	$2.27^{ac} \pm 0.12$	$3.50^g \pm 0.01$	-	$0.93^c \pm 0.00$	$79.65^{abc} \pm 0.29$	$13.65^d \pm 0.17$
Y_{3C}	$1.95^{cd} \pm 0.18$	$3.34^h \pm 0.02$	-	$0.95^d \pm 0.01$	$79.63^b \pm 0.14$	$14.12^d \pm 0.34$

Yoghurt samples=Y_{1A}, Y_{1B} and Y_{1C} were from manufacturer 1; Y_{2A}, Y_{2B} and Y_{2C} were from manufacturer 2 and Y_{3A}, Y_{3B} and Y_{3C} were from manufacturer 3; values are means ± standard deviation (SD) of triplicate determinations; values with different superscript within the same column are significantly different ($p < 0.05$).

Table 1: The percentage of proximate compositions of various yoghurt samples.

Samples	Total Solids (%)	Total Solids Not-Fat (%)	Gross Energy Content (Kcal/100g)
Y_{1A}	$20.84^a \pm 0.12$	$19.24^a \pm 0.11$	$90.19^a \pm 0.55$
Y_{1B}	$20.26^b \pm 0.12$	$18.77^b \pm 0.13$	$87.09^b \pm 0.56$
Y_{1C}	$19.93^c \pm 0.02$	$18.38^c \pm 0.03$	$85.05^b \pm 0.51$
Y_{2A}	$23.92^d \pm 1.02$	$21.68^d \pm 1.00$	$104.75^c \pm 4.28$
Y_{2B}	$23.02^d \pm 0.08$	$20.95^d \pm 0.07$	$100.36^c \pm 0.58$
Y_{2C}	$23.56^d \pm 1.15$	$21.46^d \pm 1.07$	$102.89^{cd} \pm 4.98$
Y_{3A}	$20.36^b \pm 0.06$	$16.95^e \pm 0.05$	$94.71^e \pm 0.25$
Y_{3B}	$20.35^{abc} \pm 0.29$	$16.85^e \pm 0.28$	$95.23^{de} \pm 1.15$
Y_{3C}	$20.37^b \pm 0.14$	$17.03^e \pm 0.16$	$94.39^e \pm 0.51$

Yoghurt samples=Y_{1A}, Y_{1B} and Y_{1C} were from manufacturer 1; Y_{2A}, Y_{2B} and Y_{2C} were from manufacturer 2 and Y_{3A}, Y_{3B} and Y_{3C} were from manufacturer 3; values are means ± standard deviation (SD) of triplicate determinations; values with different superscript within the same column are significantly different ($p < 0.05$).

Table 2: Analysis of physiochemical properties of various yoghurt samples.

The total solids Non-Fat of Y_{1A}, Y_{1B} and Y_{1C} were found to be 19.24, 18.77 and 18.38% respectively; for Y_{2A}, Y_{2B} and Y_{2C} it was found to be 21.68, 20.95 and 21.46% respectively and for Y_{3A}, Y_{3B} and Y_{3C} it was found to be 16.95, 16.85 and 17.03% respectively. Y_{2A} showed highest SNF of 21.68% and Y_{3B} showed lowest total SNF of 16.85%. According to [21] and [15], the total SNF of yoghurts should not be less than 8.25% and the literature value is set as not be less than 8.50% [12]. Our findings showed that all nine samples comply with these standards. The energy content of Y_{1A}, Y_{1B} and Y_{1C} were found to be 90.19, 87.09 and 85 Kcal/100g

respectively; for Y_{2A}, Y_{2B} and Y_{2C} it was found to be 104.75, 100.36 and 102.89 Kcal/100g respectively and for Y_{3A}, Y_{3B} and Y_{3C} it was found to be 94.71, 95.23 and 94.39 Kcal/100g respectively. [19] proposed the gross energy content as 78 Kcal/100g for low fat yoghurt and 109 Kcal/100g whole milk fat yoghurt. Our findings showed that all nine samples are within the standard range as specified by the Dairy council.

4. Conclusion

A total of nine commercially available yoghurts purchased from Maseru, the Kingdom of Lesotho were analysed for their proximate compositions and physiochemical properties. Although, all samples exhibited small variations in most of their proximate compositions and physiochemical properties, their values are in the acceptable ranges. Our study showed that the proximate compositions and physiochemical properties of all yoghurt samples were found to be significantly different ($p<0.05$).

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Conflict of Interest

The authors declare no conflict of interest, financial or otherwise.

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