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

Comment [U1]: Not in agreement with the objective of the study

Abstract

The information on food composition is important not only to the market power but also to the health and safety of consumers. The consumption of halwa in Zanzibar especially in the urban west region has increased with limited nutrition information and a lack of regulatory supervision.This study was aimed to determine the proximate composition and total sugar content (sucrose) of groundnut-~~added~~ (groundnut-enriched) halwa produced in the urban west region of Zanzibar. A total of 13 samples were ~~taken~~ (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 using AOAC (Association of Official Analytical Chemists) methods 925.49, 900.2, 920.176, 920.177, 960.39, IS 6287and ZNS 574:2023, respectively. ~~All AOAC methods were adopted as detailed in the 21st edition of 2019~~. The halwa samples had total sugar ranging from 26.06% to 51.54%, the moisture content, ash content, acid insoluble ash, crude protein, crude fat, the acidity of extracted fat and crude fibre ranged from 13.61% to 26.15%, 0.03% to 0.48%, 0.01% to 0.252%, 0.06% to 3.61%, 1.79% to 4.77%,2.43% to 4.72% and 8.12% to 15.21%, respectively. 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 the 13 samples did not conform to the requirements of Zanzibar Standard for halwa (ZNS 574:2023) concerning moisture and fat content. Only one sample failed to conform to ZNS: 574: 2023 concerning acid insoluble ash parameters. All samples were in accordance with the requirement of ZNS 574:2023 concerning sugar content. The described requirement for halwa in ZNS 574:2023 are maximum moisture of 12%, a maximum of 0.2% of acid insoluble ash, fat content of 6% – 28% and a maximum of sugar content of 55%.

Comment [U2]: Check and confirm authenticity: kcal or Kcal?; it affects 9 other items

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. The variations in recipes and preparation methods results in unique flavours and nutritional profiles (Al-Shamsi *et al*., 2013). About 10–15% of ghee (by weight) is added in halwa preparation to improve the keeping 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 it is a food that enjoys great popularity among a wide range of populations. With reference to the nature of the ingredients used, halwa is a high-energy-dense food that consists mainly 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 assists in making informed dietary choices, considering factors like 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 that is added during the halwa processing directly influences its sweetness and taste which makes people think of enjoyment. However, too much ingestion of sugar has been alleged to be a cause of chronic diseases from obesity and metabolic syndrome to diabetes and cardiovascular disease (Clemens *et al*., 2016). Ghee as the main ingredient in halwa contained cholesterol and about 60% of saturated fat. Consumption of diets that contain higher saturated fat and cholesterol increases the risk of cardiovascular diseases, obesity and diabetes (Kumar *et al*., 2018). Although there is no data that is showing the trends of halwa intake per individual; the eating habit of Zanzibar people plus halwa intake could lead to ~~the~~ extra accumulation of fat and sugar in the body than the normally 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, which is partly driven by limited knowledge on nutrition (Islam *et al*., 2017).The observed negative trends in the health of the population of Zanzibar on the non-communicable diseases can be linked to much intake of carbohydrates (sugar) and fat because non-communicable diseases are mainly 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 within the top ten causes of hospital admissions and are among the top three leading causes of death in Zanzibar. Hypertension is consistent over the years, taking a leading position as the cause of hospital admissions in Zanzibar, in 2019 and 2020, and dropping to second in 2021(MoH, 2021). In preventing the problem of chronic diseases linked to food consumption, the information on the composition of processed foods has become a crucial issue for consumers and health policy makers (Combris *et al*., 2011). The availability of information on food composition whether labelled in packaging or documented in the office is regarded as a major means for encouraging consumers to make healthier choices when shopping for food (Grunert *et al*., 2010). Access to healthy food is a basic human right. The link between food, nutrition and health needs to be emphasized if we want a healthy population that can support development. Hence, this study aims to determine the proximate composition and total sugar (sucrose) content in halwa produced in the urban west region of Zanzibar.

Comment [U3]: Not in tandem with the title of the study

Materials and methods

The halwa samples were purchased from 13 different halwa processors located in the urban west region, Zanzibar. The samples were selected from different sizes but only with groundnut added. After purchasing, the samples were packed and transferred to the Food

Comment [U4]: Advisable to be reframed

Science and Agro- processing laboratory at Sokoine University of Agriculture (SUA) and stored at room temperature for two days before analysis.

Proximate chemical analysis

Moisture content was determined ~~by~~ using oven drying method an official method of AOAC 925.49. Five grams (5 g) of halwa sample were accurately weighed in a clean and dry petri dish. The petri dish was dried in an oven at 105°C for 5 hours until a constant weight was obtained. The ash content of halwa was determined ~~by the~~ using 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 that all possible impurities on the surface of the crucible were burned off. It was then cooled in a desiccator for 30 minutes. Five grams (5 g) of halwa sample were measured into a crucible. The crucible was placed in a muffle furnace and heated for 12 hours at 550 °C. Crude fibre content was determined by the AOAC method 991.43 by using an ankomfibre analyzer (model ANKOM 220). About 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 performed in a digestion system 2000 and a Kjeldahl analyzer 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 by AOAC method 920.177, in which 5 g in 70 mL was used for the extraction process in three automatic phases in fat analyzer 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) that is, 100% - other proximate chemical compositions, using the following formula: Total carbohydrate = 100 – (% CP + % EE + % CF + % Ash content +%MC); where: CP = Crude protein, EE = Ether 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 milliliter 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 containing 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. Then, 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 percentage fat, percentage protein, and percentage carbohydrates by the Atwater factors of 9, 4, and 4 respectively (AOAC, 2000).

Comment [U5]: Unit of hour?

Statistical data analysis

Data were analysed using a Statistical Package for Social Science (IBM SPSS Version 25, 2017). One way Analysis of Variance (ANOVA) was used to determine the significant difference between the samples at 5% level of significance. Means were separated by Turkey Honest Significant Different (HSD). Results were expressed as mean ± standard deviation and presented in tabular form

Comment [U6]: Which one, Turkey or Duncan?

Table 1:Proximate composition of halwa

Sample ID	Moisture content (%) Mean±SD	Ash content (%) Mean±SD	Crude fat (%) Mean±SD	Crude protein (%) Mean±SD	Crude fibre (%) Mean±SD	Carbohydrate (%) Mean±SD
P1	18.91±1.67^{bc}	0.035±0.004^{a}	2.436±1.299^{abc}	3.607±0.187^{e}	11.15±0.119^{e}	62.44±0.09^{b}
P2	17.79±2.19^{b}	0.083±0.012^{abc}	3.497±1.449^{bcd}	3.407±0.141^{d}	9.251±0.369^{abc}	64.22±0.58^{c}
P3	22.18±0.33^{d}	0.239±0.045^{f}	3.354±0.891^{abcd}	0.722±0.011^{c}	8.282±0.295^{ab}	65.62±0.77^{d}
P4	21.49±0.91^{cd}	0.029±0.002^{a}	2.283±0.564^{ab}	0.085±0.009^{a}	9.205±0.711^{abc}	66.41±0.36^{d}
P5	17.67±2.29^{b}	0.482±0.069^{h}	2.605±0.508^{abc}	0.389±0.055^{b}	11.08±0.602^{e}	66.11±0.95^{d}
P6	22.73±0.51^{d}	0.121±0.026^{cde}	2.177±0.569^{ab}	0.650±0.044^{c}	8.200±0.108^{a}	66.72±0.17^{d}
P7	17.37±0.84^{b}	0.367±0.007^{g}	1.793±0.366^{a}	0.679±0.037^{c}	8.914±0.175^{abc}	70.52±0.03^{e}
P8	14.37±1.15^{a}	0.465±0.054^{h}	4.226±0.8^{d}	0.586±0.074^{c}	9.413±0.702^{bc}	71.62±0.29^{f}
P9	13.61±1.22^{ad}	0.173±0.023^{e}	4.767±1.462^{d}	0.359±0.052^{b}	15.21±0.602^{f}	66.43±0.29^{d}
P10	21.21±0.79^{cd}	0.067±0.005^{ab}	3.541±0.4^{bcd}	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^{a}	3.982±0.125^{cd}	0.084±0.003^{a}	10.65±0.337^{de}	65.76±0.20^{d}
P12	20.76±1.47^{cd}	0.115±0.004^{bcd}	2.441±0.194^{abc}	0.284±0.102^{b}	8.355±0.959^{ab}	66.64±1.38^{d}
P13	26.15±2.70^{e}	0.159±0.014^{de}	2.191±0.149^{ab}	0.411±0.073^{b}	9.652±0.999^{cd}	61.27±1.04^{a}

Values are expressed as means ± standard error of the mean of triplicate determinations. Values in the same column having the same superscripted letters are not significantly different ($p > 0.05$) according to Duncan Multiple Range Test.

Comment [U7]: Error

Comment [U8]: The ANOVA Needs critical review; all data should be edited except carbohydrate

Comment [U9]: Which one, Turkey or Duncan?

The proximate composition, sugar content and acid-insoluble ash of halwa produced in the urban west region of Zanzibar are shown in Table 1. Significant differences ($p < 0.05$) were observed in proximate analysis, acid insoluble ash, acidity of extracted fat and energy content. There was no significant difference ($p > 0.05$) in sugar content. The range values for moisture, ash content, crude fat, crude fibre, crude protein and carbohydrates were13.61% to 26.15%, 0.03% to 0.48%, 1.79% to 4.77%, 8.12% to 15.21%, 0.06% to 3.61% and 61.27% to 71.62%, respectively. The acid insoluble ash, acidity of extracted fat, energy and total sugar content were in the range of 0.01% to 0.25%, 2.43% to 4.72%, 265.73 Kcal/100g to 326.74 Kcal/100 and 26.06 g/100g to 51.54 g/100g, respectively.

Comment [U10]: Contains only data for proximate composition

Comment [U11]: Your ANOVA does not justify this comment

Table 2: Physicochemical properties, total sugar and energy content of 13 samples of halwa

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

Comment [U12]: Inconsistency in ANOVA interpretation which affected columns 1, 3 and 4.

Values are expressed as means ± standard error of the mean of triplicate determinations. Values in the same column having the same superscripted letters are not significantly different ($p > 0.05$) according to Duncan Multiple Range Test.

Comment [U13]: Which one, Turkey or Duncan?

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 the samples. The determined values of moisture content were greater than 12% of the maximum moisture requirement for halwa as outlined in ZNS 574:2023. Therefore, all samples did not conform to the requirements of the standards concerning the 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~~ from 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 the environment and technology used for processing. The higher moisture content of halwa reported in this study could be attributed to processors/handlers' practices such as improper packaging time ~~and techniques after processing~~ and improper storage of products within ~~to~~ 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 difference in ERH between adjacent components in multi-component products, the stronger the moisture migration to products side and the shorter the shelf life (Plotnikova *etal*., 2021). Moisture content is closely 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 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. On the other hand, halwa with lower moisture content tends to be drier and more crumbly. Hardness, adhesiveness, firmness, cohesiveness, resilience, gumminess, and chewiness decreased with an increase in the water content, while springiness increased with an increase in the moisture content (Rahman *et al*., 2012). Water molecules are bound within a three-dimensional matrix and weaken the structure of the network. Thus, increasing the moisture content reduced the coherence of the matrix and resulted in softer products (Dimitreli & Thomareis, 2007). Moisture content can influence the nutritional profile of halwa. Higher moisture content might contribute to higher water content and lower caloric density, while lower moisture content can result in a more concentrated source of energy. Monitoring and controlling the moisture content during production is essential for maintaining consistency and quality. Batch-to-batch variations in moisture content can lead to inconsistent products that might not meet consumer expectations.

Comment [U14]: Definition of acronym; RH has been defined, what does E stand for?

Comment [U15]: Can be deleted

Total ash and acid-insoluble ash

The Total ash and acid insoluble ash contents of the samples were in a range 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 reasons for the variations could be due to the quality and type of raw materials used, for example, different types of sugar such as white sugar, brown sugar and jaggery are used by different halwa processors. 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 in total ash contents are less compared to 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 *etal.*, 2012).On the other hand, these findings are in line with the findings reported by Rahman *et al*. (2012)

Comment [U16]: The two parameters are better presented on the same table. Total ash in Table 1 and acid insoluble ash in Table 2 can be put on the same table, the latter will come on the next column to the former

Comment [U17]: Kindly recast with attention on grammar and reference

which showed that the total ash content ~~was in the~~ 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 very important quality indicator for contamination, especially with foreign matter and also, 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 like sand, soil, and other foreign materials in halwa products

Crude fat contents

The crude fat contents of the halwa samples were in a range of ~~from~~ 1.79% to 4.77%, whereby a significant difference ($p < 0.05$) was observed among the samples. The variations in fat contents could be due to the type and amount of fat used during processing. All the 13 samples failed to comply with ZNS 574:2023 concerning fat content. The ZNS 574:2023 required halwa products to have fat content that ranged from 6% to 28%.The value of fat content found in this study was less compared to the findings reportedby Ali *et al*. (2013) which 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*. (2012) showed that the mean fat contents were in a range ~~from~~ 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. These findings could reject the null hypothesis and perception among consumers and stakeholders that halwa is a highly contained-fat product. Ghee is the main fat used in halwa processing; this could be due to its characteristic flavour and aromawhich is the basic criterion for its acceptance and is greatly influenced by the processing methods (Kumar *et al*., 2018). However, high-fat content in food can disturb the quality, texture and shelf life stability of food products due to the oxidative and or/hydrolytic chemical reaction that could result in rancidity ~~formation~~ in food. For example, Rahman *et al*. (2012) showed that fat contents affected the firmness and chewiness characteristics of halwa. As human food, ghee also has been accepted universally as 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 the individual limits may show detrimental health effects, because ghee contains both saturated fat and cholesterol ~~content~~ (Manickavasagan and Al-Sabahi, 2014).World Health Organization recommends taking 15 to 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 (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. Then, the energy contributed by total fat was 42.93kca/100g (4.77x9) and the percentage of energy from total fat in total energy was 14.2% (42.93/302.26 x100%). The value is ~~near~~ close to the minimum recommended limits of 15 to 30% of total energy from total fat. Hence, the product was safe in terms of fat content. However, further studies are recommended to determine the amount of saturated fat and ~~fat~~ fatty acid composition in general.

Comment [U18]: Kindly reframe

The acidity of extracted fat

The acidity of extracted fat as oleic acid was in the range of 2.43% to 4.72% with a significant difference ($p < 0.05$) which 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 various 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, respectively which are less compared to 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 impact the overall texture and mouthfeel 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 mouthfeel. The variation in acidity could potentially result in different 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 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 the samples, the variations may be due to differences in the quantity and quality of additional ingredients 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 protein contents for white and black Oman halwa were 0.28% and 0.44%, respectively. However, majority of the samples (11) had less protein contents compared to the findings of protein contents 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 verities and the area of cultivation (Atasie *et al*., 2009; and Musa *et al*., 2010). Hence, the variation of protein contents 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 the halwa products from denser energy products and become nutrition carriers such as protein. lFor example, the study conducted to prepare multi-grain halwa reported that the protein contents 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 ~~was in a~~ ranged from 8.12% to 15.21%; significant differences ($p<0.05$) were observed among the samples. When $p<0.05$, it generally means that there is a low probability that the observed differences occurred by random variation alone. This suggests that some factors influence the differences in crude fibre contents among the halwa samples.It is important to note that halwa is not typically considered a high-fibre food. It is more known for its rich, sweet and often calorie-dense nature due to ingredients like sugar and ghee. The higher fibre content in a halwa sample might result from specific ingredient choices or preparation methods, but it is not a common characteristic of halwa as a dessert. A lower value (8.12%) suggests that the halwa is relatively more refined and might have fewer plant-based components that contribute to fibre. Conversely, a higher value (15.21%) suggests that halwa contains more plant materials that contribute to its fibre content. The variations in crude fibre contents might be attributed to the ingredients used in making each type of halwa. Different types of flour, nuts, fruits and other components can contribute to the overall fibre content.The way halwa is prepared, cooked and processed can influence its fibre content. 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 were 0.15% and 0.27% for white and black Oman halwa respectively. Crude fibre content can influence the texture of halwa. Higher fibre content could result in a slightly coarser texture due to the presence of fibrous components. This might impact the overall mouthfeel and perception of the dish. Additionally, increased fibre might 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. Dietary fibre 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~~ among the samples with a p-value of 0.072, which is greater than the typical significance level of 0.05.The p-value of 0.072 indicates that the differences in sugar contents between the samples are not statistically significant at the conventional significance level of 0.05. In other words, there isn't 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 the findings that are 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 part in both the shelf life and quality of the products. 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. Although, spoilage can occur as a result of the growth of osmophilic yeasts and xerophilic moulds (Thompson, 2009). On the other hand, the texture of halwa depends on 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 a constituent that makes consumers think of enjoyment. However,excessive consumption of sugars has been linked with several metabolic abnormalities and adverse health conditions, diseases such 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 ~~were~~ was 61.27% to 71.62%; a significant difference ($p < 0.05$) was observed in carbohydrate contents between the samples. The range of carbohydrate in the samples from 61.27% to 71.62% show that the carbohydrate contents in the halwa samples can vary by around 10%. This 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~~ among halwa samples could be attributed to variations in the ingredients used to prepare each sample. Different types and amounts of sugars, flour, ghee, nuts, and other ingredients can contribute to the overall carbohydrate content. Twenty-five years ago, Musaiger *et al.* (1998) reported 71.2% as the maximum carbohydrate in samples of Oman halwa, which ~~are~~ is the same as the findings ~~of~~ in this study. However, (Rahman *et al*., 2012) reported a little large 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~~ results of the proximate analysis in this study indicated that carbohydrates are the ~~components~~ constituent of halwa produced in the urban west region, Zanzibar. It has been reported that carbohydrates are the main sources of energy in the body, 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 must be 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 glycemic control in individuals with diabetes (Wheeler & Pi-Sunyer, 2008). Therefore information about both amount and type of carbohydrates is needed for the management of diabetes.

Comment [U19]: Complete the discussion on one table before moving to another one

Comment [U20]: To be reframed

Comment [U21]: Please, re-write correctly

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 on the proximate analysis parameter (fat, protein and carbohydrate) which may be contributed by variation in 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 percent of fat (17.95%) compared to the result they had such a quantity of energy. Once again, (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 that, 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.

Comment [U22]: Ambiguous

Conclusion

These results demonstrate significant variability in the nutritional composition and quality attributes of halwa products. The specific values within that ranges can impact the taste, texture, shelf life, and nutritional profile of halwa. The variations in the analyzed parameters can result from different recipes, cooking techniques, and regional variations. It's important for consumers and producers to be aware of these variations 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 product. This could be an important consideration for individuals who are monitoring their carbohydrate intake, such as those with diabetes and consumers seeking high-energy foods might find this appealing, but it's important to consume such products in moderation to maintain a balanced diet and prevent excessive calorie intake. To make informed choices, consumers should consider their dietary preferences and requirements. Manufacturers should aim for consistency, quality control, and appropriate labelling to assist consumers in selecting halwa products that align with their preferences and nutritional needs.

Comment [U23]: It is dvisable to rewrite the conclusion. It is not concise and not well structured

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. This underscores the importance of proper quality control and standardized production processes to ensure consistent nutritional content across different batches of halwa. The results from this study highlight the variation in nutritional composition among different halwa samples. Therefore, it is 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 dietitian before including halwa or any other food in their diets. Educating consumers about the nutritional contents of halwa and its potential health implications is important. This can help individuals make conscious decisions about their dietary choices. Regulatory authority should ensure that the halwa products meet any relevant food safety and labeling regulations.

Comment [U24]: The author should limit himself or herself to his objective

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