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Research Article

Physicochemical Properties, Proximate Composition and Microbial Hazard in Fermented Muskmelon (*Cucumis Melon* Linn) from Local Commercial Processors in Cambodia

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Abstract

Fermentation is one of the simplest and easiest methods of food preservation especially for perishable fruits and vegetables made through the action of lactic acid bacteria inherent in the raw materials. Locally grown muskmelon (*Cucumis melon* Linn.) is an important crop in Cambodia which is brine fermented and added with sugar syrup into ready-to-eat food. However, information regarding the quality of local fermented muskmelon from different retail outlets in Cambodia is limited. This study aimed to determine the physicochemical properties, proximate composition and enumerate the microbiological hazard contamination of processed fermented young muskmelon sold by different local commercial processor/market. Samples of ready-to-eat fermented muskmelon were purchased from local commercial processors in Kompong Cham, Tboungkhmum, Preveng and Kandal provinces in Cambodia. The results revealed significant differences among samples in terms of physicochemical properties, proximate composition (except for crude protein, crude fat and crude fiber) and mineral contents. The pH of the products ranged from 3.59 to 4.28, while the lactic acid (5) from 0.14 to 1.00%. Samples contained significantly high Total Soluble Solids (TSS) ranging from 16.5°Brix to 63.0°Brix. Likewise, salt content was relatively high with values ranged 5.71% to 10.06% the local processors do not practice desalting of brine fermented muskmelon before final processing in sugar syrup. The products have the following proximate composition: 36.83%-84.52% moisture content; 5.14%-11.14% crude ash; 1.95%-4.07% crude protein; 0.028%-0.060% crude fat; 16.6%-24.25% crude fiber; and 11.74%-60.32% total carbohydrates. The Ca and Mn contents were found very low while Fe was absent in the products. Microbial analysis suggests that the total viable count (TVC) of 10^3 CFU/mL means different kinds of microorganisms are present and represent only the microbiological quality of the samples. The presence of indicator bacteria such as Enterobacteriaceae and coliform (10^2-10^3 CFU/mL) indicated poor personal hygiene of workers and of post-processing contamination of heat processed foods. On the other hand, the presence of pathogenic bacteria like Salmonella ("potentially hazardous"), Staphylococcus and Bacillus species (both "marginal" quality) suggest the potential of the processed fermented muskmelon to cause food illnesses. There is therefore a need for these local processors to learn the basic concepts of "Good Manufacturing Practices" to produce consistent good quality products and be competitive in the international market.

Keywords: Lactic acid fermentation; Microbial hazard; Muskmelon; Physicochemical properties; Proximate composition

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Introduction

Vegetables are highly nutritious and perishable foods that have very short shelf lives. Thus, the importance of food preservation was practiced for a long time using various methods. Fermented vegetables are a traditional process that preserves vegetables and fruits through anaerobic fermentation [1], resulting in products being regularly consumed in most societies throughout the world. Recently, many technologies have been developed for vegetable fermentation. The main process used relies on microorganisms' biological activity that produces metabolites capable of suppressing the growth of many contaminating and undesirable microorganisms. Based on the preparation methods and ingredients used, fermentation products are classified into two general classes: (1) fermented or brined pickles cured for several weeks during which fermentative bacteria produce acids, thereby lowering the pH and consequently preserving the products; and (2) fresh pack or quick process pickles, which are simply vegetables that are packed in jars, covered with vinegar and other flavorings, and then pasteurized by heat [2]. The market for preserved vegetable products is dominated by fermented and non-fermented pickles [3]. The fermentation environment is stressful for many types of microorganisms. However, some microorganisms have evolved sophisticated physiological systems that enable them to survive under very inhibitory conditions. The types of microbial spoilage are limited to various heterofermentative lactic acid bacteria, yeasts, and molds that can tolerate acetic acid concentrations, salt and low pH [4] in the products. Yeasts are responsible for the spoilage of approximately three-fourths of acidified specialty vegetable products [5]. During the fermentation process, salt is often used at a high concentration (10-15%) to support the growth of fermenting lactic acid bacteria thus enhancing the fermentation process [6]. However, human intake of a high salt concentration is restricted as it can increase the risk of heart attack and hypertension. This is the major drawback of consuming high salt vegetable pickles [7]. Thus, salt content determination in local commercial products is of great importance for both consumers and health specialists. In addition, poor hygienic conditions during the processing, storing and handling of vegetable fermentation are responsible for their spoilage and poisoning in consumers. Information regarding the quality of local fermented muskmelon in terms of their physicochemical and microbiological properties from different retail outlets in Tboung Khmoum, Kompong Cham, Preveng, and Kondal province, in Cambodia is limited. Therefore, the study aimed to: (1) determine the physicochemical and proximate properties of locally processed fermented muskmelon; and (2) enumerate the microbiological hazard contamination of fermented muskmelon sold in selected local commercial processors/market.

Materials and Methods

Collection of samples

Samples of bottled processed fermented muskmelon products (Figure 1) were purchased from local commercial processors in Kompong Cham, Tboungkhmum, Preveng and Kandal provinces in Cambodia, at two samples per province (total of 8 samples). The samples were brought to the Laboratory of Faculty of Agro-Industry, Royal University of Agriculture for physicochemical and microbial analysis. The duplicate of the samples were also transported to the Industry Laboratory of Cambodia Center (ILCC) for proximate analysis.

Figure 1: Processed fermented muskmelon collected from local commercial processors in Cambodia.

Physicochemical analysis

The pH of the samples was measured in a suspension, prepared by blending 10 g fermented muskmelon with 10 mL of deionized water for 2 min, using a calibrated pH meter (Model F-71G, MFG No. B16L0032). The titratable acidity (expressed as lactic acid) of the samples was measured following the procedure in AOAC [8]. Salt content was determined by titrating the filtrate prepared for the determination of acidity with 0.1 N AgNO3 using 5% $K_2Cr_2O_7$ as indicator, after its neutralization [9]. The total (TS) and Reducing Sugar (RS) were determined by phenol-sulfuric and dinitrosalicylic acid methods [10], respectively. All trials were done in duplicates.

Proximate analysis

Samples of processed fermented muskmelon were analyzed for their proximate composition using the standard analytical methods of Association of Official Analytical Chemist [11]. The moisture content was determined using air-forced draft oven drying method at temperature of 103 ± 1°C for 5 h (AOAC Method 930.15). The ash content was analyzed through removal of all organic components (AOAC Method 977.02) wherein the samples were ashed at 550°C then dissolved with 10 mL of 20% hydrochloric acid and filtered into a 100 mL standard flask. This was made up to the mark with deionized water. The crude fat content was determined using AOAC Method 920.39; and crude protein using Kjeldahl method (AOAC Method 984.13). Crude fiber was measured following the AOAC Method 930.10. The carbohydrate was analyzed following the method described by James and Bemiller [12]. Total carbohydrate (5) was obtained by subtracting the percentages calculated for each nutrient from 100, any errors in evaluation was reflected in the final calculation. The minerals were determined from the resulting solution of ash analysis and calcium (Ca), magnesium (Mg) and iron (Fe) contents were analyzed using Atomic Absorption Spectrophotometer (Model: U-2900/2910).

Microbiological analysis

Microbial analysis of the processed fermented muskmelon samples was conducted simultaneously with proximate analysis. Ten (10) mL of the liquid solution of the samples was aseptically transferred to 90mL sterile 0.1% peptone water, as diluent. Decimal dilutions in diluent solution were prepared and standard pour plating technique was carried out in appropriate agar media (Paramithiotis et al., 2010). After the required incubation time and temperature, enumeration of different kinds of microorganisms was performed. The Total Viable Count (TVC) was enumerated following the method by [13-15]; coliforms were enumerated as described by Feng et al. [16]; and Kornacki and Johnson [17]; and yeast and mold counts using the method of Touma et al. [18]; and Beuchat and Cousin [19]. Lactic acid bacteria were enumerated following the method described by Hoque et al. [20], using MRS (de Man, Rogosa, and Sharpe) agar plus 1% $CaCO_3$ and incubated at 37°C for 2 days before the colonies were counted. Acid-forming bacteria are differentiated by clearing around the colonies. Pathogenic bacteria such as Staphylococcus, *Salmonella* spp., Enterobacteriaceae, and *Bacilus* spp. were determined following the methods described by Bennett and Lancette [21], Andrews et al. [22] and Depaolo and Kaysner [23].

Statistical Analysis

Data obtained were analyzed for absolute values of the microbial count, physicochemical, and proximate properties. Significance of treatment means differences were analyzed by ANOVA ($p \leq 0.05$). When found significant, DMRT was employed.

Results and Discussion

Samples of processed fermented muskmelon produced by local commercial processors were collected from four (4) local selected provinces (Kompong Cham, Tboungkhmum, Preveng and Kandal) in Cambodia. The physicochemical properties, proximate compositions, mineral contents (Ca, Mn and Fe), and microbial hazards of the samples were evaluated.

Physicochemical properties of processed fermented muskmelon

Table 1 shows that physicochemical properties [pH, lactic acid (%), NaCl (%), TSS (°Brix), TS (%) and RS (%)] were significantly different ($P<0.05$) among fermented muskmelon samples. The pH of the products ranged from 3.59 to 4.28, while the titratable acidity (expressed as lactic acid) from 0.14 to 1.00 %. The highest pH (4.28) was obtained from processor 2 in Kandal province (TKD2) and lowest was from processor 2 in Tboung Kmom province (TTK2). The increase in titratable acidity and decrease in pH could be attributed to the dominance of the environment by lactic acid bacteria during partially anaerobic brine fermentation which degrades carbohydrates resulting in acidification. In general, as the pH values decreases, the acidity increases. The optimum values of pH 3.2-3.8 and 0.6% lactic acid were suggested for brine fermented cucumber, the differences obtained in the study can be due to the condiments and sugar added during processing of fermented muskmelon into their final products. There were also differences in the time of brine fermentation among processors which ranged from 7-15 days prior to addition of sugar. Higher salt content was found in TTK2 followed by TTK1 (10.06 and 9.65%, respectively) while the TKD2 had the lowest value of 5.71%. Visits to production areas revealed that the local processors do not practice desalting of brine fermented muskmelon before final processing in sugar syrup hence the high salt content of the finished products.

The TSS (°Brix) is the amount of sucrose in 100g sucrose water solution. All samples contained significantly high values ranging from 16.5°Brix (TKC1) to 63.0°Brix (TTK1) or simply light to heavy syrup. Significant differences in the amount of sugar were also noted even in samples collected from the same provinces. This suggests the lack of standard in the addition of sugar among local processors in ready-to-eat processed muskmelon.

Total sugars comprise all mono- and disaccharides, regardless of source while reducing sugar is any sugar that is capable of acting as a reducing agent because it has a free aldehyde group or a free ketone group. The highest total sugar was obtained from TTK1 (38.85%) followed by TKD1 (23.47%) and the lowest from TPV1 (5.88%). The TKD2 got the highest amount of reducing sugar (12.13%) followed by TKD1 (11.76%) while TPV1 obtained the lowest (5.8%). Most of the fermented cucumbers are added with pickling solution comprised mainly of sugar and vinegar giving sweet-sour taste in the final products. In Cambodia, however, the brine fermented muskmelon is not desalted and added solely with sugar syrup during processing, resulting in sweet and salty taste ready-to-eat product. This practice also contributed to the high salt and sugar contents (Table 1) obtained in the samples from local processors in Cambodia.

Proximate composition and mineral contents of processed fermented muskmelon

The proximate properties and mineral contents of processed fermented muskmelon from local commercial products are presented in Table 2. Except for crude protein, crude fat and crude fiber, the proximate composition and mineral contents were significantly different ($P<0.05$) among samples. The moisture content revealed that the sample from TPV1 was highest (84.52%) while samples from TTK1 obtained the lowest (36.83%). The relatively low moisture content of the other samples (below 60%) is an indication that the fermented muskmelon from TTK1 (36.83%), TTK2 (48.23%) and TKD1 (58.43%) will have longer shelf-life. The rest of the samples are considered prone to microbial spoilage especially when not properly package during processing. In general, the higher the TSS and salt content of the samples, the lower is the moisture content because of the osmotic pressure created by salt and sugar solutions during fermentation and processing, respectively. The increased moisture content in TPV1 and TPV2 may be due to the soaking of muskmelon in solution of brine and sugar. It may also be attributed to the decomposition of the fermenting bacteria on the products. This agreed with the report of David and Aderibigbe [24] on fermentation of melon seed.

The crude ash content showed that TTK2 had the highest (11.14%) while TKC2 obtained the lowest (5.14%). Based on the analysis of variance, the ash contents differ significantly among samples. The high ash content of the above samples could be as a result of just partial consumption of minerals by fermenting microorganisms in the process of fermentation. According to Ojokoh and Babatunde [13] the increase in ash content of millet-soybean blends is caused by incomplete utilization of minerals by fermenting organisms during their metabolism.

Protein contents may vary between different fruits and different products. The protein content of the samples had no significant differences among samples which ranged from 1.95% (TTK2) to 4.07% (TKD2). Oboh and Akindahumsi [25] studied the biochemical changes in cassava product (flour and garri) subjected to *Saccharomyces cerevisiae* solid media fermentation, results suggested that increased in protein content of the samples could be attributed to the ability of the yeast that was present in the course of the fermentation to secrete some extracellular enzymes (protein) into the fermented sample during their metabolic activities on the products. The high protein content of fermented food samples has a good implication in a society with high protein deficiency and will no doubt complement protein from cereals and other plant foods [14].

Sample Code	pH	Lactic acid (%)	NaCl (%)	TSS (Brix)	Total sugar (%)	Reducing sugar (%)
TTK1	4.08^{c}	0.30^{cd}	9.65^{a}	63.00^{a}	38.85^{a}	10.12^{c}
TTK2	3.59^{f}	0.24^{d}	10.06^{a}	56.20^{b}	22.90^{bc}	8.55^{e}
TPV1	3.85^{e}	0.62^{b}	8.07^{b}	27.40^{e}	5.88^{f}	4.66^{g}
TPV2	4.17^{b}	0.33^{c}	6.93^{e}	36.50^{d}	10.86^{e}	5.98^{f}
TKC1	4.01^{d}	0.35^{c}	7.07^{e}	16.50^{f}	13.93^{d}	8.17^{e}
TKC2	3.96^{d}	0.14^{e}	6.39^{f}	25.90^{e}	21.18^{c}	9.58^{d}
TKD1	3.99^{d}	1.00^{a}	7.75^{c}	50.30^{c}	23.47^{b}	11.76^{b}
TKD2	4.28^{a}	0.23^{d}	5.71^{g}	27.30^{b}	14.87^{d}	12.13^{a}

Table 1: The physicochemical properties of processed fermented muskmelon from local commercial processors in Cambodia.

Means in the same column with the same superscripts are not significantly different at $P \leq 0.05$.

Note: TTK1=Thboung Khmom processor 1, TTK2=Thboung Khmom processor 2, TPV1=Preveng processor 1, TPV2=Preveng processor 2, TKD1=Kandal processor 1, TKD2=Kandal processor 2, TKC1=Kompong Cham processor 1, TKC2=Komong Cham processor 2.

TSS=Total soluble solids

Sample	Proximate Composition								
	Moisture (%)	Crude Ash (%)	Crude Protein (%)^{ns}	Crude Fat(%)^{ns}	Crude Fiber (%)^{ns}	Total Carbohydrates (%)	Ca(% M/M)	Mn (g/kg)	Fe (%)
TTK1	36.83^{h}	10.31^{b}	2.15	0.028	19.34	60.32^{a}	0.298^{b}	0.031^{b}	0
TTK2	48.23^{g}	11.14^{a}	1.95	0.037	21.14	49.03^{b}	0.491^{a}	0.066^{a}	0
TPV1	84.52^{a}	8.89^{c}	3.49	0.045	20.35	11.74^{g}	0.165^{cd}	0.039^{b}	0
TPV2	73.12^{b}	8.63^{c}	2.68	0.029	22.01	23.92^{f}	0.190^{cd}	0.060^{b}	0
TKC1	71.70^{c}	6.20^{d}	2.46	0.053	24.00	25.96^{e}	0.172^{cd}	0.000^{c}	0
TKC2	63.79^{e}	5.14^{e}	2.13	0.060	21.37	34.06^{d}	0.133^{d}	0.028^{b}	0
TKD1	58.43^{f}	8.35^{c}	3.73	0.045	16.60	37.55^{c}	0.243^{bc}	0.00^{c}	0
TKD2	70.04^{d}	5.59^{e}	4.07	0.049	24.25	25.71^{ef}	0.129^{d}	0.00^{c}	0

Table 2: The proximate composition and mineral contents of processed fermented muskmelon from local commercial processors in Cambodia.

Means in the same column with the same superscripts are not significantly different at $P \leq 0.05$.

Note: TTK1=Thboung Khmom processor 1, TTK2=Thboung Khmom processor 2, TPV1=Preveng processor 1, TPV2=Preveng processor 2, TKD1=Kandal processor 1, TKD2 =Kandal processor 2, TKC1=Kompong Cham processor 1, TKC2=Komong Cham processor 2

The crude fat content of the samples did not differ significantly among samples, with values ranging from 0.028% (TTK1) to 0.060% (TKC2). This denotes that the crude fat content of the samples is not affected by the processing of the muskmelon. The observed low fat content in samples could be due to the breakdown of fatty acid and glycerol by lipolytic microorganisms present in the sample during fermentation, and the breakdown of the fatty acid and glycerol could enhance the aroma, taste, odor and texture of products. The low levels of crude fat indicate that the product is not a good source of energy.

The crude fiber content of the samples showed no significant differences among samples, which ranged from 16.6% (TKD1) to 24.25% (THD2). The high crude fiber content observed in the study could be as a result of the decreased in moisture content which tends to increase the concentration of nutrients (Morris et al 2004 as cited by Wijewardana et al., [26]. According to Eromosele and Eromosele [27], the high fiber food expands the inside walls of the colon and easy passage of waste, thus making it an effective anti-constipation agent. They also stated that high fiber food lowers cholesterol level in the blood, reduce the risk of various cancers, bowel diseases and improve general health and well-being.

Significant differences were observed for total carbohydrates among samples ranging from 11.74% (TPV1) to 60.32% (TTK1). The observed values are probably attributed to the differences in the amount of sugar added into the fermented muskmelon during processing by local processors. Possible errors in the result might be encountered since total carbohydrate is the only component in the proximate analysis which is calculated by difference and not analytically, any errors in evaluation are reflected in the final calculation. The total carbohydrate by difference method used in the study includes fiber, as well as some components which are not strictly speaking carbohydrates, e.g. organic acids [28]. Thus, dietary fiber, sugars, and starches make up the total carbohydrate of the foods. Our body's main source of energy is the carbohydrate. In their absence, our body will use protein and fat for energy.

The mineral contents were found very low in the products. The highest values of Ca was observed in TTB2 (0.491 %M/M) followed by TTK1 (0.298%M/M) while the lowest Ca content was found in TKD2 and TKC2 (0.129%M/M and 0.133%M/M, respectively). Hu et al. [29] reported that the edible portion of fresh muskmelon contained 11mg calcium, 11mg magnesium, 0.21mg iron and 0.05mg manganese. The Mn content was highest in TTK2 (0.066g/kg) and none or undetected in samples from TKC1, TKD1 and TKD2. The differences in values might be due to the differences in variety of muskmelon and the method of processing underwent by the products. The Fe was not found in fermented muskmelon products. According to USDA, ARS [30], like pickled vegetables such as sauerkraut, sour pickled cucumbers are low in calories (12kcal). Most sour pickled cucumbers are also high in sodium; one pickled cucumber can contain 350-500mg, or 15-20% of the American recommended daily limit of 2400 mg. Sudhanshu et al. [31] reported the mineral contents of sodium 809mg/100g, magnesium 7mg/100g, calcium 57mg/100g in pickles.

Microbial hazard contamination

Enumeration of microbial hazard contamination in processed fermented muskmelon from local commercial processors in Cambodia is shown in Table 3. The Total Viable Counts (TVC) ranged from 3.1-5.8x10^3 CFU/mL which suggest that different kinds of microorganisms are present in all the bottled samples. The high count of TVC in the samples only signified the microbiological quality of the samples and that safety of food should not only be based on this count but rather on the microorganisms that predominates and whether or not these are pathogenic or useful bacteria. The quality of fermented muskmelon can be rated as "acceptable" according to the International Commission for Microbiological Specification for Foods [32], in which the plate counts of $\leq 10^3$ are "acceptable, $\geq 10^4$ to $\leq 10^5$ as tolerable, and $\geq 10^6$ as unacceptable.

The yeast and mold counts differ significantly among samples which obtained values from 6.0 x 10^2 (TKD2) to 1.2x10^3 CFU/mL (TPV2). There was no typical mold colonies observed on the agar medium after the required incubation period. Molds are aerobic hence unable to grow in bottled samples. On the other hand, facultative anaerobe, osmophilic yeasts able to grow on the samples. The presence of yeast suggests that prolonged storage can cause bloated muskmelon and bulging of container due to the presence of carbon dioxide as end product of metabolism. Identification of yeast species can ensure the safety of the products. The absence of heat sensitive lactic acid bacteria is expected after the samples have been subjected to heat during processing [33].

The total coliform and Enterobacteriaceae counts also varied significantly among the processors products with the highest total coliform occurring in TPV2 and TKC1 (1.4x10^3 CFU/ml and 1.3x10^3 CFU/ml, respectively) while the lowest was observed in TTK2 (3.0x10^2 CFU/ml). The Enterobacteriaceae, on the other hand, showed highest counts in TKC2 and TKD2 (both with 9.5x10^2 CFU/ml, while the lowest was observed in TKC1 and TTK2 (both with 3.0x10^2 CFU/ml).

Samples	Total Viable Count (CFU/ml)	Yeast and molds (CFU/ml)	LAB (CFU/ml)	Coliform (CFU/ml)	Enteroba teriaceae (CFU/ml)	Salmonella (CFU/ml)	Staphylococcus (CFU/ml)	Bacillus (CFU/ml)
TTK1	4.9 x 103^{b}	1.1 x 103^{ab}	0	8.5 x 102^{b}	5.5 x 102^{b}	9.5 x 102^{a}	3.0 x 102^{c}	7.0 x 10^2
TTK2	3.1 x 103^{c}	7.8 x 102^{bc}	0	3.0 x 102^{c}	3.0 x 102^{c}	1.5 x 102^{d}	4.0 x 102^{c}	9.0 x 10^2
TPV1	5.8 x 103^{a}	9.5 x 102^{abc}	0	8.0 x 102^{b}	9.0 x 102^{a}	8.5 x 102^{ab}	9.5 x 102^{b}	1.2 x 10^3
TPV2	5.7 x 103^{a}	1.2 x 103^{a}	0	1.4 x 103^{a}	3.5 x 102b^{c}	4.5 x 102^{cd}	1.3 x 103^{a}	6.5 x 10^2
TKC1	5.6 x 103^{a}	9.5 x 102^{abc}	0	1.3 x 103^{a}	3.0 x 102^{c}	5.0 x 102b^{cd}	1.1 x 103^{b}	1.1 x 10^3
TKC2	5.6 x 103^{a}	9.0 x 102^{abc}	0	8.0 x 102^{b}	9.5 x 102^{a}	8.5 x 102^{ab}	9.0 x 102^{b}	7.5 x 10^2
TKD1	5.6 x 103^{a}	1.1 x 103^{ab}	0	8.0 x 102^{b}	4.0 x 102^{bc}	3.0 x 102^{d}	5.0 x 102^{c}	1.3 x 10^3
TKD2	5.5 x 103^{o}	6.0 x 102^{c}	0	1.0 x 103a^{b}	9.5 x 102^{a}	8.0 x 102^{abc}	9.5 x 102^{d}	7.0 x 10^2

Table 3: Microbial count (CFU/mL) of fermented muskmelon from local commercial processors in Cambodia.

Means in the same column with the same superscripts are not significantly different at P ≤ 0.05.

Note: TTK1=ThboungKhmom processor 1, TTK2=ThboungKhmom processing 2, TPV1=Preveng processor 1, TPV2=Preveng processor 2, TKD1=Kandal processor 1, TKD2=Kandal processor 2, TKC1=Kompong Cham processor 1, TKC2=Komong Cham processor 2

According to the Guidelines for Food Microbiological Examination of Ready-to-eat Foods [33], Enterobacteriaceae are useful indicators of hygiene and of post-processing contamination of heat processed foods. Furthermore, their presence in high numbers (>10^4 per gram) in ready-to-eat foods indicates that an unacceptable level of contamination has occurred or there has been under processing. The results of the study suggest that the fermented muskmelon is within the marginal quality (10^2-10^4 CFU/g), with counts ranging from 10^2-10^3 CFU/mL. However, pathogenic strains of coliforms should be absent. Members of the Enterobacteriaceae group occur in the environment as well as in the gut of humans and animals. Microbial indicators are more often employed to assess food safety and sanitation rather than quality. It is clear that the potential for *E. coli* to survive for extended periods in acidified vegetable products with a pH below 4 clearly exists; pasteurization for some acidified food products may be needed to ensure safety [34].

The safety of fermented muskmelon against pathogenic bacteria such as salmonella, staphylococcus and Bacillus species was assessed. The highest counts of salmonella was observed in TTK1 (9.5x10^2 CFU/ml) and lowest in TTK2 (1.5x10^2 CFU/ml). According to ICMSF [33], the ready to eat foods should be free of Salmonella as consumption of food containing this pathogen may result in food borne illnesses. In addition, the presence of this organism indicates poor food preparation and handling practices such as inadequate cooking or cross contamination. Consideration may also be given to investigating the health status of food handlers on the premises who may have been suffering from salmonellosis or asymptomatic carriers of the organism [33]. According to CSF [35] foods may be contaminated by salmonellae in animal feces and cross-contamination may occur during further processing and preparation. Also, salmonellae may survive in the environment and equipment of food-processing facilities. Many foods, particularly those of animal origin and those subject to sewage pollution, have been identified as vehicles for transmitting these pathogens [32]. Hence, the presence of salmonella in relatively high numbers (10^2) signified that bottled fermented muskmelon is "unsatisfactory" and "potentially hazardous" to consumers' health.

In the case of Staphylococcus, the counts significantly differed among samples with ranged from 10^2 to 10^3 CFU/mL. A test for enterotoxin may be appropriate where levels of staphylococci exceed 10^3 CFU/ gram or where poor handling practices are suspected but it is likely that viable organisms may no longer be present in significant numbers. Levels of ≥ 10^4 CFU/g are considered as potentially hazardous as foods with this level of contamination may result in food borne illness if consumed [33]. The border line of *Staphylococcus aureus* ranged from 20- ≤ 10^4 CFU/g for the specific foodborne pathogens in ready-to-eat foods in general [35]. A contamination of ready-to-eat foods with staphylococci is largely as a result of human contact. Contamination should be minimized through good food handling practices and growth of the organism prevented through adequate temperature controls. Unsatisfactory levels of staphylococci indicate that time/temperature abuse of a food is likely to have occurred following improper handling during food preparation [33]. The most common way of contamination of food is by contact with food handlers' hands, especially in the cases where the food is handled subsequent to cooking. Prolonged storage without refrigeration allows the bacteria to grow and form toxins. Since the toxins are heat stable, the incriminated food may also cause food poisoning even if it is further heat treated [35]. In the present study, the processed fermented muskmelon in sugar syrup with staphylococcus counts of 10^2-10^3 CFU/mL suggests that the product has marginal quality that means it is not unsatisfactory but also not satisfactory which indicate potential for development of public health problems.

The Bacillus species counts ranged from 10^2-10^3 CFU/mL. The CSF [35] reported that Bacillus borderline was 10^3- ≤ 10^5 CFU/g for specific foodborne pathogens in ready-to-eat food, in general. The ICMSF [33] stated that the detection of high levels (>10^3 CFU/g) of *B. cereus* should result in an investigation of the food handling controls used by the food business. Levels of ≥ 10^4 CFU/g are considered potentially hazardous as consumption of foods with this level of contamination may result in food borne illnesses. The count of Bacillus species in processed fermented muskmelon (10^2-10^3 CFU/mL) in this study suggests that the products have "marginal" quality.

It is well known that variations in the microbiological properties of a product greatly influence their chemical properties particularly the pH and acidity [36-42]. This could also be attributed to the differences in the processing types and chemical composition and the processing condition during pickle handling and preparation.

Conclusion

The physicochemical properties, proximate composition and mineral contents significantly differ among samples of processed fermented muskmelon (P<0.05) except for crude protein, crude fat and crude fiber contents. The values for salt and sugar contents are relatively high and differed significantly even samples from the same provinces showing lack of standard quality control among local processors. The mineral contents, Ca and Mn, are very low while Fe is absent in the products. In terms of microbial analysis, the TVC of 10^3 CFU/mL suggest that different kinds of microorganisms are present and represent only the microbiological quality of the samples; the safety of food should not only be based on this count but rather on the microorganisms that predominates and whether or not these are pathogenic or useful bacteria. The presence of indicator bacteria such as Enterobacteriaceae and coliform (10^2-10^3 CFU/mL) indicated poor personal hygiene of workers and of post-processing contamination of heat processed foods. On the other hand, the presence of pathogenic bacteria like Salmonella ("potentially hazardous"), Staphylococcus and Bacillus species (both "marginal" quality) suggest the potential of the processed fermented muskmelon to cause human health problems and food poisoning. There is therefore a need for these local processors to learn the basic concepts of "Good Manufacturing Practices" to produce consistent good quality products and be competitive in the international market.

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