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Analysis of physicochemical properties of two varieties of sorghum biscuits from The Kingdom of Lesotho

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Abstract

Sorghum bicolor belongs to the Graminae family. The common name of *S. bicolor* is sorghum. The grains of *S. bicolor* are used to prepare variety of food products and these grains are served as a staple food for approximately 500 million people in more than thirty countries. Various classes of secondary metabolites have been reported from the grains of *S. bicolor.* The presence of these secondary metabolites in *S. bicolor* has been responsible for its biological and pharmacological activities. The objective of the present study was to analyze the physicochemical properties of two varieties sorghum of biscuits *viz.* sorghum nutty biscuits (SNB) and sorghum ginger biscuits (SGB) that are sold in the Kingdom of Lesotho. The physicochemical properties of these two varieties of biscuits were analyzed as per the established procedures outlined in the literature. The analyzed physicochemical properties are listed below and the determined values are given in brackets for SNB and SGB, respectively. The pH (9.27±0.02 and 8.37±0.11), moisture content (17.6±0.76 and 6.21±0.19%), crude fiber content (2.99±0.09 and 4.48±0.12%), crude protein content (17.37±0.01 and 6.61±0.01%), crude fat content (11.13±0.41and 20.20±0.70%), carbohydrate content (48.89±0.91 and 60.83±0.69%), ash content (2.24±0.06 and 1.67±0.22%), total solids content (82.37±0.76 and 93.79±0.19%), total solids non-fat content (71.23±0.62 and 73.59±0.73%) and gross energy (1526.83±6.01 and 1887.56±4.25 kcal/100 g of sample). Most of the determined values of physicochemical properties of these two varieties of biscuits were within the acceptable ranges as reported in the literature. From this study, we concluded that both SNB and SGB sold in the Kingdom of Lesotho have nutritional contents that are beneficial to health.

1. Introduction

Sorghum bicolor belongs to the Graminae family, which consists of approximately 10,000 known species (Owuama, 2019). *Sorghum bicolor* is popularly known by its common name *viz.* sorghum. Additionally, *S. bicolor* is also known by its vernacular names such as great millet, milo, guinea corn, broomcorn, imphee, durra and jowar. *Sorghum bicolor* is cultivated in an estimated area of 42 million hectares in 98 countries in the world (Belum *et al*., 2010). *Sorghum bicolor* grows in Africa, Asia, Oceania and the Americas (Belum *et al*., 2010; Udachan *et al*., 2012). *Sorghum bicolor* is a subsistence dry land crop and it has the ability to sustain drought and harsh conditions (Belum *et al*., 2010; Udachan *et al*., 2012). *Sorghum bicolor* is one of the major cereal crops and it stands as the fifth most important cereal crops in the world besides rice, wheat, maize and barley. The grains of *S. bicolor* are the edible part and they are served as a staple food for approximately 500 million people in more than 30 countries. The grains of *S. bicolor* have been used to prepare a variety of food products including gluten-free products (Leonard *et al*., 2017; Shahzadi, *et al*., 2021). Gluten is a naturally available complex protein composed of two fractions *viz.* glutenin and gliadin. Food grains such as wheat, oats, rye and barley have been a rich source of this complex protein. Previous reports revealed that some groups of people in various regions across the world are allergic to gluten since they cannot tolerate the presence of gluten in their diet due to genetic susceptibility (Leonard *et al*., 2017; Shahzadi, *et al*., 2021). Consumption of gluten-containing food

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products by these groups of people leads to indigestion in the small intestine and causes issues associated with health and such a condition is called celiac disease or chronic immune-mediated enteropathy (Leonard *et al*., 2017; Shahzadi, *et al*., 2021). Therefore, gluten-free food products are suitable and are recommended to these groups of people (Leonard *et al*., 2017; Shahzadi, *et al*., 2021). Fortunately, the food products obtained from the grains of *S. bicolor* are gluten-free and therefore, fulfilled this requirement. Additionally, various classes of phytochemicals have been reported from the grains of *S. bicolor*, which include phenolics, flavonoids, flavonoid glycosides, tannins, sterols, phenolic acids, anthocyanins, polycosanols and coumarin derivatives (Awika and Rooney, 2004; Dykes and Rooney, 2006; Kamath *et al*., 2004; Phi-Hung *et al*., 2014). The presence of these secondary metabolites has been responsible for various biological and pharmacological activities of *S. bicolor* (Dykes and Rooney, 2006; Kamath *et al*., 2004; Phi-Hung *et al*., 2014). For example, phenolics, flavonoids and tannins present in the grains have been responsible for antiradical and antioxidant properties (Dykes and Rooney, 2006; Kamath *et al*., 2004), flavonoid glycosides present in the grains of *S. bicolor* have been responsible anti-diabetic and antithrombotic activities (Phi-Hung *et al*., 2014).

The grains of *S. bicolor* have been used to prepare a variety of food products. However, the flour obtained from the grains of *S. bicolor* cannot be used to make soft products like bread, cakes and the like due to its excessive grittiness. In the bakeries, these soft products are prepared mainly from wheat flour (Gallagher *et al*., 2004; Olaoye *et al*., 2007; Serrem *et al*., 2011; Adefegha and Oboh, 2013; Rao *et al*., 2016). Various composite flours obtained by mixing flours of cereals, legumes, roots and tubers at various proportions can also be used instead of wheat flour (Adefegha and Oboh, 2013; Feyera, 2020). Nevertheless, sorghum flour can be used in making biscuits in the bakeries (Serrem *et al*., 2011). Additionally, the production of biscuits from sorghum flour has been reported as economical since sorghum flour is easily available in the market for cheaper prices due to its large-scale production (Shinde, 2005; Singh *et al*., 2009). The key ingredients used in the production of biscuits are flour, sugar and fat. Additional ingredients such as nuts, dry fruits and ginger have been added to the key ingredients to enrich the nutritional contents and other dietary principles of vital importance. For example, the availability of proteins, vitamins, minerals and fibers contents of biscuits is ensured by the addition of these extra ingredients. Furthermore, the taste and sensory quality of biscuits are also enriched by the addition of these extra ingredients. Generally, biscuits are served as important ready-to-eat baked foods, especially for elderly people (Arshad *et al*., 2007; Serrem *et al*., 2011; Adeola *et al*., 2017; Dhankhar *et al*., 2019). Additionally, biscuits are cheaper, flavorsome and shelf-stable (Arshad *et al*., 2007; Serrem *et al*., 2011; Adeola *et al*., 2017; Dhankhar *et al*., 2019). The literature search revealed that the physicochemical properties of a few varieties of biscuits prepared from sorghum flour have previously been reported (Serrem *et al*., 2011; Niaba *et al*., 2013; Omoba and Omogbemile, 2013). To the best of our knowledge, the physicochemical properties of biscuits that are prepared using sorghum flour in the Kingdom of Lesotho have not been reported so far. Two varieties of sorghum biscuits *viz.* sorghum nutty biscuits (SNB) and sorghum ginger biscuits (SGB) have been prepared in the Kingdom of Lesotho and are sold in the market. The SNB has been prepared using sorghum flour together with peanuts as one of the added ingredients, whereas the SGB has been prepared using sorghum flour together with ginger as one of the added ingredients. The present study aimed to analyze physicochemical properties such as pH, moisture content, crude fiber content, protein content, crude fat content, carbohydrate content, ash content, total solids content, solids non-fat content and gross energy of SNB and SGB. The results are summarized in this article.

2. Materials and methods

2.1 Samples of biscuits

A 100 g of sorghum nutty biscuits (SNB) sample pocket that contained light brown coloured and disc-shaped eight biscuits and a 100 g of sorghum ginger biscuits (SGB) sample pocket that contained dark brown coloured and disc-shaped eight biscuits were purchased from a local market in Roma, Maseru district of the Kingdom of Lesotho. Each biscuit has a diameter and thickness of approximately 5.00 cm and 1.00 cm, respectively. The biscuit samples were powdered separately using a pestle and mortar and then used for the following physicochemical analysis.

2.2 pH

The pH value of these two varieties of biscuits was determined by methods described in the literature (Niaba *et al*., 2013; Igbabul *et al*., 2014; Matela *et al*., 2019). Briefly, 5 g of each sample powder was dissolved separately in 50 mL distilled water. Each of these solutions was allowed to stand for 1 hr and the supernatant liquid was decanted. The pH value of this supernatant liquid was determined using a pH meter (HANNA, Italy), which was previously calibrated using buffer solutions of pH 4.0 and 7.0, respectively.

2.3 Moisture content

The percentage of moisture content of each sample was determined by methods outlined in the literature (Omoba and Omogbemile, 2013; Latimer, 2016; Gbenga -Fabusiwa *et al*., 2018; Matela *et al*., 2019). Briefly, 2 g of each sample of biscuits was dried separately in an oven for 24 h at 100˚C. The percentage moisture content was calculated by the formula given below.

$$\%\ \text{Moisture} = \frac{\text{Weight of original sample (g)} - \text{Weight of dried sample(g)}}{\text{Weight of original sample (g)}} \times 100$$

2.4 Crude fiber content

The crude fiber content of each sample was determined according to the procedure reported in the literature (Matela *et al*., 2019). Briefly, 2 g of each sample of biscuits was taken in a beaker separately. To each of these samples, a volume of 299 mL of 1.25% of sulphuric acid was added separately and the mixture was boiled for 30 mins. Each of these mixtures was then filtered separately, and dried under vacuum and the residue thus obtained was washed with hot distilled water three times and then boiled again for 30 mins with 200 mL of 1.25% of sodium hydroxide and filtered. Each of these filtered samples was digested and washed with hydrochloric acid to neutralize sodium hydroxide and then rinsed with hot distilled water three times. The residue was taken into a crucible and dried at 100°C for 2 hrs in an oven. Each of these samples was cooled in a desiccator and then weighed. Each of these samples in the crucible was incinerated at 500°C for 5 hrs until all carbonaceous matter was burnt. Finally, the crucible containing the ash was cooled in the desiccator and was weighed. The percentage of crude fiber content was calculated by the formula given below.

$$\%\ \text{Crude fibre} = \frac{\text{Weight loss after ignition (g)}}{\text{Weight of the original sample (g)}} \times 100$$

2.5 Crude protein content

The crude protein content of each sample of biscuits was determined by the macro-Kjeldahl digestion method as described in the literature (Latimer, 2016; Matela *et al*., 2019). Briefly, 2 g of each sample was placed separately in a Kjeldahl digestion flask together with 10 g of copper sulphate and 2 g of sodium sulphate (5:1 ratio). A volume of 25 mL of concentrated sulphuric acid was added to the mixture. The mixture was heated at around 1500°C in the fume cupboard until frothing ceased and the mixture was allowed to stand to cool at room temperature. The mixture was diluted to 100 mL in a volumetric flask using distilled water. A volume of 10 mL of this diluted mixture was poured into the distillation apparatus containing 18 mL of 40% sodium hydroxide. A volume of 25 mL of 2% boric acid was added through a receiving conical flask. Two drops of mixed indicator of bromocresol green and methyl red were also added to the mixture. The solution was distilled into a conical flask and the solution in the conical flask was titrated against 0.1N hydrochloric acid until the endpoint, which was the colour change of the boric acid solution from pink to yellowish-green. A blank titration with distilled water alone was also done using the same procedure. The protein content of the sample was calculated by the formula given below.

$$\%\ \text{Crude protein} = \text{Total nitrogen} \times \frac{6.25}{1000} \times 100$$

$$\text{Total nitrogen} = \frac{(\text{Vol. of standard acid in mL} - \text{Vol. of blank in mL})\ 14.0067}{\text{Sample in grams}} \times 0.1\text{N}$$

Where, 6.25 = Protein-nitrogen conversion factor, 1000 = The conversion factor of milligram nitrogen/100 g sample to gram nitrogen/100 g of sample, 14.0067 = Atomic weight of nitrogen, 0.1 N = Normality of hydrochloric acid.

2.6 Fat content

The fat content of each sample of biscuits was determined by methods detailed in the literature (Offia-Olua, 2014; Latimer, 2016). Briefly, 5 g of each sample was mixed separately with 0.88 mL of hydrochloric acid and 10 mL of 95% ethanol in a flask. Fat was extracted by adding 25 mL of diethyl ether and by shaking the contents vigorously for 1 min. A volume of 25 mL of petroleum ether was also added to this mixture and the contents were shaken vigorously for thorough mixing. The mixture was then allowed to stand for 1 h to separate aqueous and organic layers. The organic layer that contained fat was collected separately in another flask. The extraction was repeated three times to get a complete extraction. The combined fat extract in the flask was allowed to dry in an oven at 100°C for 30 mins to remove the organic solvents completely. The flask was then cooled in a desiccator and was weighed for its mass of fat. The percentage of fat was calculated by the following formula.

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

2.7 Carbohydrate content

The carbohydrate content of each sample was determined by methods as reported in the literature (Gbenga-Fabusiwa *et al*., 2018; Matela *et al*., 2019). The carbohydrate content was calculated by the formula given below.

$$\%\ \text{CHO} = 100 - (\%\ \text{Moisture} + \%\ \text{Ash} + \%\ \text{Protein} + \%\ \text{Fat} + \%\ \text{Crude fibre})$$

The percentages of moisture, ash, protein, fat and crude fiber contents of each sample were already determined.

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2.8 Ash content

The ash content of each sample of biscuit was determined by direct heating method as per the procedure outlined in the literature (Latimer, 2016). Briefly, 2 g of each biscuit sample was taken separately in a dried glass crucible. The sample was then incinerated to ash in a muffle furnace for 3 hrs at 550°C. The crucible was then removed from the furnace and was cooled in a desiccator and then the weight of the ash content was determined. The percentage of ash content was calculated by the following formula.

$$\% \text{ Ash} = \frac{[(\text{Weight of crucible} + \text{ash}) - (\text{Weight of crucible})](g)}{[(\text{Weight of crucible} + \text{sample}) - (\text{Weight of cucible})](g)} \times 100$$

2.9 Total solids content

The total solids content of each sample of biscuit was obtained from moisture content analysis as described in the literature (Niaba *et al*., 2013; Matela *et al*., 2019). The percentage of total solids content can be calculated if the percentage of moisture content is known. The percentage of total solids was calculated by the formula given below.

$$\% \text{ Total solids} = 100 - \% \text{ Moisture content}$$

2.10 Total solids non-fat content

The total solids non-fat content of each sample of biscuit was determined by the difference between the percentage of total solid contents and the percentage of fat contents by the method as detailed in the literature (Matela *et al*., 2019).

$$\% \, Total \, solids \, non \, fat = \% \, Total \, solids - \% \, Fat \, content$$

2.11 Gross energy

The gross energy for each sample of biscuit was determined by methods given in the literature (Paul and Southgate, 1979; Okoye *et al*., 2008; Omoba and Omogbemile, 2013; Matela *et al*., 2019). The gross energy is expressed in kilocalories/100 g of sample (kcal/100 g).

$$\text{Gross energy} = [(\% \text{ Crude protein} \times 4) + (\% \text{ Crude fat} \times 9) + (\% \text{ Carbohydrate} \times 4)]$$

2.12 Statistical analysis

All determinations were performed in triplicates (n = 3) and the results are expressed as mean±SD. Data analysis was performed using SPSS 17.0 application software. The means were considered statistically significant when $p \leq 0.05$.

3. Results and discussion

A total of ten physicochemical properties such as pH, moisture content, crude fiber content, crude protein content, crude fat content, carbohydrate content, ash content, total solids content, total solids non-fat content and gross energy of two varieties of biscuits *viz.* sorghum nutty biscuits (SNB) and sorghum ginger biscuits (SGB) purchased from a local market in the Kingdom of Lesotho were analyzed. The results are summarized in Table 1. The physicochemical properties of other varieties of sorghum biscuits such as sorghum soy flavour biscuits and defatted sorghum biscuits with soy flour have already been reported in the literature and are also listed in Table 1 for comparison.

To begin with, the pH values of SNB and SGB were determined to be 9.27±0.02 and 8.37±0.11, respectively. These values indicated that both SNB and SGB were alkaline in nature. The SNB showed slightly more alkalinity than the SGB. The literature value of sorghum soy flavour biscuits has been reported to be slightly acidic in nature and the pH value of these soy flavour biscuits has been reported as 5.64±0.81 (Dhankhar *et al*., 2019) (Table 1). The pH value of blood has been reported to be within a narrow range of 7.35-7.45 and maintenance of this range is necessary for the normal function of cells, tissues and organs (Rajkumar and Pluznick, 2018). Any values of pH outside of this range will cause significant pathophysiology in humans including death (Rajkumar and Pluznick, 2018). Fortunately, the lungs and kidneys work together to regulate the bicarbonate ion and carbon dioxide and to maintain the pH value within this range (Rajkumar and Pluznick, 2018). The present study showed that both SNB and SGB exhibited significantly higher values of pH than the expected pH range of blood. Therefore, based on this report, it was suggested that the pH value of both these two varieties of biscuits (SNB and SGB) has to be reduced such that the pH value could be maintained close to the narrow range of 7.35-7.45 as indicated in the literature (Rajkumar and Pluznick, 2018). Next, the moisture contents of SNB and SGB were determined to be 17.6±0.76 and 6.21±0.19%, respectively. The literature value of moisture contents of the other two varieties of sorghum biscuits (*i.e.* sorghum soy flavour biscuits and defatted sorghum biscuits with soy flour) have been reported to be 3.2±0.6 and 4.0±0.0%, respectively (Serrem *et al*., 2011; Latimer, 2016). The acceptable level of moisture content reported in the literature has been <10% (Gbenga-Fabusiwa *et al*., 2018). Therefore, the present study revealed that the moisture content of SGB was found to be well within the acceptable level. On the other hand, the moisture content of SNB was found to be much higher (17.6±0.76%) than the acceptable level of 10%. It has previously been reported that although the moisture content of various biscuits varied according to the types of biscuits

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Table 1. Analysis of physicochemical properties of sorghum nutty biscuits (SNB) and sorghum ginger biscuits (SGB).

Physicochemical properties analyzed	Sorghum nutty biscuits (SNB)	Sorghum ginger biscuits (SGB)	Literature values of sorghum soy flavour biscuits and/or defatted sorghum biscuits with soy flour
pH	9.27±0.02[c]	8.37±0.11[a]	5.64±0.81 (Niaba *et al*., 2013).
Moisture content (%)	17.6±0.76[d]	6.21±0.19[b]	3.2±0.6 and 4.0±0.0 (Serrem *et al*., 2011; Omoba and Omogbemile, 2013).
Crude fiber content (%)	2.99±0.09[b]	4.48±0.12[c]	1.7±0.4 and 3.3±0.0 (Serrem *et al*., 2011 Omoba and Omogbemile, 2013).
Crude Protein content (%)	17.37±0.01[a]	6.61±0.01[a]	9.2±0.4 and 7.6±0.0 (Serrem *et al*., 2011; Omoba and Omogbemile, 2013).
Crude fat content (%)	11.13±0.41[b]	20.20±0.70[d]	21.0±0.6 and 12.0±0.2 (Serrem *et al*., 2011; Omoba and Omogbemile, 2013).
Carbohydrate content (%)	48.89±0.91[e]	60.83±0.69[d]	63.5±0.4 and 70.6±0.0 (Serrem *et al*., 2011; Omoba and Omogbemile, 2013).
Ash content (%)	2.24±0.06[d]	1.67±0.22[c]	1.4±0.0 and 2.5±0.1 (Serrem *et al*., 2011; Omoba and Omogbemile, 2013).
Total solids content (%)	82.37±0.76[d]	93.79±0.19[b]	96.06±0.36 (Niaba *et al*., 2013).
Total solids non-fat content (%)	71.23±0.62[c]	73.59±0.73[d]	Not available
Energy (kilocalories)	1526.83±6.01[e]	1887.56±4.25[c]	2013.0 and 1992.2±0.0 (Serrem *et al*., 2011; Omoba and Omogbemile, 2013).

Values are presented as mean±SD (n = 3). Values with different superscripts within the same row are statistically significantly different (p≤0.05).

produced, it should not be exceeded more than 10%. Indeed, a high level of moisture content will significantly reduce the shelf-life of biscuits (Gbenga-Fabusiwa *et al*., 2018). Additionally, the crude fiber contents of SNB and SGB were determined to be 2.99±0.09 and 4.48±0.12%, respectively. The literature values of crude fiber contents of the other two varieties of sorghum biscuits (*i.e.* sorghum soy flavour biscuits and defatted sorghum biscuits with soy flour) have been reported as 1.7±0.4 and 3.3±0.0%, respectively (Serrem *et al*., 2011; Omoba and Omogbemile, 2013). The present study revealed that the crude fiber content of SNB was found to be within the acceptable range as that of literature value (Serrem *et al*., 2011). On the other hand, the crude fiber content of SGB was found to be slightly higher than the literature value (Omoba and Omogbemile, 2013). Previous studies revealed that *S. bicolor* has been a rich source of dietary fibre and this dietary fibre has a compound *viz.* β-glucan. In addition to its health benefits as prebiotics, β-glucan has prevented colon cancer, and diabetes (Niba and Hoffman, 2003) and exhibited antimicrobial and antitumor stimulatory capabilities (Brown and Gordon, 2001). The presence of dietary fiber has additional health benefits such that it could bind with fat deposits in the digestive tract and this process prevents numerous degenerative diseases including obesity and diabetes (Slavin, 2005; Ionita-Mîndrican *et al*., 2022). In general, diets with high fiber content are usually low in fat and contribute low energy density and therefore, help to maintain healthy body weight (Slavin, 2005; Ionita-Mîndrican *et al*., 2022). It has been recommended that at least 50% of the total intake of cereals should be unprocessed (Ionita-Mîndrican *et al*., 2022). An intake of 18-38 g of fiber per day for adults has been recommended to keep normal body weight, to avoid cardiovascular diseases and for excellent digestion (Ionita-Mîndrican *et al*., 2022). The World Health Organization (WHO), Food and Agricultural Organization of the United Nations (FAO) and European Food Safety Authority (EFSA) recommend an average daily intake of 25 g of fiber per day per adult (Nishida, 2004; EFSA, 2010).

Furthermore, the protein content of SNB and SGB were determined to be 17.37±0.01 and 6.61±0.01%, respectively. The literature values of protein content of two other varieties of biscuits (*i. e.* sorghum soy flavour biscuits and defatted sorghum biscuits with soy flour) have been reported as 9.2±0.4 and 7.6±0.1%, respectively (Kamath *et al*., 2004; Arshad *et al*., 2007; Serrem *et al.,* 2011). The protein content of biscuits obtained from sorghum-wheat composite flour and malted sorghum-soy samples have also been reported previously and the values of protein content have been reported in the ranges of 7.06-11.84% and 7.28-11.74%, respectively (Adebowale *et al*., 2012; Feyera, 2020). The present study showed that SGB has a comparable value of protein content as that of literature value. However, SNB has a very high level of protein content of 17.37±0.01%. In fact, higher content of protein is good for health, especially for elderly people (Mulyo *et al*., 2022). The high content of protein in SNB must be due to the added ingredients. As stated previously one of the added ingredients in the SNB was peanuts, which supply more protein content. However, one of the added ingredients in the SGB was ginger and this ginger does not supply more protein. It has previously been reported that the biological functions of humans would decrease with increasing age (Mulyo *et al*., 2022). Therefore, biscuits with adequate nutritional content including protein contents have been one of the best choices for the elderly people to meet their food requirements (Mulyo *et al*., 2022). The crude fat contents of SNB and SGB were determined to be 11.13±0.41 and 20.20±0.70%, respectively. The crude fat content of the other two varieties of biscuits (*i. e.* sorghum soy flavour biscuits and defatted sorghum biscuits with soy flour) reported in the literature have been 21.0±0.6 and 12.0±0.2%, respectively (Serrem *et al.,* 2011; Omoba and Omogbemile, 2013) (Table 1). Therefore, the result from the present study revealed that both SNB and SGB have comparable crude fat contents as those of literature values (Serrem *et al*., 2011; Omoba and Omogbemile, 2013). However, it was noticed that the crude fat content of SGB was found to be significantly higher than SNB. Previous studies revealed that fat content in biscuits plays an important role in providing the desirable textural properties of biscuits (Hasmadi and Sandra, 2014). However, a high level of crude fat content could accelerate spoilage of biscuits by promoting rancidity and thus could reduce the shelf-life of biscuits (Omoba and Omogbemile, 2013). A total fat intake of 20-35% of total calories has been recommended by the Dietary Reference Intakes (DRI) and World Health Organization (WHO) (Trumbo *et al*., 2003; FAO, 2010). A minimum of 20% of total fat intake is required to prevent atherogenic dyslipidemia and the presence of such a condition increases the risk of coronary heart disease (Trumbo *et al*., 2003). In other words, an intake of diet with low-fat and high carbohydrates causes coronary heart diseases and obesity (Trumbo *et al*., 2003). The total carbohydrate content of SNB and SGB were found to be 48.89±0.91 and 60.83±0.69%, respectively. The reported values of carbohydrate content of two other varieties of biscuits (*i. e.* sorghum soy flavour biscuits and defatted sorghum biscuits with soy flour) have been 63.5±0.4 and 70.6±0.1%, respectively (Serrem *et al*., 2011; Omoba and Omogbemile, 2013) (Table 1). This result indicated both SNB and SGB exhibited lower values of carbohydrate content compared to literature values. Carbohydrates are the prime source of energy for the function of the body's muscles. Approximately, 4-5 calories of energy are obtained from one gram of carbohydrate and 0.7 litre of oxygen is required for this process to occur (Burke *et al*., 2004; McKevith, 2004; Banerjee *et al*., 2014; Eke-Ejiofor and Williams, 2016; Feyera, 2020). The carbohydrate content of food products depends on the types of ingredients used. In general, biscuits produced from rice and legumes will have more carbohydrate contents (Burke *et al*., 2004; McKevith, 2004; Banerjee *et al*., 2014; Eke-Ejiofor and Williams, 2016; Feyera, 2020). The level of carbohydrates will decrease with increasing added ingredients such as soy flour, bean flour and flour of defatted soy-bean blends (Burke *et al*., 2004; McKevith, 2004; Banerjee *et al*., 2014; Eke-Ejiofor and Williams, 2016; Feyera, 2020).

We then analyzed the ash contents of SNB and SGB. The residual remaining inorganic minerals after a complete combustion of organic matter in food products is called ash (Harris and Marshall, 2017). The ash contents of SNB and SGB were found to be 2.24±0.06 and 1.67±0.22%, respectively. The reported values of ash contents of other varieties of biscuits (*i. e.* sorghum soy flavour biscuits and defatted sorghum biscuits with soy flour) have been 1.4±0.0 and 2.5±0.1%, respectively (Serrem *et al*., 2011; Omoba and Omogbemile, 2013) (Table 1). This result showed that both SNB and SGB showed acceptable values of ash content as that of literature values (Serrem *et al*., 2011; Omoba and Omogbemile, 2013) (Table 1). Minerals such as calcium, magnesium, sodium and potassium together with traces of zinc, iron and other metals have been reported in the ash (Harris and Marshall, 2017). Food can have a maximum of 12% of ash content but the ash content of fresh food rarely exceeds 5% (Roberta *et al*., 2019). Although minerals represent a small proportion of dry matter, they play important physicochemical and nutritional roles (Harris and Marshall, 2017). The total solids contents of SNB and SGB were determined to be 82.37±0.76 for 93.79±0.19%, respectively. The total solids content of two other varieties of biscuits (*i. e.* sorghum soy flavour biscuits) has been reported as 96.06±0.36% (Arshad *et al*., 2007). The percentage of total solids contents is dependent on the percentage of moisture content. Compared to the literature value, SGB showed a very close value of total solids content and SNB showed a slightly lower value of total solids content. The total solids non-fat content of SNB and SGB were determined to be 71.23±0.62 and 73.59±0.73%, respectively. Both SNB and SGB showed comparable total solids non-fat content to each other. However, reports on the total solids and non-fat content of other varieties of biscuits were not available for comparison. Finally, the gross energy of SNB and SGB were determined to be 1526.83±6.01 and 1887.56±4.25 kcal/100 g of sample, respectively. The literature values of gross energy of two other varieties of biscuits (*i. e.* sorghum soy flavour biscuits and defatted sorghum biscuits with soy flour) have been reported to be 2013.0 and 1992.2±0.0 kcal/100 g of sample, respectively (Serrem *et al*., 2011; Omoba and Omogbemile, 2013) (Table 1). This result indicated that both SNB and SGB have lower energy compared to literature values. The total energy density of biscuits is contributed by three energy sources viz. carbohydrates, proteins and fats. As

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we stated previously carbohydrates have been the prime source of total energy density and are required for all our muscle activity. However, proteins have also contributed significantly to the total energy density of food products. A higher content of proteins in food products has been good for health, especially for elderly people (Mulyo *et al*., 2022). Similarly, fat has also contributed significantly to the total energy density (Roberta et al., 2019). In general, a biscuit that has high-fat contents effectively reduce energy density, and calorie intake and help to prevent obesity (Roberta *et al*., 2019).

4. Conclusion

In this study, we analyzed the physicochemical properties such as pH, moisture content, crude fiber content, protein content, crude fat content, carbohydrate content, ash content, total solids content, solids non-fat content and gross energy of two varieties of biscuits prepared from sorghum flour *viz.* sorghum nutty biscuits (SNB) and sorghum ginger biscuits (SGB) sold in the market in the Kingdom of Lesotho. Most of the determined values of physicochemical properties of these two varieties of biscuits were within the acceptable ranges, except for the moisture content of SNB. The moisture content of SNB was determined to be much higher (17.6±0.76%) than the acceptable range. Therefore, we recommended that the moisture content of SNB has to be reduced to prolong its shelf-life. From this study, we concluded that both SNB and SGB sold in the Kingdom of Lesotho are rich in nutrition and are beneficial to health.

Conflict of interest

The authors declare no conflict of interest.

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