Original Research Article

Assessment foodsafety knowledge, hygienic practices and microbiological quality of halwa produced in Urban West Region, Zanzibar

Abstract

Contamination of food by microorganismspossess both economic and health threats. Food safety knowledge and hygienic practices is a key tool in the prevention of food microbial contamination. The aim of this study was to determine microbiological quality in halwa and assess the level of food safety knowledge and hygienic practices of halwa processors. For microbiological quality, 13 samples were used to analyze total bacteria count, *Staphylococcus aureus*, yeasts and moulds. Total bacteria count was analyzed using ISO 4833 -1:2013, *Staphylococcus aureus*was analyzed using ISO 6888- 1:2003, yeasts and moulds were analyzed using ISO 21527 -2:2017. The semi-structured questionnaires were administered to 13 halwa processors to assess their level of food safety knowledge and hygienic practices. The total bacteria count in halwa detected in 11samples ranged from $2.0x10^2$CFU/g to $4.9x10^2$CFU/g, the moulds were detected in 11 samples in a range from $1.4x10^2$CFU/g to $5.5x10^2$CFU/g, the yeasts were detected in threesamples in a range from $1.4x10^2$CFU/g to $2.6x10^2$CFU/g and the *Staphylococcus aureus*were detected in 8 samples in a range from $1.4x10^2$CFU/g to $2.1x10^2$CFU/g. Twelve (12) samples out of13 analyzed samples were in accordance to Zanzibar standards for halwa (ZNS 574:2023) for yeasts, while only seven samples were found to comply with ZNS 574:2023 for moulds requirement. The ZNS 574:2023indicates the maximum number of yeasts and moulds is 10^2CFU/g. Five samples were in accordance to ZNS 574:2023for *S. aureus.*ZNS 574:2023requires halwa to be free from*S. aureus*. All samples were in accordance to ZNS 574:2023for total bacteria count. The ZNS 574:2023 indicates $5x10^3$CFU/g for total bacteria count.The halwa processors were observed to have poor food safetyknowledge and all processors were observed to lack formal training in food safety management aspects. Poor personal hygiene and hygienic practices such as wearing protective gears, covering of hair and hand washing after toilet and nose blowing were observed.

Key words: Halwa, food safety knowledge, hygienic practices, *Staphylococcus*, total bacteria count, yeasts and moulds

Introduction

Halwa is a local tradition dish that plays an important part as a snack food in many social activities of Zanzibar society. They are usuallyconsumed with black coffee,taken almost every day and served especially in wedding ceremonies(Callenberg, 2016). Sugar, flour (tapioca or corn flour) and ghee are the main raw materials required for halwa production (Ali *et al*., 2013). Other ingredients such as color, nuts, rose water, cardamom, saffron, eggs and milk may be added to obtain multiple sensory perceptions such as aroma, pleasant, enjoyable and lingering taste in the mouth(Manickavasagan & Al-Sabahi, 2014). The mouth feel such as flavour, aroma and taste mayvaryfrom place to place due to the variations of ingredients and processing parameters(Nayi & Kumar, 2021).Although halwa is highly thermally processed, that most of microorganisms can be killed, but the handling practices

of the finished product could be risk of contamination for finished products by both spoilage and pathogenic microorganisms. In practices, some processors pack and sell the finished products on their own shops while others sell the unpacked products to the retailer, where they pack themselves and sell in the marketsor bus stations. These practices can contribute andenhance the biological hazards regarding the food safety and microbiological food quality(Sousa, 2008). Despite the fact that halwa processors are small scale food processors, indeed they must ensure the safety of the food products and great precautions need to be practiced to prevent food bornediseases(Vasconcellos, 2003). Consumption of contaminated food due to pathogenic contamination can cause more than 200 diseases, ranging from mild diarrhea to cancer (Hassanzadazar *et al*., 2018).*Escherichia coli, Staphylococcusaureus*, *Salmonella enteric serotypes, Campylobacter*, molds and yeasts are among the most important food borne microorganisms which threaten public health and causes economic loses (Abdul-Mutalib *et al*., 2015). High consumption of halwa during ceremonies likewedding can be athreat to consumers if proper hygienic conditions were not followed during preparation.Therefore food safety knowledge and hygienicpractices are important components for any food producers to prevent food contamination and reduce foodborne incidences to the target consumers. Although there is no report on food borne diseases related to halwa in Zanzibar, but understanding the status of microbial contamination on such products is an important for all interested parties, including consumers, regulatory authority, owners and health officers. Different studies have been conducted to assess the microbial quality and hygienic practices of the food processors and food handlers, for example, the study conducted in India to assess the quality and safety and hygienic practicesof market and homemade carrot halwa,the findings indicated that there was microbial load contamination on market halwa, poor storage of ingredients and unhygienic practices(Mathpal *et al*., 2017).Also, a study conducted in Vietnam indicated the lack of food safety knowledge and hygienic practices among the processors and sellers (Tran *et al*., 2018).The current studies conducted in Zanzibar indicate poor environmental sanitation and waste handling practices, moderate adherence to food handling practices, safety measures and hygiene practices among food handlers (Hassan &Fweja, 2020a).In other study reported that, some food handler's demonstrated sufficient knowledge about food safety and hygiene such as identifying the causes of food poisoning and measures needed to avoid food poisonings, but they lack formal food safety training (Hassan & Fweja, 2020b). Hence, lack of formal training in food safety management and hygienic practices results in poor implementation of control measures and the food products will be at risk of contamination. Therefore, this study examines microbial quality in halwa and the level of food safety knowledge and hygienic practices of halwa processors in Zanzibar.

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

conducted to collect information of the of halwa processors' knowledge about food safety and hygienic practices through a semi-structured questionnaire.

Determination of CFU counts

For microbiological analysis the halwa samples were processed after two from the production date. The total count of bacteria (TCB), *Staphylococcus aureus* (SA), yeasts and mouldswere observed.Standard pour plate technique method was applied for quantitative CFU (Colony Forming Units) counts determination of respective groups of microorganisms in 10 g of halwa products. Homogenized samples of halwa were prepared based by sequential diluting based on decimal dilution system.One ml of sample was inoculated in a petri dishes containingrelated nutritive substrate for desired group of microorganismsin three replications. For TBC,molten nutrient agar having temperature around 40-45oC was used. Then, plates were left to solidify and then incubated in an oven at 37oC for 24 hrs as described in ISO 4833- 1:2013. For yeasts and moulds molten potatoes dextrose agar having temperature around 40-45oC was used. The prepared plates were incubated aerobically, lids uppermost, in an upright position in the incubator at 25 °C ± 1 °C for 5 days as per ISO 21527- 2:2017. Yeasts and moulds were determined by their color difference of the colony, as the colonies of moulds appear black while that of yeast appeared with cream color as shown in figure 1 and 2 (Al-Joda & Jasim, 2021). For*Staphylococcus aureus*,molten mannitol salt agar having a temperature around 40-45 °C was used,then the plates were left to solidify and then incubated at 37°C for 24 hrs as described inISO 6888-1:2003.

Biochemical test: Conformation test of *Staphylococcus aureus* by coagulase test

Coagulase test was done in the identification of Staphylococcus aureus, which is a coagulase and catalase test positive bacteria. Coagulase is one of the virulence factors found in S. aureus. During the reaction phase, the coagulase enzyme was coagulating the rabbit blood plasma in test tube and on slides. This test was carried out by combining blood plasma with a bacterial colony. Bacteria generate the coagulase enzyme, which causes the blood plasma to coagulate, indicating a positive reaction (Al-Joda & Jasim, 2021)

Gram stain

This was done to identify whether the bacteria were gram positive or gram negative, the procedure was done as described by Anne, (2019), a small drop of bacterial sample was fixed on the slide to prepare a smear, then primary stain (crystal violet) was applied to the slide and allowed it to sit for 1 minute. After rinsing the slide with water, iodine was applied to the slide for 1 minute to fix the crystal violet to the cell wall, then after rinsing with water, the slide was rinsed with alcohol for 3 seconds, followed immediately with a gentle rinse using water for 5 seconds, most cells were stained purple, which were gram positive bacteria. The slide was further observed by using a compound microscope, cells shape of gram positive were spherical-shaped/cocci, and these observations were used to predict the presence of *Staphylococcus aureus* in the food sample.

Statistical data analysis

Data from the questionnaires were processed by editing, coding and analyzing by using a Statistical Package for Social Science (IBM SPSS Version 25, 2017). Descriptive statistics were used to summarize the data. The data were then presented as frequency and percentages. Data from microbiological analysiswere also analyzed 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

Result and discussion

Demographic information

The information of processors on demographic information is summarized in Table (1) below.

Table 1: Demographic characteristics of halwa processors

Variable	Respondent/categories	Frequency	Percent
Location	West "A " district	1	7.7
	Urban district	12	92.3
Gender	Male	13	100
	Female	0	0
Age	20 – 30	1	7.7
	31 – 40	9	69.2
	41 – 50	2	15.4
	51 -60	1	7.7
Marital status	Married	13	100
	Single	0	0
	Widow	0	0
Position	Owner	9	69.2
	Supervisor	4	30.8
Education level	Primary	4	30.8
	Secondary	8	61.5
	Not been at school	0	0
	Higher education	1	7.7

Halwa processors are dominated by males by 100%, where by majority of the processors aged from 31 to 40 years, perhaps this due to the nature of the environment and job as it

demands high energy during processing. These findings contradicts with the findings of the earlier studies such as (Hassan & Fweja, 2020b) which reported 67.5% of the processors were females and 32.5% males, (Rabia *et al*., 2017), 74.9% were males and 24.1% females, (Masunzu, 2017), 80% were males and 20% females. In terms of education, all processors went to school but the majority (61.5%) ended up with secondary education, 7.7% higher diploma and the remaining had finished primary schools. The findings agreed with other findings reported by (Masunzu, 2017), majority of respondents accomplished secondary school, but contrast with findings reported by (Chijoriga, 2017), that 64% SMEs food processors had vocational education in food processing. Majority of the processors (92.3%) are situated at urban west district, the reason behind is that, urban west district is a trade and governmental offices center in urban west region and Zanzibar in general.

Table 2: Characteristics of halwa processors

Variable	Respondent/categories	Frequency	Percent
Food manufacturing license	Yes	7	53.8
	No	6	46.2
Experience in halwa processing	5 and above	13	100
Number of employees	Below 5	7	53.8
	5 – 10	5	38.5
	11 and above	1	7.7
ZFDA permit	Yes	3	23.1
	No	10	76.9
Building ownership	Rented	6	46.2
	Owned	7	53.8
Production frequency per week	7 days	2	15.4
	5 days	3	23.1
	4 days	5	38.5
	3 days	3	23.1
Quantity produced per day in Kg	35	6	46.2
	70	5	38.5
	175	2	15.4

Characteristics of halwa processors

The findings in processors attributes are shown in Table 2 above.Despite the fact that about half (53.8%) of the processors have manufacturing license from municipal council, only 23.1% of the processors are registered by Zanzibar Food and Drug Agency (ZFDA). The ZFDA it has an authority to register and regulate all food premises in Zanzibar.Unregistered processors may not adhere to proper hygiene and sanitation practices, increasing the risk of microbial contamination. Cross-contamination between ingredients, lack of hand washing facilities, and unsanitary equipment can contribute to the growth of harmful pathogens such as bacteria, viruses, and molds.Without regulation, there's a risk that unscrupulous processors might use low-quality or adulterated ingredients to cut costs. Substandard ingredients can compromise the quality and safety of the final product, leading to health concerns for consumers.The findings showed that there are variations in number of employee, about half of the processors had employee below five and only one processor had employees ranging from 11-15. Hence, all are categorized as small scale entrepreneurs. The excited findings on this study is that all processors have an experience of over years, the experience adds value to the work and can determine SMEs ability to upgrade (Loewe *et al*., 2013).

Quality control of end products

The information on how halwa processors assure the quality and safety of the products are summarized in Table 3 below.

Table 3: Quality control of end products

Variable	Respondent/categories	Frequency	Percent
Standard requirement of halwa	Yes	0	0
	No	13	100
Work instruction and operating procedure	Yes	0	0
	No	13	100
Food processing flow chart	Yes	0	0
	No	13	100
Indicators used to monitor quality	Visual checks	13	100
	Testing	0	0
Product safety assurance	Using good raw materials	9	69.2
	Conducting good hygienic practices	3	23.1
	Proper product packaging and storage	1	7.7

Despite the fact that all processors have an experience of more than five years, they were not familiar with standard requirements of halwa and they used common sense to judge the quality of end products. Relying solely on common sense to judge the quality of end food products, such as halwa, can be risky in terms of food safety. While common sense can provide some general guidance, modern food safety practices are based on scientific principles, standards, and regulations that are designed to protect consumers from potential health hazards. Foodborne illnesses can occur even in foods that appear fresh and well-prepared. Proper food handling, storage, and temperature control are essential to prevent the growth of harmful microorganisms. Most of the processors (69.2%) could use quality raw materials as means of assuring quality of the products. On other hand, all processors have no documented working procedure and no documented production flow chart of which its risk for cross contamination.

Food safety Knowledge and training

It was observed that all surveyed halwa processors and their staffs had no formal training in food processing, food safety management and quality and safety standards' requirement for halwa. Such that condition could poses a risk of contamination to various microorganism in halwa product. The findings are opposite to the findings of study conducted in Hanoi, Vietnam, reported that majority of the small processors and food handlers had undergone formal training in food safety. Although , the rate of processors and food handlers having sufficient knowledge was low (Tran *et al*., 2018). Also, (Ntomola, 2014) had reported that, 49.5% of food handlers had formal training on food safety. The current study conducted in urban district, Zanzibar reported that, about half of them had formal training on food safety (Hassan & Fweja, 2020a). The findings of this study in terms of food safety knowledge and formal training indicate that there are gaps in that area. It should be understood that food safety knowledge and training on different food safety aspects play a vital role in assuring the quality and safety of the products. The impacts of food safety knowledge among food handlers to prevent contamination and minimize the risks of foodborne diseases (Al-Ghazali *et al*., 2020). All employees, working in food premises, including temporary employees, should be trained in the basics of food safety principles and practices that are required to prevent contamination and cross-contamination of (FAO & WHO, 2004). This training should cover hygienic food handling practices, personal hygiene requirements and the risks related to poor personal hygiene and insanitary personnel practices in a food processing.

Handling of raw materials

The findings of this study showed 100% of the processors acquired raw materials from the market, 76.9% of the processors used quality parameter as a key factor in purchasing and visual check as tools for verifying the quality of purchased raw materials, 53.8% of the processors stored their raw materials in their home while 46.2% have specific store for their raw materials. The data showed that, 69.2% of the processors experienced raw materials' spoilage problem of which 84.6% spoilage by moulds (Table 4). Food safety is a critical aspect of the food industry, and ensuring the quality of raw materials is essential to prevent contamination, adulteration, and the production of unsafe products. Visual checks can only identify visible contaminants, such as dirt, insects, or foreign objects that are large enough

to be seen with the naked eye. However, many harmful contaminants, such as bacteria, viruses, chemical residues, allergens, and pathogens, are not visible and cannot be detected through visual inspection alone (Tolmacheva *et al*., 2019).A comprehensive approach that incorporates laboratory testing, supplier verification and training is crucial to prevent foodborne illnesses, maintain regulatory compliance, and protect consumer health.Storing raw materials for food processing at home is crucial for maintaining food safety and ensuring the quality of the final products. Improper storage can lead to contamination, spoilage, and health risks. The food hygiene practices requires food storage to be designed and constructed to provide an environment which minimizes the deterioration of food such as by temperature and humidity control (Alli, 2003).The presence of mold-related spoilage in halwa processors' raw materials highlights the critical importance of food safety in the production of consumable goods. This situation presents several food safety implications that need to be addressed to ensure the production of safe and quality food products for consumers.It is imperative for halwa processors to take proactive measures to prevent mold growth, uphold quality and safety standards, and protect the health of consumers.

Table 4: Handling of raw materials

Variable	Respondent/categories	Frequency	Percent
Acquiring of raw materials	Buy from the market	13	100
Considered factor during purchasing of raw materials	Price	3	23.1
	Quality	10	76.9
Tools used to check quality of raw materials	Checking expire date	3	23.1
	Visual check	10	76.9
Storage of raw materials	Storage room	6	46.2
	In the home I'm living	7	53.8
Spoilage problems with your stored raw materials	Yes	9	69.2
	No	4	30.8
Possible sources of spoilage	Insects	2	15.4
	Moulds	11	84.6

Hygiene practices

The findings of this study showed that 53.8% of the processors, their employer undertake a medical examination yearly. About half of the processors were not washing their hands with soap after toilet. Only one of processors had a changing room and it has been segregated from the production area (Table 5).Maintaining a clean and hygienic environment is crucial

in preventing the contamination of food and the spread of foodborne illnesses. Without a structured cleaning plan, surfaces and equipment that come into contact with food might not be properly sanitized. Cross-contamination can occur when pathogens from one area are transferred to another, increasing the risk of foodborne diseases (Al-Bahry *et al*., 2014). Also, personal hygiene is a key factor in assuring the safety and quality of finished products in food processing and handling. People who do not conducting medical checks while working in food production can have significant implications for food safety. Employees who are carrying infectious diseases can inadvertently contaminate the food they handle, either through direct contact or by contaminating surfaces, utensils, and equipment. This can lead to the spread of pathogens to the final food product, increasing the risk of foodborne illnesses among consumers (Djukic *et al*., 2016). Lack of hair covering during food processing can pose significant risks to food safety and hygiene. Loose hair can easily fall into food products during processing, packaging, or handling. Even a single strand of hair can introduce bacteria, allergens, or foreign substances into the food, compromising its safety and quality. Hair can carry bacteria and other microorganisms, especially when not properly washed or maintained. These microorganisms can multiply in food, leading to spoilage or causing foodborne illnesses if consumed. Protective clothing is an essential component of a comprehensive food safety program, as it helps prevent contamination and the spread of harmful microorganisms that can cause foodborne illnesses. Protective clothing, including aprons, gloves, hairnets, and footwear, acts as a barrier between workers and the food they are handling, reducing the chances of transferring contaminants from the workers' clothing, hair, or skin to the food and helps maintain high standards of personal hygiene among food processing workers(Todd *et al*., 2010). Failing to wash hands with soap after using the toilet and blowing the nose can have significant implications for food safety. Proper hand hygiene is crucial in preventing the spread of harmful bacteria, viruses, and other pathogens that can cause foodborne illnesses. When individuals do not wash their hands after using the toilet or blowing their nose, they carry potential pathogens on their hands. If they then handle food, these pathogens can transfer from their hands to the food, leading to cross-contamination. The findings of this study are in line with the findings of the other studies such as that reported by (Biotech, 2019) and (Floridiana, 2019). On the other hand, the findings of this study contradicts with the other studies such that reported by (Shuvo, 2018) and (Cempaka *et al*., 2019).

Table 5: hygiene practices

Variable	Respondent/categories	Frequency	Percent
Periodical medical check	Yes	7	53.8
	No	6	46.2
Changing room	Yes	1	7.7
	No	12	92.3
Toilet facilities segregated from manufacturing areas	Yes	13	100
	No	0	0
Hand washing with soap after toilet	Yes	7	53.8
	No	6	46.2
Hand washing with soap after blowing nose	Yes	4	30.8
	No	9	69.2
Cleaning plan for premises	Yes	1	7.7
	No	12	92.3
Wearing of protective clothes	Yes	1	7.7
	No	12	92.3
Hair covering	Yes	1	7.7
	No	12	92.3
Dispose of solid waste	Communal collection municipal point	13	100

Packaging and labeling information

The data showed that all processors packed their products. Most of them don't indicate labeling information as shown in Table 6 below. Packaging acts as a barrier that protects food from physical, chemical, and biological contamination. It prevents external contaminants such as dirt, dust, insects, and microorganisms from coming into contact with the food(Alamri *et al*., 2021). Proper packaging helps to preserve the quality and freshness of food products. It can slow down the growth of spoilage microorganisms and reduce exposure to oxygen and light, which can degrade the nutritional value and taste of food over time. The findings of this study showed that all processors pack their food and majority of them use polypropylene (PP) containers as packaging materials. Polypropylene has good barrier properties, meaning it can effectively prevent moisture, gases, and odors from penetrating the packaging. This is important for maintaining the freshness, flavor, and quality of the halwa, as it helps to protect the product from external factors that could lead to

spoilage. However, the study observed the risk of contamination during packaging, because majority of the processors transport their products and pack them at their shops. The food product is required to be transported in cleaned transport and environment that could not allow contamination (Mahajan *et al*., 2014).Also, it was observed that, for the halwa to be packed it is placed in a container and allowed to cool before it is sealed to avoid condensation, but this could be risk of contamination since the shops are widely opened, persons are talking, hairs are not covered by protective gears and protective clothes are not won. The codex general principles of hygiene require food to be placed in a place that is free from dust, smoke pest and any source of contamination (FAO & WHO, 2004). Among the required information in food labeling that includes but not limited to production and expiry date, manufacturers name and address, type of products, name of products, batch number, storage information, list of ingredients, barcode and net mass (Wingfield, 2016). The findings of this study showed that only three processors indicatedproduct name, manufacturers name and address. Failure to indicate other required information could result in misuse or storage of those products. Also, failure to indicate list of ingredients could risk the health of the allergic persons (Messer *et al*., 2017).

Table 6: Packaging information

Variable	Respondent/categories	Frequency	Percent
Product packaging	Yes	13	100
	No	0	0
Type packaging materials used	Polypropylene (PP)	9	69.2
	Any plastic container that resist heat	4	30.8
Packaging site/area	On the processing area	4	30.8
	On the Shop	9	69.2
Production expiry date	Yes	0	0
	No	13	100
Batch number	Yes	0	0
	No	13	100
Manufacture name and address	Yes	3	23.1
	No	10	76.9

Microbial quality

The analysed microorganism in the sample of halwa produced in the urban west region of Zanzibar are shown in Table 7 with significant difference ($p<0.05$).Total bacteria counts,*Staphylococcus aureus*,moulds and yeasts were in a range from $1.41x10^2$ CFU/g to $4.9x10^2$ CFU/g, $1.38x10^2$ CFU/g to $2.14x10^2$ CFU/g,$1.41x10^2$ CFU/g to $5.5x10^2$CFU/gand $1.48x10^2$ CFU/g to $2.68x10^2$ CFU/g respectively.

Table 7: Total bacteria count, yeasts, moulds and *Staphylococcus aureus* in halwa

Sample ID	Total bacteria count (CFU/g) Mean±SD	Yeast (CFU/g) Mean±SD	Moulds (CFU/g) Mean±SD	*Staphylococcus* (CFU/g)Mean±SD
P1	169.67±2.6^{d}	148.65±13.51^{b}	551.05±6.89^{h}	177.18±11.34^{d}
P2	339.34±10.4^{f}	0.0±0.0^{a}	237.24±2.6^{e}	214.71±11.34^{e}
P3	0.0±0.0^{a}	0.0±0.0^{a}	145.65±11.34^{bc}	0.0±0.0^{a}
P4	406.91±5.2^{g}	0.0±0.0^{a}	354.35±5.2^{g}	151.65±21.29^{bc}
P5	153.15±11.92^{bc}	268.77±6.88^{c}	159.16±14.48^{c}	0.0±0.0^{a}
P6	490.99±4.5^{h}	0.0±0.0^{a}	141.14±2.6^{b}	142.64±2.6^{b}
P7	145.65±5.2^{b}	0.0±0.0^{a}	193.69±13.51^{d}	145.65±18.2^{bc}
P8	145.65±2.6^{b}	0.0±0.0^{a}	240.24±11.34^{e}	0.0±0.0^{a}
P9	141.14±2.6^{b}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}
P10	159.16±9.38c^{d}	0.0±0.0^{a}	265.77±13.51^{f}	138.14±5.2^{b}
P11	165.17±13.76c^{d}	0.0±0.0^{a}	255.26±2.6^{f}	162.16±11.92^{cd}
P12	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}
P13	190.69±6.89^{e}	150.15±11.3^{4b}	148.65±4.5^{bc}	163.66±11.34^{cd}

Values are 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.

Total bacterial count (TBC)

The presence of bacteria in food products is common, and it can arise from various sources such as raw ingredients, processing equipment, and handling practices. The fact that bacteria were detected in the majority of the samples (11 out of 13) suggests that halwa, like many other food products, can serve as a potential medium for bacterial growth.Halwa has a high sugar content, which can act as a preservative by reducing water activity and inhibiting microbial growth(Thompson, 2009). However, if the halwa is not properly processed, stored, or handled, it can still become a suitable environment for bacterial growth. The presence of moisture, contamination from equipment, or improper storage conditions can contribute to increased bacterial loads.High bacterial counts in food products like halwa can have both quality and safety implications. Elevated bacterial counts can contribute to spoilage, affecting the texture, taste, and overall quality of the product. Additionally, some bacteria may produce enzymes or compounds that lead to off-flavors or odors in the halwa.The Zanzibar Standard for halwa had provided out the requirement for total bacteria count, where the indicated maximum limit is $1x10^{5}$CFU/g. Hence, in comparison to the findings of this study, all samples were in accordance to the requirements of ZNS 574: 2023 with respect to total bacterial count parameter. The findings of this study was less compared with findings from similar study in India, whereby the reported total plat count in carrot halwa was $1.9x10^{9}$ CFU/g (Mathpal, 2017). On other hand, the findings of

this study are much lower compared with other studies that analyzed bacterial counts in food items with similar characteristics to halwa.For example, (PetrovÃ *et al*., 2014a) reported $1x10^3$CFU/g to $5.5x10^3$CFU/g range of total bacterial account in difference confectionery products. Also, (PetrovÃ *et al.*, 2014b)7.9 $x10^2$CFU/g to $4.5x10^3$CFU/g in a selected confectionery products. The reason for low level of total bacteria account could be due to the high thermal processing of halwa that could kill most of the bacteria.

Yeasts and moulds

Yeasts are common microorganisms that can be found in various foods, including sweets like halwa,the presence of yeast, might suggest issues related to hygiene, production processes, or storage conditions. The range of yeasts counts ($1.48x10^2$ to $2.68x10^2$ CFU/g) indicates variability in the level of yeasts contamination among the positive samples. On other hand, the presence of mold in a significant number of samples is a cause for concern, especially for this halwa that intended for consumption. Mould can produce mycotoxins, which can be harmful if ingested. The variation in mold concentration also suggests that some samples may have higher levels of mycotoxins than others, posing a potential health risk.The fact that molds were detected in the majority of samples indicates that there might be challenges in maintaining proper hygiene during the production process or storage. Contamination could occur at various stages, including raw ingredients, equipment, or storage containers.The p-value of less than 0.05 indicates that there is a statistically significant difference in either the levels of moulds or yeasts (or both) between the samples. This means that the variations observed in mold and yeast levels are not likely due to random chance but may be attributed to factors such as different ingredients, processing methods, storage conditions, or contamination sources.In this study,yeasts were detected in three samples out 13 samples while moulds were detected in 11 samples out of 13. Only one sample exceeded the maximum permissible limit ($2x10^2$ CFU/g) for yeasts in halwa and six samples for moulds as indicated in Zanzibar standards for halwa (ZNS 574:2023).The previous study conducted in India, showed that there were high levels of yeasts and mouldsin carrot halwa sold in the market,compared to these findings(Mathpal *et al*., 2017).This could be due to differences in ingredients used, processing environment and handling practices. Some of other studies that analyzed yeasts and moulds in food items with similar characteristics to halwa reported higher or less findings compared to this study. For example,(Kačániová & Juhaniaková, 2011) reported $<1x10^1$ to $5.5x10^2$CFU/g for yeasts in confectionery products while (PetrovÃ *et al*., 2014a) reported zero number of yeasts in different confectionery products.

Although the high level of sugar in these products imparts significant microbial stability in most cases, the presence of additional ingredients in halwa such as nuts which have nutritional advantage to the growth of microorganisms, could be one of the reasonsof the detected amounts of yeast and moulds(Subramaniam, 2016). Also, yeasts and moulds could be brought into food premises by personnel, whether employees or visitors, through the clothes and shoes. Because of the lack of exchanging rooms and poor practices of wearing protective gears reported in this study, the products are expected to be contaminated because moulds and yeasts can be transported throughout the food

production environment by the ways of clothes, shoes or in air movement(Bernardi *et al*., 2019). All halwa processors and handlers store their products at room temperature, this could influence the growth of yeasts and moulds, their temperature range (10-35°C) are broad, with a few species capable of growth below or above this range(Chupia *et al*., 2022). Food contamination by yeasts and moulds can cause significant financial losses for the manufacturer, processor and consumer. Due to their capacity to produce poisonous byproducts known as mycotoxins a number of foodborne moulds and possibly yeasts may also be harmful to human or animal health. Additionally, some moulds and yeasts that are present in food might induce infections or allergic reactions(Rawat, 2015).

Staphylococcus aureus

The fact that *Staphylococcus aureus* was present in the majority of the samples (8 out of 13) is concerning. This bacterium is a common foodborne pathogen known to cause food poisoning, and its presence suggests inadequate food handling and hygiene practices during production, processing, or storage(Kotzekidou, 2013). The packaging practices of halwa could be another factor that influences the replication of *S. aureus*. The halwa is left open for time before sealed to allow it to cool. The pathogen *S. aureus* replicate in foods subject to temperature abuse, such as foods left at room temperature for a long period (Marshall & Warren, 2018)The p-value being less than 0.05 suggests that the observed results (detection of *Staphylococcus aureus* in these samples) are statistically significant. This implies that the likelihood of these results occurring by random chance alone is low. According ZNS 574:2023, halwa is required to be free from Staphylococcus aureus.Therefore, the eight samples were not complying with the standard requirements respect *Staphylococcus aureus* parameter and do not fit for human consumption.Although there are different sources of *S. aureus*, but humans are considered to be the major source of *S. aureus* which is found in the nasal passages, throat, hair and skin of carriers(Bencardino & Vitali, 2019). Food is usually contaminated from nasal secretions, sneezing and coughing and direct hand contact of infected carriers. Hence,the presence of nasal carriers among healthy food handlers increases the contamination risk (Bencardino *et al*., 2021). Poor hygienic practices among halwa processors as observed on this study could be factor to the determined quantity of *Staphylococcus aureus.*On other hand, the findings of this study are higher compared with other studies that analysed *Staphylococcus aureus*in food items with similar characteristics to halwa. For example, (PetrovÃ *et al.*, 2014a)reported zero number of staphylococci in the analysis of different confectionery products and(Kačániová & Juhaniaková, 2011) reported 0 to <1x10^{1}CFU/g *staphylococci* in confectionery products.

Conclusions

The microbiological counts in the halwa products suggest a potential issue with hygiene, manufacturing processes, and storage conditions as described in a part of this study.The data suggests that the halwa products have acceptable total bacteria counts, but there are concerns regarding the presence of *Staphylococcus aureus*, moulds, and yeasts. The presence of microorganisms in food products, especially those that are potentially harmful,

can impact consumer health. Proper handling, storage, and preparation of the halwa products are important to minimize any risks associated with these microorganisms.

Recommendations

Further study is recommended on other microorganism such *Escherichia coli* and *Salmonella* as well as to identify specific bacterial and fungal species present. This will help assess the potential health risks associated with the microorganisms and guide appropriate control measures. Provide training to halwa processors on food safety and hygiene practices. This will help them understand the importance of proper handling, processing, and storage to minimize microbial contamination. Implement rigorous quality control measures to ensure consistent product quality and safety. Regularly monitor microbial contamination levels to identify trends and deviations.

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