

Proximate composition and physicochemical properties of halwa produced in the urban west region, Zanzibar

Abstract

Information on food composition is important not only for the power of the market, but also for the health and safety of consumers. Halwa consumption in Zanzibar, especially in the urban west region, has increased with limited nutrition information and a lack of regulatory supervision. This study aimed to determine the proximate composition and total sugar content (sucrose) of groundnut-added halwa produced in the urban west region of Zanzibar. A total of 13 samples were taken for laboratory analysis. Moisture content, ash content, crude protein, crude fat, crude fibre, acid insoluble ash, acidity of extracted fat and total sugar were determined by AOAC methods 925.49, 900.2, 920.176, 920.177, 960.39, IS 6287 and ZNS 574:2023 respectively. All AOAC methods were adopted as detailed in the 21st edition of 2019. The halwa samples had a total sugar content ranging from 26.06% to 51.54%, moisture content from 13.61% to 26.15%, ash content from 0.03% to 0.48%, acid insoluble ash from 0.01% to 0.252%, crude protein from 0.06% to 3.61%, crude fat from 1.79% to 4.77%, acidity of extracted fat as oleic acid from 2.43% to 4.72% and crude fibre ranged 8.12% to 15.21%. The carbohydrate and energy contents of the halwa were in the range of 61.27% to 71.62% and 265.73 Kcal/100g to 326.74 Kcal/100g respectively. All 13 samples did not conform to the requirements of Zanzibar Standard for halwa (ZNS 574:2023) concerning moisture and fat content, while seven (samples complied with ZNS 574:2023 concerning the acidity of extracted fat as oleic acid. Only one sample did not conform to ZNS: 574: 2023 in terms of the acid-insoluble ash parameters. All samples were in accordance with the requirements of ZNS 574:2023 concerning sugar content. The requirements described for halwa in ZNS 574:2023 are maximum moisture of 12%, acid ash of 0.2%, fat content of 6% – 28%, acidity of extracted fat as oleic acid maximum of 3% and a maximum sugar content of 55%.

Keywords: halwa, moisture, ash content, crude protein, crude fat, crude fibre, total sugar, energy

Introduction

Halwa, often referred to as a confectionery masterpiece, is celebrated for its ability to combine taste, aroma and texture into a harmonious treat. This dessert is prepared using macerated starch, sugar, ghee or vegetable oil/fat and other suitable ingredients such as colour, nuts, rose water, cardamom, saffron, eggs and milk. Variations in recipes and preparation methods result in unique flavours and nutritional profiles (Al-Shamsi *et al.*, 2013). Approximately 10–15% of ghee (by weight) is added in halwa preparation to improve the quality and obtain multiple sensory perceptions such as aroma, pleasant, enjoyable and

lingering taste in the mouth (Manickavasagan and Al-Sabahi, 2014). Halwa is consumed daily depending on individual desires and habits regardless of the consumer's age, gender, or status, and enjoys great popularity among a wide range of populations. Referring to the nature of the ingredients used, halwa is a high-energy-dense food that mainly consists of fat, starch and sugar, with low nutrients or minerals. Hence, the relationship between halwa intake and health needs to be considered. However, in Zanzibar, there is limited information on the nutrient composition of halwa. Understanding the composition of halwa is paramount for several reasons. Firstly, it aids in determining its nutritional value and potential health implications. Secondly, it helps to make informed dietary choices, considering factors such as sugar intake, fat content and mineral composition. Lastly, the analysis provides insights for improving recipes, production techniques and quality control in the food industry. Sugar added during halwa processing directly influences its sweetness and taste making people think of enjoyment. However, excessive ingestion of sugar has been linked to chronic diseases such as obesity, metabolic syndrome, diabetes and cardiovascular disease (Clemens *et al.*, 2016). Ghee, the main ingredient in halwa is high in cholesterol and contains about 60% saturated fat. Consuming of diets that are higher in saturated fat and cholesterol increases the risk of cardiovascular diseases, obesity and diabetes (Kumar *et al.*, 2018). Although there is no data showing the trends of halwa intake per individual, the eating habits of Zanzibar people, combined with halwa intake could lead to accumulation of fat and sugar in the body greater than the required amount. In Zanzibar, there is a high intake of cereals (carbohydrates) and fat especially in the urban west region and limited use of protein-source food, partly driven by limited knowledge about nutrition (Islam *et al.*, 2017). The observed negative trends in the health of the population of Zanzibar in term of non-communicable diseases can be linked to the high intake of carbohydrates (sugar) and fat, as non-communicable diseases are caused by unhealthy diets associated with food production that are high in salt, sugar, trans-fatty acids, unhealthy additives and behavioural risk factors. In 2019, 2020 and 2021, NCD-related diseases became among the top ten causes of hospital admissions and were among the top three leading causes of death in Zanzibar. Hypertension has been a consistent leading cause of hospital admissions in Zanzibar, in 2019 and 2020, dropping to second in 2021 (MoH, 2021). To prevent the problem of chronic diseases related to food consumption, information on the composition of processed foods has become crucial for consumers and health policy makers (Combis *et al.*, 2011). The availability of information on food composition, whether labelled on packaging or documented at the office, is regarded as a major means of encouraging consumers to make healthier choices when buying food (Grunert *et al.*, 2010). Therefore, this study aimed to determine the proximate composition and total sugar (sucrose) content of halwa produced in the urban west region of Zanzibar.

Materials and methods

The halwa samples were bought from 13 different halwa processors located in the urban west region of Zanzibar. After purchasing, the samples were packed and transferred to the Food Science and Agro-processing laboratory at Sokoine University of Agriculture (SUA) where they were stored at room temperature for two days before analysis

Proximate chemical analysis

Moisture content was determined by the oven drying method an official AOAC method (925.49). Five grams (5 g) of halwa sample was accurately weighed into a clean and dry petri dish. The petri dish was then dried in an oven at 105°C for 5 hours until a constant weight was obtained. The ash content of halwa was determined using the gravimetric method as described in AOAC method 900.02. A clean empty crucible was placed in a muffle furnace at 550°C for an hour to ensure all impurities on the surface of the crucible were burnt off. The crucible was then cooled in a desiccator for 30 minutes. Five grams (5 g) of halwa sample was measured into the crucible and placed in a muffle furnace and heated for 12 hours at 550°C. The crude fibre content was determined using AOAC method 991.43 with an Ankom fibre analyser (model ANKOM 220). Approximately 1 g of the sample was taken for crude fibre determination. Crude protein was determined by the Kjeldahl method using AOAC method no. 920.176. One gram of the sample was weighed in Kjeldahl flasks for analysis. Digestion and analysis were then carried out in a digestion system 2000 and a Kjeldahl analyser unit 2300 (Foss Tecator, Höganäs, Sweden). The conversion factor 5.55 x N was used. Total fat content was determined by using the Soxhlet extraction unit (Foss Soxtec 2055) as described in AOAC method 920.177, in which 5 g in 70 ml was used for the extraction process in three automatic phases in a fat analyser machine, the boiling phase for 30 min, the rinsing phase for 30 min and petroleum ether recovery phase for 10 min. The total carbohydrate content was determined by difference, according to AOAC (2000), using the following formula: Total carbohydrate = 100 – (% CP + % EE + % CF + % Ash content + %MC) Where: CP = crude protein, EE = ethyl alcohol extract, CF = crude fibre, MC = moisture content and AC = ash content.

The acidity of extracted fat, acid-insoluble ash, total sugar and energy content

The acidity of the extract was determined using the method described in ZNS 574:2023. The obtained fat weights were transferred into a 200 ml conical flask. About 25 ml of hot ethyl alcohol was added followed by one millilitre of the phenolphthalein indicator and titrated against potassium hydroxide. Total sugar expressed as sucrose was determined by ZNS 574:2023. About 10 g of halwa were weighed in a 150 ml beaker and then triturated with hot alcohol. The mixture was filtered through a dry filter and the hot alcoholic extract having the free-reducing sugar and the sucrose was collected into the beaker. Then, an incremental method of titration was conducted. Acid insoluble ash was determined by using Indian Standards IS 6287. About 25 ml of the diluted hydrochloric acid was added to the ash, and then heated near boiling. The mixture was cooled and filtered through Whatman filter paper No. 42. The residues were ignited in the muffle furnace at 550±25°C for one hour and cooled in a desiccator and weighed. Energy value was calculated using the Atwater's convention factors that is, energy values for the collected samples were calculated by multiplying the percentage of fat, percentage of protein, and percentage of carbohydrates by the Atwater factors of 9, 4, and 4 respectively (AOAC, 2000).

Statistical data analysis

Data were analysed using the Statistical Package for Social Science (IBM SPSS Version 25, 2017). A one way Analysis of Variance (ANOVA) was used to determine the significant

differences between the samples at a 5% level of significance. Means were separated using the Tukey Honest Significant Different (HSD). Results were expressed as mean \pm standard deviation and presented in tabular form.

Results

The results for physicochemical properties and proximate composition are summarised in Table 1 and 2 respectively

Table 3.1: Physicochemical properties, total sugar and energy content of halwa

Processors ID	Acid insoluble ash (%)	The acidity of extracted fat (%)	Sugar content (g/100g)	Energy content (Kcal/100g)
P1	0.024 \pm 0.004 ^{ab}	3.679 \pm 0.085 ^h	34.39 \pm 5.61 ^{ab}	293.71 \pm 5.78 ^{bc}
P2	0.058 \pm 0.014 ^{ab}	2.879 \pm 0.016 ^{cd}	39.94 \pm 13.49 ^{ab}	308.44 \pm 13.19 ^c
P3	0.172 \pm 0.029 ^{de}	2.7 \pm 0.002 ^{bc}	36.71 \pm 11.49 ^{ab}	291.11 \pm 0.75 ^b
P4	0.014 \pm 0.003 ^a	3.352 \pm 0.064 ^g	41.47 \pm 5.91 ^{ab}	287.56 \pm 2.29 ^b
P5	0.252 \pm 0.021 ^f	3.093 \pm 0.023 ^{ef}	29.14 \pm 0.83 ^{ab}	292.49 \pm 0.32 ^{bc}
P6	0.033 \pm 0.023 ^{ab}	3.377 \pm 0.047 ^g	34.27 \pm 5.67 ^{ab}	287.72 \pm 0.81 ^b
P7	0.124 \pm 0.009 ^{cd}	2.439 \pm 0.078 ^a	42.51 \pm 6.76 ^{ab}	301.35 \pm 3.17 ^{bc}
P8	0.185 \pm 0.049 ^e	3.266 \pm 0.019 ^{fg}	51.54 \pm 12.09 ^b	326.74 \pm 8.08 ^d
P9	0.069 \pm 0.023 ^{abc}	4.721 \pm 0.182 ⁱ	26.06 \pm 8.76 ^a	302.26 \pm 0.69 ^{bc}
P10	0.021 \pm 0.004 ^{ab}	2.922 \pm 0.003 ^{de}	28.35 \pm 2.82 ^{ab}	298.65 \pm 4.93 ^{bc}
P11	0.021 \pm 0.007 ^{ab}	3.409 \pm 0.017 ^g	31.93 \pm 12.09 ^{ab}	299.90 \pm 1.77 ^{bc}
P12	0.016 \pm 0.004 ^a	2.832 \pm 0.002 ^{cd}	35.81 \pm 4.98 ^{ab}	293.01 \pm 8.41 ^{bc}
P13	0.077 \pm 0.017 ^{bc}	2.617 \pm 0.018 ^b	36.54 \pm 7.63 ^{ab}	265.73 \pm 3.97 ^a

Values are expressed as means \pm standard deviation of the triplicate determinations. Values in the same column having the same superscripted letters are not significantly different ($p > 0.05$) according to Turkey Honest Significant Different (HSD).

Table 3. 2: Proximate composition of halwa (%)

Sample ID	Moisture content	Ash content	Crude fat	Crude protein	Crude fibre	Carbohydrate
P1	18.91±1.67 ^{bc}	0.035±0.004 ^{ab}	2.436±1.299 ^{abc}	3.607±0.187 ^f	11.15±0.119 ^c	62.44±0.09 ^{ab}
P2	17.79±2.19 ^{ab}	0.083±0.012 ^{abc}	3.497±1.449 ^{abc}	3.407±0.141 ^f	9.251±0.369 ^{ab}	64.22±0.58 ^{bc}
P3	22.18±0.33 ^{cd}	0.239±0.045 ^e	3.354±0.891 ^{abc}	0.722±0.011 ^e	8.282±0.295 ^a	65.62±0.77 ^{cd}
P4	21.49±0.91 ^{bc}	0.029±0.002 ^a	2.283±0.564 ^{ab}	0.085±0.009 ^a	9.205±0.711 ^{ab}	66.41±0.36 ^d
P5	17.67±2.2 ^{9ab}	0.482±0.069 ^g	2.605±0.508 ^{abc}	0.389±0.055 ^{bc}	11.08±0.602 ^c	66.11±0.95 ^{cd}
P6	22.73±0.5 ^{cd}	0.121±0.026 ^{bcd}	2.177±0.569 ^{ab}	0.650±0.044 ^{de}	8.200±0.108 ^a	66.72±0.17 ^d
P7	17.37±0.84 ^{ab}	0.367±0.007 ^f	1.793±0.366 ^a	0.679±0.037 ^e	8.914±0.175 ^{ab}	70.52±0.03 ^e
P8	14.37±1.15 ^a	0.465±0.054 ^g	4.226±0.8 ^{bc}	0.586±0.074 ^{cde}	9.413±0.702 ^{abc}	71.62±0.29 ^e
P9	13.61±1.22 ^a	0.173±0.023 ^{de}	4.767±1.462 ^c	0.359±0.052 ^{bc}	15.21±0.602 ^d	66.43±0.29 ^d
P10	21.21±0.79 ^{bc}	0.067±0.005 ^{ab}	3.541±0.4 ^{abc}	0.064±0.002 ^a	8.119±0.827 ^a	66.46±0.22 ^d
P11	19.00±0.48 ^{bc}	0.043±0.002 ^{ab}	3.982±0.125 ^{abc}	0.084±0.003 ^a	10.65±0.337 ^{bc}	65.76±0.20 ^{cd}
P12	20.76±1.47 ^{bc}	0.115±0.004 ^{abcd}	2.441±0.194 ^{abc}	0.284±0.102 ^{ab}	8.355±0.959 ^a	66.64±1.38 ^d
P13	26.15±2.70 ^d	0.159±0.014 ^{cde}	2.191±0.149 ^{ab}	0.411±0.073 ^{bcd}	9.652±0.999 ^{abc}	61.27±1.04 ^a

Values are expressed as means ± standard deviation of the triplicate determinations. Values in the same column having the same superscripted letters are not significantly different ($p > 0.05$) according to Turkey Honest Significant Different (HSD).

Discussion

Moisture content

The moisture content of halwa samples plays a significant role in determining the texture, flavour, shelf life and overall quality of the products. The range of moisture content from 13.61% to 26.15% in the halwa samples indicates variability in the water content within them. These determined values were greater than 12% of the maximum moisture requirement for halwa as outlined in ZNS 574:2023, meaning that all samples did not meet the requirements of the standards concerning moisture content. Ali *et al.* (2013) reported a lower amount of moisture in white and black Oman halwa compared to the findings of this study; however, the findings of this study are in line with the findings reported by Rahman *et al.* (2012) for the moisture content of black and yellow Oman halwa. The difference in moisture content between this study and others could be attributed to the environment and technology used for processing as well as the practices of processors/handlers such as improper packaging time and techniques after processing and improper storage of products in the environment. The capability of products to uptake or lose moisture during storage is determined by the difference between the relative humidity (RH) of the environment during storage and the equilibrium relative humidity of the product (Subramaniam, 2016). The greater the difference in ERH between adjacent components in multi-component products, the stronger the moisture migration to the product side and the shorter its shelf life (Plotnikova *et al.*, 2021). Moisture content is intricately linked to the shelf life of halwa. Higher moisture content creates an environment conducive to the growth of microorganisms such as bacteria and moulds, which can lead to spoilage. In contrast, lower moisture content can help to extend the shelf life of halwa by reducing the availability of water for microbial growth. The moisture content of halwa can greatly affect its texture and consistency. Halwa with higher moisture content tends to be softer, more pliable, and sometimes even gooey or sticky, while halwa with lower moisture content tends to be drier and crumblier. Hardness, adhesiveness, firmness, cohesiveness, resilience, gumminess, and chewiness all decrease with an increase in water content, while springiness increases (Rahman *et al.*, 2012). Water molecules bound within a three-dimensional matrix weaken the structure of the network, leading to softer products when moisture content is increased (Dimitreli & Thomareis, 2007). Moisture content can influence the nutritional profile of halwa, with higher moisture content contributing to higher water content and lower caloric density, and lower moisture content resulting in a more concentrated source of energy. Thus, monitoring and controlling the moisture content during production is essential for maintaining consistency and quality, as batch-to-batch variations in moisture content can lead to inconsistent products that might not meet consumer expectations.

Total ash and acid-insoluble ash

Total ash and acid insoluble ash contents of samples ranged from 0.03% to 0.48% and 0.01% to 0.25% respectively. Significant differences ($p < 0.05$) were observed in both total and acid-insoluble ash. The variations could be due to the quality and type of raw materials used, such as white sugar, brown sugar and jaggery. Only one sample did not comply with ZNS 574:2023 with respect to acid insoluble ash content since its value was greater than

0.2%, the maximum standard requirement for halwa products. The findings of this study for total ash contents are lower than the study reported by (Ali *et al.*, 2013) where ash content was 0.68% and 0.57% for white and black Oman halwa respectively. The use of brown or raw sugar in preparing black halwa could result in higher ash content than using white sugar in preparing yellow halwa (Rahman *et al.*, 2012). These findings are in line with the findings reported by Rahman *et al.* (2012) which showed that total ash content ranged from 0.27% to 0.48% for Oman black halwa and 0.14% to 0.36% for white halwa. The ash content in food is a particularly important quality indicator for contamination, especially with foreign matter and, it is an indicator for mineral density (Reddy and Miravete, 2018). The low quantity of acid-insoluble ash in these findings indicates the absence or very minimum contaminants such as sand, soil, and other foreign materials in halwa products

Crude fat contents

The crude fat content of the halwa samples ranged from 1.79% to 4.77%, with a significant difference ($p < 0.05$) observed among the samples. The variations in fat content could be due to the type and amount of fat used during processing. All 13 samples did not comply with ZNS 574:2023, which requires halwa products to have fat content in a range from 6% to 28%. The value of fat content found in this study was lower compared to the findings reported by Ali *et al.* (2013) who showed that the mean fat contents were $(12.94 \pm 0.9)\%$ and $(13.84 \pm 1.1)\%$ for black and white halwa respectively. Another study, reported by Rahman *et al.* (2012) showed that the mean fat contents were in a range from 0.8% to 3.9% for black and 5.7% to 14.4% for yellow halwa. The difference in findings between this study and other studies could be the quality, type and amount of fat used during processing. These findings could reject the null hypothesis and perception among consumers and stakeholders that halwa is a highly fat-contained product. Ghee is the main fat used in halwa processing, likely to its characteristic flavour and aroma which is the basic criterion for its acceptance and is greatly influenced by processing methods (Kumar *et al.*, 2018). However, high-fat content in food can disrupt the quality, texture and shelf-life stability of food products due to oxidative and/or hydrolytic chemical reaction that could result in rancidity formation in food. For example, Rahman *et al.* (2012) showed that fat content affected the firmness and chewiness characteristics of halwa. As human food, ghee is also universally accepted as a superior fat to other fats, mainly because of its characteristic short-chain fatty acids content, which is responsible for its better digestibility and anti-cancer properties (Kumar *et al.*, 2018). However, consuming it beyond individual limits may show detrimental health effects, as ghee contains both saturated fat and cholesterol content (Manickavasagan and Al-Sabahi, 2014). World Health Organization recommends taking 15 - 30% of total energy from total fat and less than 10% of energy from saturated fat due to their health effects in obesity, cardiovascular diseases and diabetes (WHO, 2003). Based on the findings of this study, where the maximum fat content observed was 4.77% (sample ID P9 in Table 1), and the total energy for P9 was 302.26Kcal/100g, the energy contributed by total fat was 42.93kca/100g (4.77×9) and the percentage of energy from total fat in total energy was 14.2% $(42.93/302.26 \times 100\%)$. This value is near the minimum recommended limits of 15 - 30% of total energy from total fat, so the product is safe in terms of fat content. However,

further studies are recommended to determine the amount of saturated fat and fatty acid composition in general.

The acidity of extracted fat

The acidity of extracted fat as oleic acid ranged from 2.43% to 4.72% with a significant difference ($p < 0.05$) that can have important implications for halwa products. Halwa is a popular confectionery item in many cultures, and its texture, taste, and shelf life can be influenced by several factors, including the acidity of the ingredients used. Oleic acid is a fatty acid found in many edible oils and fats, and its presence can contribute to the flavour profile of the halwa. The range of acidity observed could lead to differences in taste perception. Fats can carry and enhance flavours, so the variation in acidity might influence the intensity and character of the halwa's flavour. More than half of the samples (7) complied with ZNS 574:2023 concerning the acidity of extracted fat parameter, which indicated 3% as the maximum requirement of acidity extracted fat in halwa. Ali *et al.* (2013) reported 1.848% and 1.961% of oleic acid in white and black samples of Oman halwa, which are lower than the findings of this study. This may be due to the difference in types and quality of fat/oil used during processing. The acidity of the extracted fat can affect the overall texture and mouth feel of halwa. Higher acidity levels might lead to changes in the way fats interact with other ingredients, affecting the halwa's creaminess, smoothness, and overall mouth feel. The variation in acidity could potentially result in distinct levels of firmness or melt-in-the-mouth characteristics. A higher acidity might introduce a slightly tangy or acidic note to the halwa's taste, which might not be desirable in a sweet confectionary like halwa. The acidity of fats can also influence the shelf life of food products, including halwa. Fats with higher acidity levels might be more prone to oxidation, which can lead to rancidity and off-flavours over time. A consistent and controlled acidity level in fats used for making halwa could help maintain its freshness and quality for a longer period.

Crude protein

Protein is an important macronutrient and a functional ingredient in food formulations, the protein content of halwa ranged from 0.06% to 3.61% (Table 1). Significant differences ($p < 0.05$) were observed among these samples, the variations may be due to differences in the quantity and quality of additional ingredients used during processing. About half of the samples (6) had greater protein contents compared to the findings reported by Ali *et al.* (2013) which showed that the protein contents for white and black Oman halwa were 0.28% and 0.44% respectively. However, the majority of the samples (11) had less protein content compared to the findings of protein content in yellow and black Oman halwa as reported by Rahman *et al.* (2012). The main source of protein in halwa was found to be the addition of groundnuts. It is commonly known worldwide that groundnuts are rich sources of proteins ranging from 5% to 31.3% depending on the varieties and the area of cultivation (Atasie *et al.*, 2009; Musa *et al.*, 2010). Hence, the variation of protein content in halwa may be due to the difference in ratio and quality of groundnuts added in halwa during processing. The relationship between food and health is having an increasingly significant impact on food processing. Nutrition knowledge has been used to improve consumer health which represents the functional food concept in general (Cheng *et al.*, 2016). The introduction of

quality and nutritive raw materials and ingredients may modify halwa products from denser energy products to nutrition carriers such as protein. For example, the study conducted to prepare multi-grain halwa reported that the protein content ranged from 5.7% to 6.3% (Itagi *et al.*, 2013). Therefore, there is a need to impart knowledge through formal training on how halwa products can be modified into nutritive carrier food products.

Crude fibre

The crude fibre content of the samples ranged from 8.12% to 15.21%, with significant differences ($p < 0.05$) observed among them. When $p < 0.05$, it means that the observed differences are unlikely to be due to random variation alone, suggesting that certain factors influence the differences in crude fibre content among the halwa samples. It is important to note that halwa is not typically known for its high-fibre content, but rather for its rich, sweet and often calorie-dense nature due to ingredients such as sugar and ghee. The higher fibre content in a halwa sample might result from specific ingredient choices or preparation methods, but it's not a common characteristic of halwa as a dessert. Consequently, a lower value (8.12%) suggests that the halwa is relatively more refined and may contain fewer plant-based components that contribute to fibre, while a higher value (15.21%) suggests that halwa contains more plant materials that contribute to its fibre content. These variations in crude fibre contents could be attributed to the ingredients used in making each type of halwa, such as various types of flour, nuts, fruits and other components. Furthermore, the way halwa is prepared, cooked and processed can influence its fibre content, as cooking methods, temperature and duration can impact the breakdown of fibre and its availability in the final product. These findings are much higher compared to the findings reported by Ali *et al.* (2013) which showed that the maximum crude fibre was 0.15% and 0.27% for white and black Oman halwa respectively. Crude fibre content can influence the texture of halwa, with higher fibre content could resulting in a slightly coarser texture due to the presence of fibrous components. This might impact the overall mouth feel and perception of the dish. Additionally, increased fibre could affect the sweetness perception, as fibre can blunt the perception of sweetness to some extent. A higher crude fibre content generally indicates a greater presence of dietary fibre in the halwa, which is essential for maintaining digestive health, regulating blood sugar levels, and promoting a feeling of fullness. Halwa with higher fibre content could be considered more nutritious and might provide more sustained energy due to the slower digestion and absorption of nutrients.

Total sugar

The sugar content ranged from 26.06 g/100 to 51.54 g/100, and the statistical analysis indicated that there were no significant variations in sugar contents between the samples with a p-value of 0.072, which is greater than the typical significance level of 0.05. This p-value indicates that the differences in sugar content between the samples are not statistically significant at the conventional significance level of 0.05. In other words, there is not enough evidence to conclude that the observed differences in sugar content are due to anything other than random chance. All samples complied with the requirement of ZNS 574:2023 by having total sugar contents of less than 55% the maximum standard requirements. These findings are in line with those reported by Rahman *et al.* (2012) except

for one sample out of their 15 samples, which showed to have a total sugar content of 56.3%. The quantity of sugar in halwa plays a significant role in both the shelf life and quality of the product. A common intrinsic parameter associated with high-sugar products is their low water activity (a_w), which is known to inhibit the growth of most spoilage and pathogenic bacteria. However, spoilage can occur due to the growth of osmophilic yeasts and xerophilic moulds (Thompson, 2009). On the other hand, the texture of halwa depends on the sugar content in the product, it has been reported that sugar content in halwa is positively correlated with hardness and cohesiveness (Rahman *et al.*, 2012). Sugar in halwa is also a constituent that makes consumers think of enjoyment. However, excessive consumption of sugars has been linked with several metabolic abnormalities and adverse health conditions, such as non-communicable diseases (NCDs) as well as shortfalls of essential nutrients (Johnson *et al.*, 2009). For health diet intake of sugar, it is recommended to limit the intake of free sugar to less than 10% of total energy intake and a further reduction to less than 5% of total energy intake is suggested for additional health benefits (WHO, 2003).

Carbohydrate

The range of carbohydrates in halwa samples ranged from 61.27% to 71.62%, a significant difference ($p < 0.05$) was observed in carbohydrate contents between the samples. This range 10% indicates that the recipes or preparation methods of the halwa samples likely differ, leading to varying carbohydrate levels. The significant difference in carbohydrate contents between halwa samples could be attributed to variations in the ingredients used to prepare each sample, such as the types and amounts of sugars, flour, ghee, nuts, and other ingredients. Twenty-five years ago, Musaiger *et al.* (1998) reported 71.2% as the maximum carbohydrate in samples of Oman halwa, which is the same as the findings of this study. However, Rahman *et al.* (2012) reported a broader range of carbohydrates (67.5% to 82.2%) in samples of Oman halwa compared to this study. This may be due to variability in ingredients and ingredient compositions used in the preparation of halwa in Zanzibar and Oman. The proximate results of this study indicated that carbohydrates are the main components of halwa produced in the urban west region, Zanzibar. Carbohydrates are the main sources of energy in the body and, with a prolonged lack of carbohydrates; the body begins to synthesize glucose from its proteins, which significantly reduces its protective ability against environmental factors (Saitkulov *et al.*, 2022). However, the consumption of carbohydrates is of considerable importance when recommending diets intended to reduce the risk of type II diabetes and cardiovascular diseases and in the treatment of patients who already have established diseases (Mann, 2007). Both the type and amount of carbohydrates found in foods influence postprandial glucose levels and can also affect overall glycaemic control in individuals with diabetes (Wheeler & Pi-Sunyer, 2008). Therefore, information about both the amount and type of carbohydrates is needed for the management of diabetes.

Total energy

The calculated energy values represent the caloric content of halwa per 100 grams. The significant range of values (265.73 to 326.74 Kcal/100g) indicates that different halwa

samples have varying energy densities. The significant difference ($p < 0.05$) suggests that the variation in energy contents among the halwa samples is not due to random chance. A p-value of less than 0.05 indicates that the observed differences are statistically significant, implying that the variations in energy content are likely due to real differences in the composition or preparation of the halwa samples, rather than being a result of random fluctuations. This is due to variations in the proximate analysis parameters (fat, protein and carbohydrate) which may be contributed by variations in the ingredients' composition. The findings of this study on the energy contents of halwa in Zanzibar are much lower compared to 446.5 Kcal/100g reported by Musaiger *et al.* (1998) in samples of Oman halwa. This is due to the fact that they reported a high percentage of fat (17.95%) compared to the result they had such a quantity of energy. Ali *et al.* (2013) reported 418.6 Kcal/100g and 403.8 Kcal/100g for white and black Oman halwa respectively which are higher compared to the findings of this study. Those findings were due to the higher fat content of 13.84% and 12.94% in white and black Oman halwa respectively, while the highest value of fat content in this study was 4.77%. The fat content had nine (9) multiplication factors in total energy contribution, the higher the fat content the higher the energy of the food product. In addition to this, in this study, the number of carbohydrates was lowered by the higher percentage of crude fibre. The variation in energy content also reflects the varying caloric density of the different halwa samples. This information can be important for individuals who are conscious of their caloric intake or are following specific dietary plans. The range of energy content might also influence consumers' choices based on their preferences for higher or lower-calorie options.

Conclusion

These results demonstrate significant degree of variability in the nutritional composition and quality attributes of halwa products. The specific values within that range can impact the taste, texture, shelf life, and nutritional profile of the halwa. Variations in the analysed parameters may arise from different recipes, cooking techniques, and regional variations. It's important for both consumers and producers to be aware of these variations in order to understand the nutritional profile of the specific halwa they are consuming or producing. The study suggests that halwa products can be quite carbohydrate-rich and relatively energy-dense. This could be appealing to individuals who are monitoring their carbohydrate intake, such as those with diabetes or to consumers seeking high-energy foods, however it is important to consume such products in moderation in order to maintain a balanced diet and prevent excessive calorie intake. To make informed choices, consumers should consider their dietary preferences and requirements, while manufacturers should strive for consistency, quality control, and appropriate labelling to assist consumers in selecting halwa products that align with their preferences and nutritional needs.

Recommendations

Further research could focus on optimizing halwa recipes to enhance its nutritional profile while maintaining its traditional taste and texture. This could involve experimenting with ingredient substitutions, processing techniques, and portion sizes. The wide range of values for each nutrient highlights the variability in the composition of halwa, underscoring the

importance of proper quality control and standardized production processes to ensure consistent nutritional content across different batches. The study's results emphasize the variation in nutritional composition among different halwa samples, and therefore, it's advisable to enjoy halwa, in moderation to achieve a well-rounded and balanced diet. Individuals with specific dietary restrictions or health conditions should consult with a healthcare professional or registered dietician before including halwa or any other food in their diets. Educating consumers about the nutritional content of halwa and its potential health implications is important, helping individuals make conscious decisions about their dietary choices. Regulatory authorities should ensure that the halwa products meet any relevant food safety and labelling regulations.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgement

The authors are grateful for the financial support provided by the Zanzibar Bureau of Standards

Reference

- Al-Shamsi, Q., M.S. Rahman, Abdullah, A., & Claereboudt, M. . (2013). Consumers ' Preference Mapping and Their Behavior with Regard to Traditional Halwa Using a Structured Survey Questionnaire classification of commercial omani halwa by physico-chemical properties and instrumental texture profile analysis (TPA). *Journal of Food Products Marketing*, 19(4): 311-328., July. <https://doi.org/10.1080/10454446.2013.781563>
- Ali, A., Al-Zuhaibi, K. M., Waly, M. I., Al-Alawi, A. A., Al-Sabahi, J. N., & Sankar, D. (2013). Chemical composition, fatty acids content and glycemic index of two different types of Omani Halwa. *Pakistan Journal of Nutrition*, 12(8): 753–760. <https://doi.org/10.3923/pjn.2013.753.760>
- Atasie, V. N., Akinhanmi, T. F., & Ojiodu, C. C. (2009). Proximate analysis and physico-chemical properties of groundnut (*Arachis hypogaea* L.). *Pakistan Journal of Nutrition*, 8(2): 194–197. <https://doi.org/10.3923/pjn.2009.194.197>
- Chaokromthong, K., & Sintao, N. (2021). Sample size estimation using Yamane and Cochran and Krejcie and Morgan and Green formulas and Cohen statistical power analysis by G*power and comparisons. *Apehit International Journal*, 10(2): 76–88.
- Cheng, Y.-L., Lee, C.-Y., Huang, Y.-L., Buckner, C. A., Lafrenie, R. M., Dénommée, J. A., Caswell, J. M., Want, D. A., Gan, G. G., Leong, Y. C., Bee, P. C., Chin, E., Teh, A. K. H., Picco, S., Villegas, L., Tonelli, F., Merlo, M., Rigau, J., Diaz, D., ... Mathijssen, R. H. J. (2016). We are IntechOpen , the world ' s leading publisher of Open Access books Built by scientists , for scientists TOP 1 %. *Intech*, 11(tourism), 13. <https://www.intechopen.com/books/advanced-biometric-technologies/liveness-detection-in-biometrics>
- Clemens, R. A., Jones, J. M., Kern, M., Lee, S. Y., Mayhew, E. J., Slavin, J. L., & Zivanovic, S. (2016). Functionality of Sugars in Foods and Health. *Comprehensive Reviews in Food Science and Food Safety*, 15(3): 433–470. <https://doi.org/10.1111/1541-4337.12194>
- Combris, P., Goglia, R., Henini, M., Soler, L. G., & Spiteri, M. (2011). Improvement of the nutritional quality of foods as a public health tool. *Public Health*, 125(10): 717–724. <https://doi.org/10.1016/j.puhe.2011.07.004>
- Dimitreli, G., & Thomareis, A. S. (2007). Texture evaluation of block-type processed cheese as a function of chemical composition and in relation to its apparent viscosity. *Journal of Food Engineering*, 79(4): 1364–1373. <https://doi.org/10.1016/j.jfoodeng.2006.04.043>
- Grunert, K. G., Wills, J. M., & Fernández-Celemín, L. (2010). Nutrition knowledge, and use and understanding of nutrition information on food labels among consumers in the UK. *Appetite*, 55(2): 177–189. <https://doi.org/10.1016/j.appet.2010.05.045>
- Islam, S. N., Reinstädter, S., Sáxavier De, M. A., & Gnauck, A. (2017). Food security and nutrition policy. *Handbook of Drought and Water Scarcity: Environmental Impacts and Analysis of Drought and Water Scarcity*, 521–545. <https://doi.org/10.1201/b22244>
- Itagi, H. N., Singh, V., Indiramma, A. R., & Prakash, M. (2013). Shelf stable multigrain halwa mixes: Preparation of halwa, their textural and sensory studies. *Journal of Food Science*

and Technology, 50(5): 879–889. <https://doi.org/10.1007/s13197-011-0423-z>

- Johnson, R. K., Appel, L. J., Brands, M., Howard, B. V., Lefevre, M., Lustig, R. H., Sacks, F., Steffen, L. M., & Wylie-rosett, J. (2009). *Dietary Sugars Intake and Cardiovascular Health A Scientific Statement From the American Heart Association*. <https://doi.org/10.1161/CIRCULATIONAHA.109.192627>
- Kumar, A., Tripathi, S., Hans, N., Pattnaik, F., & Naik, S. N. (2018). Ghee: Its Properties, Importance and Health Benefits. *Lipid Universe*, 6(): 1–14. <https://www.researchgate.net/publication/339499398>
- Manickavasagan, A., & Al-Sabahi, J. N. (2014). Reduction of saturated fat in traditional foods by substitution of ghee with olive and sunflower oils - A case study with halwa. *Journal of the Association of Arab Universities for Basic and Applied Sciences*, 15(1): 61–67. <https://doi.org/10.1016/j.jaubas.2013.06.003>
- Mann, J. (2007). Dietary carbohydrate : relationship to cardiovascular disease and disorders of carbohydrate metabolism. *European Journal of Clinical Nutrition*, 61(1): S100-S111. <https://doi.org/10.1038/sj.ejcn.1602940>
- MoH, Ministry of Health Zanzibar (2021). *Annual Health Information Bulletin 2021*, 102.
- Musa, A. K., Kalejaiye, D. M., Ismaila, L. E., & Oyerinde, A. A. (2010). Proximate composition of selected groundnut varieties and their susceptibility to *Trogoderma granarium* Everts attack. *Journal of Stored Products and Postharvest Research*, 1(2): 13–17. <http://www.academicjournals.org/jsprr>
- Musaiger, A. O., Ahmed, M. A., & Rao, M. V. (1998). Chemical composition of some traditional dishes of Oman. *Food Chemistry*, 61(1–2): 17–22. [https://doi.org/10.1016/S0308-8146\(97\)00148-9](https://doi.org/10.1016/S0308-8146(97)00148-9)
- Plotnikova, I. V., Zharkova, I. M., Magomedov, G. O., Magomedov, M. G., Khvostov, A. A., & Miroshnichenko, E. N. (2021). Forecasting and quality control of confectionery products with the use of “water activity” indicator. *IOP Conference Series: Earth and Environmental Science*, 640(6). <https://doi.org/10.1088/1755-1315/640/6/062003>
- Rahman, M. S., Al-shamsi, Q., Abdullah, A., Claereboudt, M. R., Al-belushi, B., Al-maqbaly, R., & Al-sabahi, J. (2012). Classification of commercial Omani halwa by physico-chemical properties and instrumental texture profile analysis (TPA). *Italian Journal of Food Science*, 24(3): 292-304.
- Reddy, J. N., & Miravete, A. (2018). Crash Analysis. *Practical Analysis of COMPOSITE LAMINATES*, 211–256. <https://doi.org/10.1201/9780203742594-8>
- Saitkulov, F., Azimov, I., Ergasheva, M., & Jo'raqulov, H. (2022). CARBOHYDRATES ARE THE MAIN SOURCE OF ENERGY IN THE. *Solution of Problems in Management and Economy*, 1(7):68–71.
- Subramaniam, P. (2016). The stability and shelf life of confectionery products. In *The Stability and Shelf Life of Food*. Elsevier Ltd. <https://doi.org/10.1016/B978-0-08-100435-7.00019-8>

The United Republic of Tanzania (URT), Ministry of Finance and Planning, T., National Bureau of Statistics and President's Office - Finance and Planning, O. of the, Chief Government Statistician, Z. T. 2022 P. and H. C., & Administrative Units Population Distribution Report; Tanzania Zanzibar, D. 2022. (2022). *Administrative Units Population Distribution Report, Tanzania - Zanzibar*. 1–54.

Thompson, S. (2009). *Compendium of the Microbiological Spoilage of Foods and Beverages*. *Compendium of the Microbiological Spoilage of Foods and Beverages*. <https://doi.org/10.1007/978-1-4419-0826-1>

Wheeler, M. L., & Pi-Sunyer, F. X. (2008). Carbohydrate Issues: Type and Amount. *American Dietetic Association*, 108(4): 2, S34–S39. <https://doi.org/10.1016/j.jada.2008.01.024>

WHO. (2003). Diet, nutrition, and the prevention of chronic diseases (report of a joint WHO and FAO Expert Consultation). *WHO Technical Report Series*, 916, 11–12. https://apps.who.int/iris/bitstream/handle/10665/42665/WHO_TRS_916.pdf?sequence=1

UNDER PEER REVIEW