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Proximate Composition and Caloric Content of Halwa Produced in the Urban West Region, Zanzibar

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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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, total sugar content (sucrose) and caloric content of groundnut-enriched halwa produced in the urban west region of Zanzibar. A total of 13 samples were collected 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. 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 61.44% to 70.94% and 267.14

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kcal to 324.16 kcal, respectively. All the 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.

Keywords: Halwa; moisture; ash content; crude protein; crude fat; crude fibre; total sugar; energy.

1. 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. The variations in recipes and preparation methods result in unique flavours and nutritional profiles [1]. 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 [2]. 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 [3]. 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 [4]. 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 [5]. The observed negative trends in the health of the population of Zanzibar in term of non-communicable diseases can be linked to the high consumption of refined carbohydrates, food rich in saturated fatty, and a low consumption of vegetables [6], [7]. 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 [8]. Non communicable diseases are caused mainly by unhealthy diets associated with food production high in salt, sugar, trans fatty acids, harmful additives and behavioural risk factors that accompany economic transition, rapid urbanization and 21st century lifestyles [9]. Acquiring accurate and adequate nutrition information is important as it could inform nutritional choices positively and promote the maintenance of a healthy nutritional status [10]. Therefore, this study aimed to determine the proximate composition total sugar (sucrose) and caloric content of halwa produced in the urban west region of Zanzibar.

2. 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.

2.1 Proximate Chemical Analysis

Moisture content was determined by the oven drying method an official AOAC method (925.49). Five grams (5 g) of the halwa sample were accurately weighed using a precision electronic balance (contech – model CA -224) and placed into a clean and dry petri dish. The petri dish with halwa sample was then placed in a preheated oven (ADVANTEC – model FC – 612) set at 105°C for a period of 5 hours. During the drying process, the petri dish was regularly removed from the oven, allowed to cool in a desiccator, and weighed until a constant weight was achieved. The ash content of halwa was determined using the gravimetric method as described in AOAC method 900.02. Five grams (5 g) of the halwa sample were accurately weighed using an analytical balance and placed into the pre-treated crucible. The crucible with the halwa sample was then placed back in the muffle furnace (CARBOLITE – model CWF 11/5) and heated at a constant temperature of 550°C for duration of 12 hours. For crude fibre analysis, AOAC Method 991.43 was used, which involves the Ankom Fibre Analyser (Model ANKOM 220). Approximately 1 gram of the sample was accurately weighed and placed in a labelled container designed for use with the Ankom Fibre Analyser. The sample underwent an initial extraction to remove soluble materials according to AOAC Method 991.43. The instrument was set to run the determination of crude fibre according to the same method. The crude protein content was determined using the Kjeldahl method specified in AOAC Method No. 920.176. The analysis involved the use of a digestion system 2000 and a Kjeldahl analyser unit 2300 from Foss Tecator, Höganäs, Sweden. One gram of the sample was accurately weighed using an analytical balance and placed in Kjeldahl flasks for digestion. After digestion, the liberated ammonium ions were distilled, and the distillate was titrated with a standardized acid solution to determine the ammonia content, which indicates the nitrogen content in the sample. The crude protein content was calculated using the conversion factor of 5.5 x N, where N represents the percentage of nitrogen determined from the titration. For total fat content, AOAC Method 920.177 was employed using a Foss Soxtec 2055 Soxhlet extraction unit. A 5 g sample was accurately weighed and placed into a glass extraction thimble. A total of 70 mL of petroleum ether was used as the extraction solvent. The extraction process included a 30-minute boiling phase, followed by a 30-minute rinsing phase. Finally, a 10-minute petroleum ether recovery phase was carried out to reclaim the solvent from the extracted fat. The total carbohydrate content was determined by difference, according to AOAC [11], 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.

2.2 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±25ºC 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, protein, and carbohydrates by the Atwater factors of 9, 4, and 4 respectively.

2.3 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 Turkey Honest Significant Different (HSD). Results were expressed as mean ± standard deviation and presented in tabular form.

3. RESULTS AND DISCUSSION

The results for proximate composition and caloric content and proximate composition are summarised in Table 1 and 2 respectively.

3.1 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. [12] reported a lower amount of moisture in white and black Oman halwa compared to the findings of this study; however, the findings from this study are in line with the findings reported by [13] 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 improper storage of products within 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 [14]. The greater the difference in equilibrium relative humidity between adjacent components in multi-component products, the stronger the moisture migration to the product side and the shorter its shelf life [15]. 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 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 [13]. Water molecules bound within a three-dimensional matrix weaken the structure of the network, leading to softer products when moisture content is increased [16]. 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.

Table 1. Proximate composition and acid insoluble ash of halwa (%)

Sample ID	Moisture content	Ash content	Acid insoluble ash	Crude fat	Crude protein	Crude fibre
P1	18.909 ± 1.666^{bc}	0.035 ± 0.004^{fg}	0.024 ± 0.004^{ef}	2.436 ± 1.299^{abc}	3.607 ± 0.187^{a}	11.145 ± 0.119^{b}
P2	17.796 ± 2.191^{cd}	0.083 ± 0.012^{efg}	0.058 ± 0.014^{ef}	3.497 ± 1.449^{abc}	3.407 ± 0.141^{a}	9.251 ± 0.369^{cd}
P3	22.182 ± 0.329^{ab}	0.239 ± 0.045^{c}	0.172 ± 0.029^{bc}	3.354 ± 0.891^{abc}	0.722 ± 0.011^{b}	8.282 ± 0.295^{d}
P4	21.497 ± 0.906^{bc}	0.029 ± 0.002^{g}	0.014 ± 0.003^{f}	2.283 ± 0.564^{bc}	0.085 ± 0.009^{f}	9.205 ± 0.711^{cd}
P5	17.668 ± 2.289^{cd}	0.482 ± 0.069^{a}	0.252 ± 0.021^{a}	2.605 ± 0.508^{abc}	0.389 ± 0.055^{de}	11.081 ± 0.602^{b}
P6	22.725 ± 0.509^{ab}	0.121 ± 0.026^{def}	0.033 ± 0.023^{ef}	2.177 ± 0.569^{ab}	0.650 ± 0.044^{bc}	8.200 ± 0.108^{d}
P7	17.368 ± 0.845^{cd}	0.367 ± 0.007^{b}	0.124 ± 0.009^{cd}	1.793 ± 0.366^{c}	0.679 ± 0.037^{b}	8.914 ± 0.175^{cd}
P8	14.366 ± 1.148^{d}	0.465 ± 0.054^{a}	0.185 ± 0.049^{b}	4.226 ± 0.801^{ab}	0.586 ± 0.074^{bcd}	9.413 ± 0.702^{bcd}
P9	13.612 ± 1.219^{d}	0.173 ± 0.023^{cd}	0.069 ± 0.023^{def}	4.767 ± 1.462^{a}	0.359 ± 0.052^{de}	15.215 ± 0.602^{a}
P10	21.209 ± 0.788^{bc}	0.067 ± 0.005^{fg}	0.021 ± 0.004^{ef}	3.541 ± 0.401^{abc}	0.064 ± 0.002^{f}	8.119 ± 0.827^{d}
P11	19.004 ± 0.481^{bc}	0.043 ± 0.002^{fg}	0.021 ± 0.007^{ef}	3.982 ± 0.125^{abc}	0.084 ± 0.003^{f}	10.646 ± 0.337^{bc}
P12	20.759 ± 1.467^{bc}	0.115 ± 0.004^{defg}	0.016 ± 0.004^{f}	2.441 ± 0.194^{abc}	0.284 ± 0.102^{ef}	8.355 ± 0.959^{d}
P13	26.147 ± 2.700^{a}	0.159 ± 0.014^{cde}	0.077 ± 0.017^{de}	2.191 ± 0.149^{bc}	0.411 ± 0.073^{cde}	9.652 ± 0.999^{bcd}

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)

3.2 Total Ash and Acid-Insoluble Ash

The 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. [12] 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 [13]. These findings are in line with the findings reported by Rahman et al. [13] 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 [17]. 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.

3.3 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 the 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. [12] who showed that the mean fat contents were (12.94±0.9)% and (13.84±1.1) % for black and white halwa respectively. Another study, reported by Rahman et al. [13] showed that the mean fat contents were in a range of 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. 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 [4]. 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 in food. For example, [13] 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 [4]. However, consuming it beyond individual limits may show detrimental health effects, as ghee contains both saturated fat and cholesterol content [2]. 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 such as obesity, cardiovascular diseases and diabetes [18]. Based on the findings of this study, where the maximum fat content observed was 4.77% (sample ID P9 in Table 2), and the total energy for P9 was 307.83 kcal/100g, the energy contributed by total fat was 42.93kca/100g (4.77x9) and the percentage of energy from total fat in total energy was 13.9% (42.93/307.83 x100%). This value is close to 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.

3.4 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. [12] 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. [13]. 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 [19]. 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 [20]. 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% [21]. Therefore, there is a need to impart knowledge through formal training on how halwa products can be modified into nutritive carrier food products.

3.5 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. Fibres are basically the residual parts of plant which are safe to consume and include components like polysaccharides, oligosaccharides, lignin and other related plant substances [22]. Consequently, suggests that the halwa is relatively higher fibre value (8.12 - 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 [23]. These findings are much higher compared to the findings reported by ali et al. [12] 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 [24]. 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 [25]. Dietary fibre intake associates with overall metabolic health (through key pathways that include insulin sensitivity) and a variety of other pathologies that include cardiovascular disease, colonic health, gut motility and risk for colorectal carcinoma [26]. Therefore, 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.

Table 2. Acidity of extracted fat, carbohydrate, total sugar and energy content of halwa

Sample ID	The acidity of extracted fat (%)	Carbohydrate contents (%)	Sugar content (g/100g)	Energy content (kcal/100g)
P1	3.679 ± 0.085^{b}	63.868 ± 2.477^{bc}	34.389 ± 5.608^{ab}	291.343 ± 5.356^{bc}
P2	2.879 ± 0.016^{fg}	65.966 ± 2.519^{b}	39.939 ± 13.495^{ab}	308.967 ± 14.496^{ab}
P3	2.700 ± 0.002^{gh}	65.221 ± 0.977^{bc}	36.706 ± 11.488^{ab}	293.940 ± 5.026^{bc}
P4	3.352 ± 0.064^{c}	66.901 ± 1.194^{ab}	41.469 ± 5.901^{ab}	288.500 ± 0.548^{bc}
P5	3.093 ± 0.023^{de}	67.775 ± 2.361^{ab}	29.143 ± 0.832^{ab}	296.100 ± 6.626^{bc}
P6	3.377 ± 0.047^{c}	66.127 ± 1.149^{b}	34.272 ± 5.674^{ab}	286.697 ± 1.384^{cd}
P7	2.439 ± 0.078^{h}	70.879 ± 0.785^{a}	42.507 ± 6.761^{ab}	302.383 ± 3.484^{bc}
P8	3.266 ± 0.019^{cd}	70.944 ± 0.164^{a}	51.538 ± 12.096^{a}	324.160 ± 7.580^{a}
P9	4.721 ± 0.182^{a}	65.874 ± 0.591^{bc}	26.060 ± 8.764^{b}	307.833 ± 10.961^{ab}
P10	2.922 ± 0.003^{ef}	67.000 ± 1.273^{ab}	28.349 ± 2.820^{ab}	300.130 ± 8.207^{bc}
P11	3.409 ± 0.017^{c}	66.241 ± 0.214^{b}	31.934 ± 12.091^{ab}	301.143 ± 1.454^{bc}
P12	2.832 ± 0.002^{fg}	68.046 ± 0.593^{ab}	35.814 ± 4.980^{ab}	295.267 ± 3.306^{bc}
P13	2.617 ± 0.018^{b}	61.440 ± 2.144^{c}	36.540 ± 7.628^{ab}	267.137 ± 7.793^{ad}

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)

3.6 The Acidity of Extracted Fat

The acidity of the extracted fat, measured as oleic acid, ranged from 2.43% to 4.72%, which is significant at ($p < 0.05$) and has 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 [27]. [11] Reported that white and black samples of Oman halwa had 1.848% and 1.961% oleic acid, respectively, this is lower than the findings of this study. This difference may be due to variations in the types and quality of fat/oil used during processing. Fats can carry and enhance flavours, so the variation in acidity might influence the intensity and character of the halwa's flavour [28]. Depending on its concentration, acidity levels may alter 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, higher acidity may introduce a slightly tangy or acidic note to the taste of the halwa, which may not be desirable in a sweet confectionery like halwa [29]. Fats with higher acidity levels are more prone to oxidation, which can lead to rancidity and off-flavours over time [30]. Maintaining a consistent and controlled acidity level in fats used for making halwa could help preserve its freshness and quality for a longer period. More than half of the samples (7) complied with ZNS 574:2023 regarding the acidity of extracted fat parameter, which sets 3% as the maximum requirement for acidity in halwa.

3.7 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 among the samples with a p-value > 0.05 except for the sample P8 and P9. 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. [13] 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 (aw), 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 [31]. 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 [13]. Sugar in halwa is also a constituent that makes consumers think of enjoyment. However, it has been noted that the intake of dietary sugars, mainly sugar-sweetened beverages, increases overall energy intake, leading to a reduced intake of healthy foods containing adequate calories, contributing to body weight gain and increased risk of NCDs [32]. 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 [18]. Furthermore, the study had reported that increased sugar intake during pregnancy contributes to maternal obesity and many cardio metabolic dysfunctions in the offspring and high-sugar diet intake during childhood induces metabolic syndrome and depressive-like behaviour [33].

3.8 Carbohydrate

The amount of carbohydrates in halwa samples ranged from 61.44% to 70.94%, 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 among 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, [34] reported 71.2% as the maximum carbohydrate in samples of Oman halwa, which is the same as the findings in this study. However, [13] 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 results of the approximately analysis in this study indicated that carbohydrates are the main components of halwa produced in the urban west region, Zanzibar. It has been reported that 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 [35]. 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 [36]. 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 [37]. Therefore, information about both the amount and type of carbohydrates is needed for the management of diabetes.

3.9 Total energy

The calculated energy values represent the caloric content of halwa per 100 grams. The significant range of values (267.14 to 324.16 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 [34] in samples of Oman halwa, that results was due to the fact that they reported a high percentage of fat (17.95%) compared to this study. [12] 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.

4. CONCLUSION

The findings of this study highlight the significant variability in the nutritional composition and quality attributes of halwa products. The wide range of values observed can influence the taste, texture, shelf life, and nutritional content of halwa, with variations stemming from diverse recipes, cooking techniques, and regional differences. These findings underscore the importance of both consumers and producers being aware of these variations to better understand the nutritional characteristics of the specific halwa they consume or produce.

5. 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.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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