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

Abstract

Contamination of food by microorganisms poses both economic and health threats. Knowledge of food safety and hygienic practices is a crucial in the prevention of microbial contamination of food. This study aimed to determine the microbiological quality of halwa and assess the level of food safety knowledge and hygienic practices of halwa processors. For microbiological quality, 13 samples were used to analyse the total bacteria count, *Staphylococcus aureus*, yeasts and moulds. Total bacteria count was analysed using ISO 4833-1:2013, *Staphylococcus aureus* was analysed using ISO 6888-1:2003, and yeasts and moulds were analysed using ISO 21527-2:2017. 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 11 samples, ranged from $2.0x10^2$ CFU/g to $4.9x10^2$ CFU/g, while 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 three samples in a range from $1.4x10^2$ CFU/g to $2.6x10^2$ CFU/g; and *Staphylococcus aureus* were detected in 8 samples in a range from $1.4x10^2$ CFU/g to $2.1x10^2$ CFU/g. Twelve samples out of 13 analysed samples were in accordance with Zanzibar standards for halwa (ZNS 574:2023) for yeasts, while only seven samples were found to comply with ZNS 574:2023 for moulds requirement. Five samples were in accordance with ZNS 574:2023 for *S. aureus*. All samples were in accordance with ZNS 574:2023 for total bacteria count. The halwa processors had poor food safety knowledge and lacked formal training in food safety management aspects. Poor personal hygiene and hygienic practices, such as wearing protective gear, covering hair, and hand washing after toilet and nose blowing, were observed.

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

1.0 Introduction

Halwa is a traditional dish that plays an important role as a snack food in many social activities of Zanzibar society. It is usually consumed with black coffee, taken almost every day and is served especially during wedding ceremonies [1]. The main raw material used for its production are sugar, flour (tapioca or corn flour) and ghee [2]. To obtain multiple sensory perceptions such as aroma, pleasant, enjoyable and lingering taste, other ingredients such as colour, nuts, rose water, cardamom, saffron, eggs and milk may be added[3]. The mouth feels such as flavour, aroma and taste of halwa may vary from place to place depending on the of ingredients and processing parameters used [4]. Although halwa is highly thermally processed, that most of the microorganisms can be killed, but the handling practices of the

finished product may still lead to contamination with spoilage and pathogenic microorganisms. In practice, some processors pack and sell their products in their own shops while others sell unpacked products to retailers, who pack and sell them in markets or bus stations. These practices can contribute and enhance the biological hazards concerning food safety and microbiological food quality [5]. Even though halwa processors are small scale food processors, indeed they must ensure the safety of their products and take great to prevent food borne diseases [6]. The consumption of contaminated food due to pathogenic contamination can cause more than 200 diseases, ranging from mild diarrhoea to cancer [7]. *Escherichia coli, Staphylococcus aureus*, *Salmonella enteric serotypes, Campylobacter*, moulds and yeasts are among the most important food borne microorganisms that threaten public health and causes economic losses [8]. High consumption of halwa during ceremonies such as weddings can be a threat to consumers if proper hygienic conditions are not followed during preparation. Therefore, food safety knowledge and hygienic practices are important components for food producers to prevent food contamination and reduce food borne incidence to the target consumers. Although there is no report of food-borne diseases related to halwa in Zanzibar, understanding the status of microbial contamination of such products is important for all interested parties, including consumers, regulatory authorities, owners and health officers. Different studies have been conducted to assess the microbial quality and hygienic practices of food processors and food handlers, for example, a study conducted in India to assess the quality, safety and hygienic practices of market and homemade carrot halwa, found that there was microbial load contamination of market halwa, poor storage of ingredients and unhygienic practices[9]. The lack of formal training in food safety management and hygienic practices results in poor implementation of the control measures during food processing and handling. Thus, this study examines the microbial quality in halwa and the level of food safety knowledge and hygienic practices of halwa processors in Zanzibar.

2.0 Materials and methods

2.1 Samples and collection

The samples were purchased from 13 different halwa processors located in the urban West region of Zanzibar. After purchase, they were packed and transferred to the Food Science and Agro-processing laboratory at Sokoine University of Agriculture (SUA) and where they were stored at room temperature for two days before analysis. Face-to-face interviews were conducted to collect information on the halwa processors' knowledge of food safety and hygienic practices through a semi-structured questionnaire.

2.1.2 Determination of CFU counts

For microbiological analysis, the halwa samples were processed two days after the production date. The total count of bacteria (TCB), *Staphylococcus aureus* (SA), yeasts and moulds were observed. The standard pour plate technique method was applied for quantitative CFU (Colony Forming Unit) counts determination of respective groups of microorganisms in 10 g of halwa products. Homogenized samples of halwa were prepared based on a decimal dilution system. One ml of a sample was inoculated in a petri dish containing related nutritive substrates for the desired groups of microorganisms in three replications. For TBC, molten nutrient agar at a temperature of 40-45^{o}C was used. Then, the plates were left to solidify and then incubated in an oven at 37^{o}C for 24 hrs as described in ISO 4833- 1:2013. For yeasts and moulds molten potatoes dextrose agar at a temperature of 40-45^{o}C was used. The prepared plates were aerobically incubated, lid 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 identified by their colour differences of the colony, the colonies of moulds appeared black while those of yeast appeared cream colour as shown figure 1 and 2 [10]. For *Staphylococcus aureus*, molten mannitol salt agar at a temperature of 40-45°C was used, and then the plates were left to solidify and then incubated at 37°C for 24 hrs as described in ISO 6888-1:2003.

Figure 1. Growth of moulds in halwa after five days of incubation.

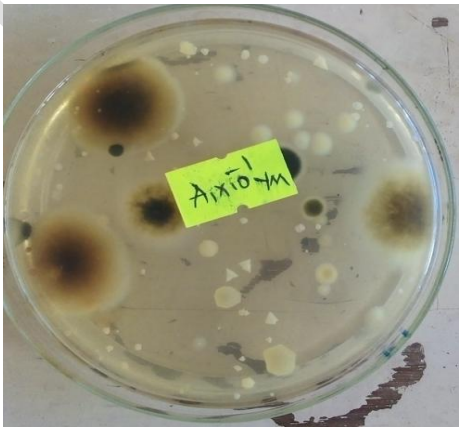

Figure 2. Growth of yeast and moulds in halwa after 5 days incubation

2.1.3 Biochemical test: Conformation test of *Staphylococcus aureus*

A coagulase test was conducted to identify *Staphylococcus aureus*. This test involved combining blood plasma with a bacterial colony and observing the reaction. If the blood plasma coagulated, indicating a positive reaction[10]. During the reaction phase, the coagulase enzyme was coagulating the rabbit blood plasma in a test tube and on slides.

2.1.4 Gram stain

As per the instructions provided by [11] a smeared sample of the bacteria was fixed on to a slide, followed by the application of crystal violet as primary stain. The slide was then rinsed with water, and iodine was added to fix the crystal violet to the cell wall for one minute. Afterwards, the slide was rinsed with water, followed by a three second rinse with alcohol and five-second rinse with water. Gram-positive bacteria were stained purple and appeared spherical or cocci-shaped under the microscope.

2.2 Statistical data analysis

Data from the questionnaires and microbiological analysis were analysed using Statistical Package for Social Science (IBM SPSS Version 25, 2017). Descriptive statistics were used to summarise the data and present it as frequency and percentages. Additionally, one way analysis of variance (ANOVA) was employed to determine the significant differences between the samples at 5% level of significance. Means were separated using Turkey's Honest Significant Different (HSD). Results were expressed as mean ± standard deviation and presented in tabular form.

3. Results and discussion

3.1 Demographic information

The information of processors on demographic information is summarized in Table 1. Halwa processors were found to be dominated by males at 100%, with many of the processors aged between 31 and 40 years. This may be due to the nature of the environment and the job which demands high energy during processing. These findings contradict those of earlier studies such as [12] which reported 67.5% of the food street vendors were females and 32.5% males. [13], reported 74.9% were males and 24.1% females, and [14], reported 80% were males and 20% females. In terms of education, all processors had gone to school, but the majority (61.5%) had ended up with secondary education, 7.7% had higher diploma and the remaining had finished primary school. These findings agreed with [14] findings that the majority of respondents had accomplished secondary school, but contrasted with findings reported by [15], which highlights that 64% of SMEs food processors had vocational education in food processing. The majority of processors (92.3%) were situated in the urban west district, likely due to it being a trade and governmental office centre in the urban west region and Zanzibar in general.

Table 1: Demographic characteristics of halwa processors

Variable	Respondent/categories	Frequency	per cent
Location	West "A " district	1	7.7

	Urban district	12	92.3
Gender	Male	13	100
	Female	0	0
Age	20 – 30	3	23.1
	31 – 40	7	53.8
	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

3.2 Characteristics of halwa processors

The findings of processors attributes are shown in Table 2. Even though about half (53.8%) of the processors had manufacturing licenses from the municipal council, only 23.1% were registered with the Zanzibar Food and Drug Agency (ZFDA). The ZFDA has the 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 moulds. Without regulation, there is a risk that unscrupulous processors might use low-quality or adulterated ingredients to cut down costs. Substandard ingredients can compromise the quality and safety of the final product, leading to health concerns for consumers. The findings showed further that there were variations in the number of employees, with about half of the processors having employees below five and only one processor having employees ranging from 11-15. Hence, all were categorized as small-scale entrepreneurs. An exciting finding of this study was that all processors

had an experience of over years, the experience adding value to the work and determining SMEs ability to upgrade [16].

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

3.3 Quality control of end products

The information on how halwa processors assure the quality and safety of the products are summarised in Table 3. Even though all processors had more than five years of experience, they were not familiar with the standard requirements for halwa and relied on their common senses to judge the quality of end products. This can be risky in terms of food safety, as common sense does not provide the same level of protection as modern scientific principles, standards and regulations. Foodborne illnesses can occur even in foods that appear fresh and well-prepared, so proper food handling, storage, and temperature control are essential to prevent the growth

of harmful microorganisms. Most processors (69.2%) could use quality raw materials as a means of assuring product quality. On the other hand, all processors had no documented working procedures or production flow chart, which increase the risk of cross contamination.

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

3.4 Food safety knowledge and training

It was observed that all surveyed halwa processors and their staff had no formal training in food processing, food safety management and quality and safety standards' requirements for halwa. Such conditions could pose a risk of contamination by various microorganisms in halwa products. This is in contrast to the findings of a study conducted in Hanoi, Vietnam, which reported that the majority of small processors and food handlers had undergone formal training in food safety [17]. Also [18], reported that, 49.5% of food handlers had formal training on food safety. The current study conducted in an urban district of Zanzibar reported that about half of them had formal training on food safety [19]. The findings of this study in terms of food safety knowledge and formal training indicate gaps in this area. It is important to understand that food safety knowledge and training on different food safety aspects are vital for assuring the quality and safety of products. Food safety knowledge of food is essential for food handlers to prevent contamination and

minimize the risks of foodborne diseases [20]. All employees working in food premises, including temporary employees, should be trained in the basics of food safety principles and practices required to prevent contamination and cross-contamination of food [21]. This training should cover hygienic food handling practices, personal hygiene requirements and the risks related to poor personal hygiene and insanitary personnel practices in food processing.

3.5 Handling of raw materials

The findings of this study showed that 100% of the processors acquired raw materials from the market, 76.9% of the processors used quality parameters 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 homes while 46.2% had specific stores for their raw materials. The data showed that 69.2% of the processors experienced raw materials spoilage of which 84.6% was due to 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 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 [22]. 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. Food hygiene practice require food storage to be designed and constructed to provide an environment which minimizes the deterioration of food such as by temperature and humidity control [23]. The presence of moulds-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 moulds growth, uphold quality and safety standards, and protect the health of consumers.

Table 4 : Handling of raw materials

Variable	Respondent/categories	Frequency	%
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

3.6 Hygiene practices

The findings of this study showed that 53.8% of the processors, had employers who undertake medical examinations yearly. Approximately half of the processors were not washing their hands with soap after using the toilets. Only one of the processors had a changing room that had been segregated from the production area (Table 5). Microbiological contamination is significantly correlated to improper environmental surroundings, deficiency of potable water, money handling, inappropriate methods of refrigeration, and the limited access to improper disposal facilities [24]. Maintaining a clean and hygienic environment is essential 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 [25]. Moreover, personal hygiene is a key factor in ensuring the safety and quality of finished products in food processing and handling. People who do not undergo medical checks while working in food production can have serious implications for food safety. Employees who are carrying infectious diseases can unintentionally contaminate the food they handle, either directly or by contaminating surfaces, utensils, and equipment. This can result in the spread of pathogens to the final food product, increasing the risk of foodborne illnesses among consumers [26]. Lack of hair covering during food processing can pose significant risks to food safety and hygiene. Loose hairs 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 part of a comprehensive food safety program, as it helps to prevent contamination and the spread of harmful microorganisms that can cause foodborne illnesses. Protective clothing, including aprons, gloves, hairnets, and footwear, act as barriers 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 [27]. Failing to wash hands with soap after using the toilet and blowing the nose can have serious implications for food safety. Proper hand hygiene is essential 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 toilets or blowing their noses, 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 other studies such as that reported by [28] and [29]. On the other hand, the findings of this study contradict the findings of other studies such as those reported by [30] and [31].

Table 5 : Hygiene practices

Variable	Respondent/categories	Frequency	%
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

3.7 Packaging and labelling information

The data showed that all processors packed their products, most of them not indicating labelling information as shown in Table 6. Packaging acts as a barrier protecting 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 [32]. Proper packaging helps preserve the quality and freshness of food products, while also slowing down the growth of spoilage microorganisms and reducing 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 packed their products; the majority of them use polypropylene (PP) containers as packaging materials. Polypropylene has good barrier properties, meaning it can effectively prevent moisture, gases, and odours from penetrating the packaging materials. This is important for maintaining the freshness, flavours, and quality of halwa, as it helps protect the product from external factors that could lead to spoilage. However, the study observed the risk of contamination during packaging because the majority of the processors transport and pack their products at their shops. The food product must be transported in a clean environment that does not allow contamination [33]. Moreover, it was observed that, for halwa to be

packed it is placed in a container and allowed to cool before it is sealed to avoid condensation, however, this could be one of the risks of contamination since the shops are widely opened, people are talking, hairs is not covered by protective gear and protective clothing is not won. The Codex General Principles of Hygiene require food to be placed in a place free from dust, smoke, pest and any source of contamination [21]. Among the required information in food labelling that includes but not limited to production and expiry date, manufacturer's name and address, type of products, name of products, batch number, storage information, list of ingredients, barcode and net mass [34]. The findings of this study showed that only three processors indicated product name, manufacturer's name and address. Failure to indicate other required information could result in misuse or storage of the products. Moreover, failure to indicate a list of ingredients could risk the health of allergic persons [35].

Table 6: Packaging and labelling information

Variable	Respondent/categories	Frequency	%
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

3.8 Microbial quality

The analysed microorganisms in the samples 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/g and 1.48x10^2 CFU/g to 2.68x10^2 CFU/g respectively.

Table 7: Total bacteria count, yeasts, moulds and *Staphylococcus aureus* in halwa (CFU/g)

Sample ID	Total bacteria count	Yeasts	Moulds	*Staphylococcus aureus*
P1	169.7±2.6^{de}	148.7±13.5^{b}	551.1±6.9^{a}	177.2±11.3^{b}
P2	339.3±10.4^{c}	*	237.2±2.6^{d}	214.7±11.3^{a}
P3	*	*	145.7±11.3^{f}	*
P4	406.9±5.2^{b}	*	354.4±5.2^{b}	151.7±21.3^{bc}
P5	153.2±11.9^{efg}	268.8±6.9^{a}	159.2±14.5^{f}	*
P6	490.9±4.5^{a}	*	141.1±2.6^{f}	142.6±2.6^{c}
P7	145.7±5.2^{fg}	*	193.7±13.5^{e}	145.7±18.2^{c}
P8	145.7±2.6^{fg}	*	240.2±11.3^{d}	*
P9	141.1±2.6^{g}	*	*	*
P10	159.2±9.4^{efg}	*	265.8±13.5^{c}	138.1±5.2^{c}
P11	165.2±13.8^{ef}	*	255.3±2.6^{cd}	162.2±11.9^{bc}
P12	*	*	*	*
P13	190.7±6.9^{d}	150.2±11.3^{b}	148.7±4.5^{f}	163.7±11.3^{bc}

Key: * - means no growth.

Values are given as mean ± 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).

3.8.1 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 [36]. However, if 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 flavours or odours in halwa. The Zanzibar Standard for halwa has provided 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 with the

requirements of ZNS 574: 2023 with respect to total bacterial counts. The total bacteria count in this study were lower than in similar study in India, whereby the reported total plate count in carrot halwa was $1.9x10^9$ CFU/g [9] reported a range of $1x10^3$ CFU/g to $5.5x10^3$ CFU/g of total bacterial count in different confectionery products. meanwhile, [37] reported a range of $7.9\ x10^2$ CFU/g to $4.5x10^3$ CFU/g of selected confectionery products. The lower total bacteria count in this study could be due to the high thermal processing of halwa, which could have killed most of the bacteria.

3.8.2 Yeasts and moulds

Yeasts are common microorganisms found in various foods, including sweets like halwa. Their presence may suggest issues related to hygiene, production processes or storage conditions. The range of yeast counts ($1.48x10^2$ to $2.68x10^2$ CFU/g) indicates variability in the level of yeasts contamination among the positive samples. Furthermore, the presence of moulds in a substantial number of samples is a cause for concern, especially for halwa intended for human consumption. Moulds can produce mycotoxins, which can be harmful if ingested. The variation in moulds concentration suggests that some samples may have higher levels of mycotoxins than others, posing a potential health risk. The fact that moulds were detected in the majority of samples indicates that there might be challenges in maintaining proper hygiene during production 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 moulds 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 while moulds were detected in 11 samples out of 13. Only one sample exceeded the maximum permissible limits ($2x10^2$ 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 elevated levels of yeasts and moulds in carrot halwa sold in the market, compared to these findings [9].This could be due to differences in ingredients used, processing environment and handling practices. Some other studies that analysed yeasts and moulds in food items with similar characteristics to halwa reported higher or lower levels compared to this study. [38] reported $<1x10^1$ to $5.5x10^2$ CFU/g for yeasts in confectionery products while [39] did not find 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 advantages to the growth of microorganisms, could be one of the reasons for the detected amounts of yeasts and moulds [40]. Moreover, yeasts and moulds can be brought into the food premises by personnel, whether employees or visitors, through their clothing and shoes. Because of the lack of exchanging rooms and the poor practice of wearing protective gear reported in this study, the products are expected to be contaminated as moulds and yeasts can be transported throughout the food production environment through clothing, shoes or air movement [41]. All halwa processors and handlers store their products at room temperature, which could influence the growth of yeasts and moulds, as their temperature ranges (10-35°C) are broad, with a few species capable of growth below or above this range [42]. Food contamination by yeasts and moulds can cause significant financial losses for manufacturers, processors and consumers. Due to their capacity to produce poisonous by-products known as mycotoxins several 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 [43].

3.8.3 *Staphylococcus aureus*

The fact that *Staphylococcus aureus* was present in the majority of the samples (8 out of 13) is concerning for the health of consumers. 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 [44]. The packaging practices of halwa could be another factor influencing the replication of *S. aureus*. The halwa is left open for some time before it is sealed to allow it to cool. The pathogen *S. aureus* replicates in foods subject to temperature abuse, such as foods left at room temperature for a prolonged period [45]. 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 to ZNS 574:2023, halwa is required to be free from *Staphylococcus aureus.* Therefore, the eight samples were not compliant with the standard requirements with respect to *Staphylococcus aureus* and were not fit for human consumption. Although there are various sources of *S. aureus*, humans are considered the major source of this pathogen which is found in the nasal passages, throat, hair and skin of carriers [46]. Food is usually contaminated from nasal secretions, sneezing and coughing as well as direct hand contact of infected carriers. Hence, the presence of nasal carriers among healthy food handlers increases the risk of contamination [47]. Poor hygienic practices among halwa

processors as observed in this study could be a factor contributing to the determined quantity of *Staphylococcus aureus.* On the other hand, the findings of this study are higher than those of other studies that analysed *Staphylococcus aureus* in food items with similar characteristics to halwa. For example, [39] reported the absence of *staphylococci* in the analysis of different confectionery products and [38] reported 0 to $<1x10^1$ CFU/g *staphylococci* in confectionery products.

Conclusion

The microbiological counts in halwa products suggest a potential issue with hygiene, manufacturing processes, and storage conditions as described in this study. The data suggests that 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 which are potentially harmful, can impact the consumer's health. Therefore, proper handling, storage and preparation of halwa products are important to minimize any risks associated with these microorganisms.

Recommendations

Further studies are recommended on other microorganisms such as *Escherichia coli* and *Salmonella* to identify the specific bacterial species present. This will help to assess the potential health risks associated with the microorganisms and guide appropriate control measures. Further training of halwa processors on food safety and hygiene practices is also recommended. This will help them understand the importance of proper handling, processing and storage to minimize microbial contamination. Rigorous quality control measures should also be implemented to ensure consistent product quality and safety. It is also imperative to regularly monitor microbial contamination levels to identify trends and deviations.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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