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PHYSICOCHEMICAL QUALITY AND STORAGE STABILITY OF RETAIL CAKES AVAILABLE IN TANGAIL CITY, BANGLADESH

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ABSTRACT

The study was carried out to assess the physicochemical and storage stability of seven different retail cake samples available in Tangail city, Bangladesh. The proximate composition of the collected cake samples was found significantly different ($p<0.05$) and was found within the acceptable range of the Bangladesh Standard and Testing Institution (BSTI) standards though most of the cake samples (except S7) had moisture content near to the BSTI borderline range for moisture (~25%). Volume and specific volume of the cake samples ranged from 12.00 to 29.99 cm^3 and 1.64 to 2.93 ml/g respectively. The color measurement of all samples were analyzed for L*, a* and b* values, hue angle, saturation index and whiteness index. Textural properties of the cake samples were analyzed for 7 days of storage where hardness of all samples were increased significantly ($p<0.05$) and springiness was decreased with storage time. Regarding the storage stability most the cake samples (except S7 containing lowest moisture) showed higher total viable count (TVC) (1×10^4 cfu/g to 2.71×10^6 cfu/g) and total fungal count (TFC) (0 cfu/g to 1.4×10^5 cfu/g) than the WHO acceptable range for consumption just after the 2nd day and 6th day of storage respectively.

1. Introduction

From the advancement of modern civilization and urbanization, different types of ready to eat foods such as confectionery and bakery goods have been consumed widely since the food habit of people has also been changed with time (Bandara *et al*., 2021). Among those cakes is one of the most delicious and liked most baked products. It is usually made up of a number of ingredients, principally flour, sugar, egg, baking powder and others (Conforti, 2006). Good quality cake should be fluffy, spongy, smooth, and should satisfy the consumers (Malav *et al.*, 2015; Jiang *et al.*, 2017). The quality and quantity of ingredients along with processing methods and baking conditions influence the wholesomeness and overall eating quality of prepared cake (Salehi F and Aghajanzadeh, 2020). The quality of cake can be compromised by faulty production (higher moisture content), improper handling, packaging and sanitization which eventually lead to microbial spoilage (fungi, bacteria etc.) (Saranraj and Geetha, 2012). To maintain good quality of cake, the Bangladesh Standard and Testing Institution (BSTI) has provided a number of specifications (e.g., moisture level, fiber content etc.) for finished cake (BSTI, 2006). Proper food processing and storage techniques can provide benefits to both commercial producers as well as consumers with a prolonged shelf life of food products (Ilbery and Maye, 2005). A wide range of processed bakery products are available in both local and supermarkets in Bangladesh with a production record of 3,472.000 Metric Ton in July, 2021 (Al-Fuad *et al.,* 2018; CEIC, 2021). A large quantity of these bakery products are being produced by numerous unlicensed and semi-authorized local manufacturers at smaller scale which are hardly scrutinized by government food regulatory authorities. As many of these local bakeries are manufacturing bakery products in unhygienic conditions with low grade raw materials even they don't have BSTI certification which may eventually endanger public health to some extent (Al-Fuad *et al.*, 2018). Now it has become a public health safety concern for bakery products (Islam *et al.*, 2013).Therefore, this study was conducted to analyze the physicochemical quality parameters as well as the storage stability regarding textural (hardness and springiness) and microbial count of different locally produced and marketed cake in Tangail region, Bangladesh. In addition, the study also drew a comparative analysis of the above specifications with standards developed by the BSTI.

2. Materials and methods

2.1. Materials

2.1.1. Study design and Sample collection

It was a laboratory-based analytical study which was based on assessment of physicochemical, microbial stability and shelf life of cake samples. Seven different locally produced cake samples (Table 1) were purchased from the different local retail shops of Tangail city (24.264423°N 89.918140°E) located in the central region of Bangladesh (Fig. 1).

Among those S7 cake samples was a countrywide recognized brand and largely consumed by the population of the study area. All samples were kept at ambient room temperature until analysis. The analysis was conducted in the Department of Food Technology and Nutritional Science (Microbiology Lab), Mawlana Bhashani Science and Technology University, Tangail, Bangladesh.

Table 1. Sample coding and identification

Sr.	Name of the cake samples	Sample ID
01.	Asha special plain cake	S1
02.	Jamuna cake	S2
03.	Master cake	S3
04.	Unknown brand	S4
05.	Tripti plain cake	S5
06.	Bondhon cake	S6
07.	Fuang anytime cake	S7

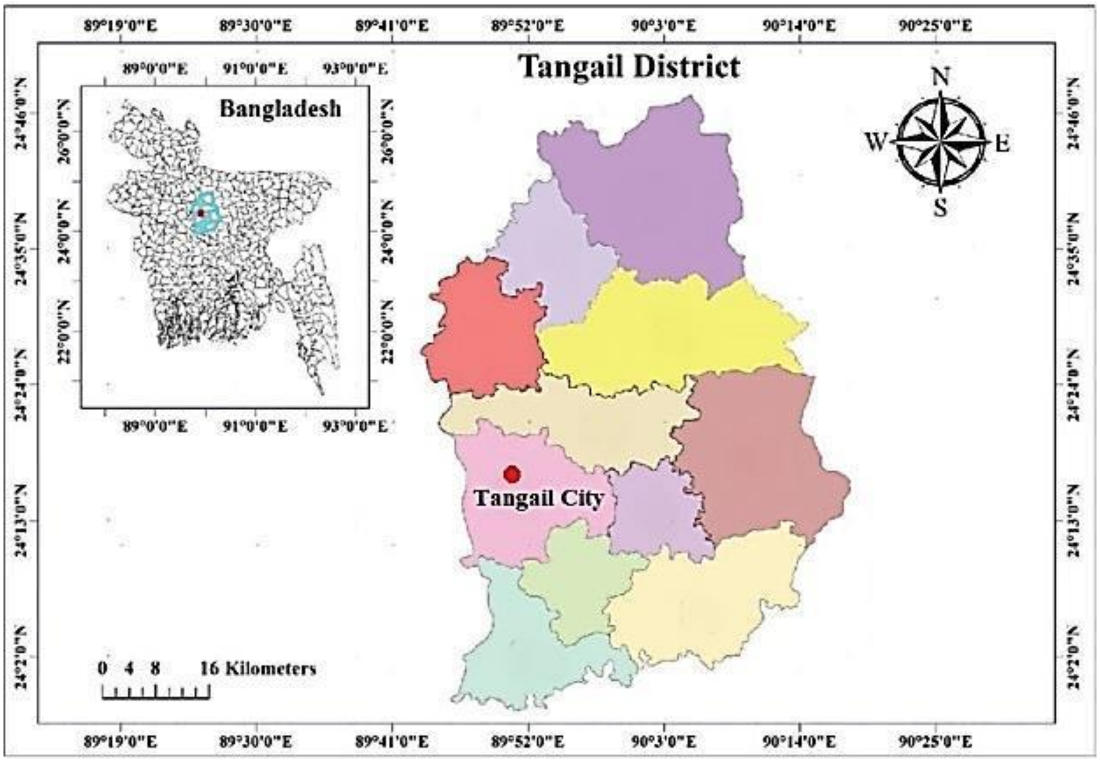

Figure 1. Map showing the study area of Tangail district, Bangladesh

2.2. Analysis of proximate composition

All the cake samples were analyzed for the moisture, ash, crude fat, crude protein and crude fiber content according to the approved methods of AOAC (2005). The utilizable carbohydrate content was determined by using the following equation (Edeogu, 2007).

% Carbohydrate= 100- {Moisture (%) + Protein (%) + Fat (%) + Ash (%) + Crude fiber (%)}

2.3. Color measurement

Color measurements were evaluated by measuring the color values (L*, a*, b*) through Hunter color scale of various cake samples (Kim *et al.*, 2011). The L, a*, b* values of the cake sample were measured by reflection using a Chromameter (CR-400; Konica-Minolta, Tokyo, Japan). Where L defines lightness, a* denotes the red/green value, and b* defines the yellow/blue value. The instrument was calibrated with standard white tiles (Y=85.1, X=0.3171, y=0.3234) prior to measurement. Other color parameters such as hue angle (h*), saturation index (SI) and whiteness index (WI) were also calculated according to the formula described by (Pathare *et al.*, 2012) At least three measurements were taken separately from three different locations on the sample case and the mean, including the standard deviation was analyzed.

2.4. Volume and specific volume of cake

Mass of cake samples were measured by using an analytical balance (Model: ALE-223, India), volumes were measured with displacement of mustard seeds as described by Begum *et al.* (2011) The specific volumes of breads were calculated according to AACC (2000) method based on the volume/mass ratio.

2.5. Texture profile analysis (TPA)

The texture profile of collected cake samples were determined by using a texture analyzer (Imada FRTS Series, Japan) adopting the method described by Feili *et al.*, (2013). A cake sample with a height of 50 mm were submitted to two cycles of compression and compressed up to 20% of the original height using a 20-mm cylindrical probe, at a speed of 1.0 mm/s, a trigger force of 5 g, and a recovery period between compressions of 15s. The parameters measured were hardness and springiness.

2.6. Storage-stability

The microbial stability of the collected cake samples were analyzed according to the U.S. Bacteriological Analytical Manual (BAM, 1980). The total bacterial and fungal counts were analyzed every day for 7 days in a row using serial dilutions method. Nutrient agar and potato dextrose agar medium were used as media for bacterial and fungal analysis respectively.

2.6.1. Bacterial and fungal count

1 g of cake sample was homogenized in 10 ml distilled water. 0.85% NaCl solution was used to make serial dilutions. After reaching the desired concentration, 0.1 ml of the solution was spread on the surface of the Petri dish containing nutrient agar and potato dextrose medium for analyzing bacterial and fungi count respectively. Prepared nutrient agar and potato dextrose media were incubated at 37^{o}C and 25^{o}C for 7 days and all plates were examined every day for recording the bacterial and fungal growth respectively. The colonies were counted by using the Stuart scientific colony counter (Stuart: SC6 PLUS, UK). After counting the colonies, they are multiplied by the dilution factor to analyze the number of CFU/g in the cake sample (Bennet, 1984; Upasen and Wattanachai, 2018).

2.7. Statistical analysis

Data analysis was performed using Statistical Package for the Social Sciences (SPSS version 20.0 SPSS Inc. Chicago, Illinois, USA). Analysis of variance (ANOVA) was carried out for the determination of significant differences ($p < 0.05$) between the means. Microsoft Excel version 10.0 was used for graphic illustration.

3. Results and discussions

3.1. Composition of cake

The chemical composition of the cake samples is detailed in Table 2. The moisture content of the samples ranged from 16.05-24.81% with significantly highest ($p<0.05$) in S2 and lowest in S7 samples. These results are in agreement with the findings of Begum *et al.* (2016). The reported higher range of moisture content indicated that the cake samples might capture the atmospheric moisture because of improper packaging after baking or due to the hygroscopic properties of wheat flour (Bhat and Bath, 2013). The reported results of moisture content complied with the acceptable moisture range (14-25%) of Bangladesh Standard and Testing Institution (BSTI, 2006) but increased amount of moisture content may faster the spoilage of cake samples.

Table 2. Proximate composition of cake samples

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fiber (%)	Carbo-hydrate (%)	Calorie (Kcal/100g of dry matter)
S1	23.23±0.01^{b}	1.0±0.001^{a}	12.67±0.12^{ab}	6.98±0.16^{b}	0.1±0.00^{c}	56.12±0.42^{d}	366.43±0.77^{c}
S2	24.81±0.02^{a}	0.77±0.00^{c}	10.83±0.04^{b}	6.02±0.1^{d}	0.1±0.00^{c}	57.57±0.23^{cd}	351.85±0.16^{e}
S3	22.37±0.01^{bc}	1.09±0.001^{a}	10.47±0.07^{c}	7.0±0.17^{b}	0.2±0.01^{bc}	59.36±0.36^{b}	359.68±0.42^{d}
S4	19.15±0.01^{d}	0.90±0.003^{b}	15.93±0.12^{a}	6.71±0.11^{c}	0.2±0.02^{bc}	57.32±0.35^{cd}	399.48±0.76^{a}
S5	20.37±0.03^{c}	0.66±0.003^{d}	12.63±0.09^{ab}	7.72±0.06^{a}	0.3±0.01^{b}	58.72±0.26^{c}	378.51±0.46^{b}
S6	22.34±0.02^{bc}	0.76±0.003^{c}	10.63±0.12^{c}	6.21±0.07^{cd}	0.2±0.00^{bc}	60.06±0.31^{b}	360.74±0.70^{d}
S7	16.05±0.01^{e}	0.73±0.002^{c}	9.23±0.06^{d}	6.22±0.04^{cd}	0.4±0.03^{a}	67.77±0.16^{a}	379.03±0.35^{b}

Values are means ± SD of triplicate. Values with the different superscript in the same column are significantly different (p<0.05)

The index of mineral constituents of any food can be calculated from the ash content of that food. The ash content of the cake samples was recorded in the range of 0.66-1.09% with the highest value in S3 and lowest value in S5. Though the plain cakes contained an inferior amount of ash content, these findings are complied with the acceptable range of BSTI standards (BSTI, 2006). The fat content of the cake samples ranges from 9.23-15.93% where S4 cake samples recorded significantly higher ($p<0.05$) fat content than other samples and S7 had the lowest fat content. Thus, the highest fat content of S4 sample contributed to the highest calorie value (399.48 Kcal/100g) also. Protein content of the cake samples was found 6.02-7.72%. Lower protein content of plain cakes may be due to the usage of soft wheat flour for cake preparation which can impart softness to the final product (Al- Dmoor, 2013) or may be usage of smaller egg portions or no egg for final cake preparation. However baking operations could also denature the protein content of the raw materials used for cake production as it was studied that different unit operations including roasting, frying and baking could unfavorably minimize the food protein content (Swaminathan, 1986). Among different nutrient content the lowest value was recorded for fiber content of the cake samples. The inferior amount of fiber (<1.0%) was reported in the analysis with the highest content (0.4%) in S7. These might be due to the fact that the soluble fibers from the cake samples may be possibly leached out though the oils and stayed on the packaging materials of the cakes (Begum *et al.,* 2016). The carbohydrate content of the cake samples was in the range of 56.12-67.77% with the highest content in S7 and lowest in S1. Carbohydrate content of S7 cake samples were found significantly higher ($p<0.05$) than other samples. Final calorie values of all the cake samples ranged from 351.85 to 399.48 Kcal/100 g indicating the samples having highest fat content would contribute to the highest calorie value. On the basis of nutritional analysis regarding moisture, ash, fat, protein, carbohydrate and total calories of the seven different plain cakes revealed that some of them are good in quality whereas numbers of them are lacking in good quality. Thus it became very difficult to make any declaration that which one is best, rather the samples exhibited their superiority in different nutrient parameters over one another.

3.2. Physical properties

3.2.1 Weight, volume and specific volume of cake samples

Consumers desire high volume cakes; thus, volume is one of the most important physical qualities of cakes (Lebesi and Tzia, 2011). It is a significant quality indicator which correlates with the dough and textural properties of cake (Pomeranz, 1980). According to Table 3 among the cake samples, S5 was analyzed with highest volume and specific volume which is a clear indicator of entrapping more air or absorbing oil and may result in development of higher cake volume. Another fact is that higher cake volume would also result from lower batter density which is very common with sponge cake (Go´mez *et al.,* 2008). Whereas S1 cake samples found to have lowest values of volume and specific volume. It may be due to lower batter quality, lower capacity of entrapping larger air volumes, improper gelatinization of starch and losses of gas by different processing operations due to baking (Begum *et al.,* 2016). Low batter quality of S1 samples might be due to the low carbohydrate and fiber content of S1 cake samples (Table 2.) as lower amount of fiber and carbohydrate can lower the batter quality which results in lower volume (Lebesi and Tzia, 2012).

Table 3. Physical properties of cake samples

Samples	Sample weight (g)	Volume (cm^3)	Specific volume (ml/g)	Crumb Color		
				L*	a*	b*
S1	7.34	12.00	1.64	72.42 ± 0.75^c	-0.84 ± 0.07^a	24.19 ± 0.18^d
S2	6.52	14.00	2.15	77.11 ± 0.21^a	-1.79 ± 0.17^b	22.99 ± 0.30^e
S3	7.81	22.00	2.82	77.38 ± 0.25^a	-1.95 ± 0.07^b	22.90 ± 0.18^e
S4	9.62	24.96	2.60	76.14 ± 0.22^b	-1.78 ± 0.13^b	26.20 ± 0.28^b
S5	10.24	29.99	2.93	76.03 ± 0.59^b	-4.92 ± 0.03^c	35.94 ± 0.36^a
S6	10.77	17.99	1.67	76.93 ± 0.22^a	-1.21 ± 0.08^b	19.39 ± 0.05^f
S7	6.24	15.00	2.41	77.42 ± 0.30^a	-1.72 ± 0.05^b	25.21 ± 0.12^c

Color values are means ± SD of triplicate. Values with the different superscript in the column are significantly different (p<0.05)

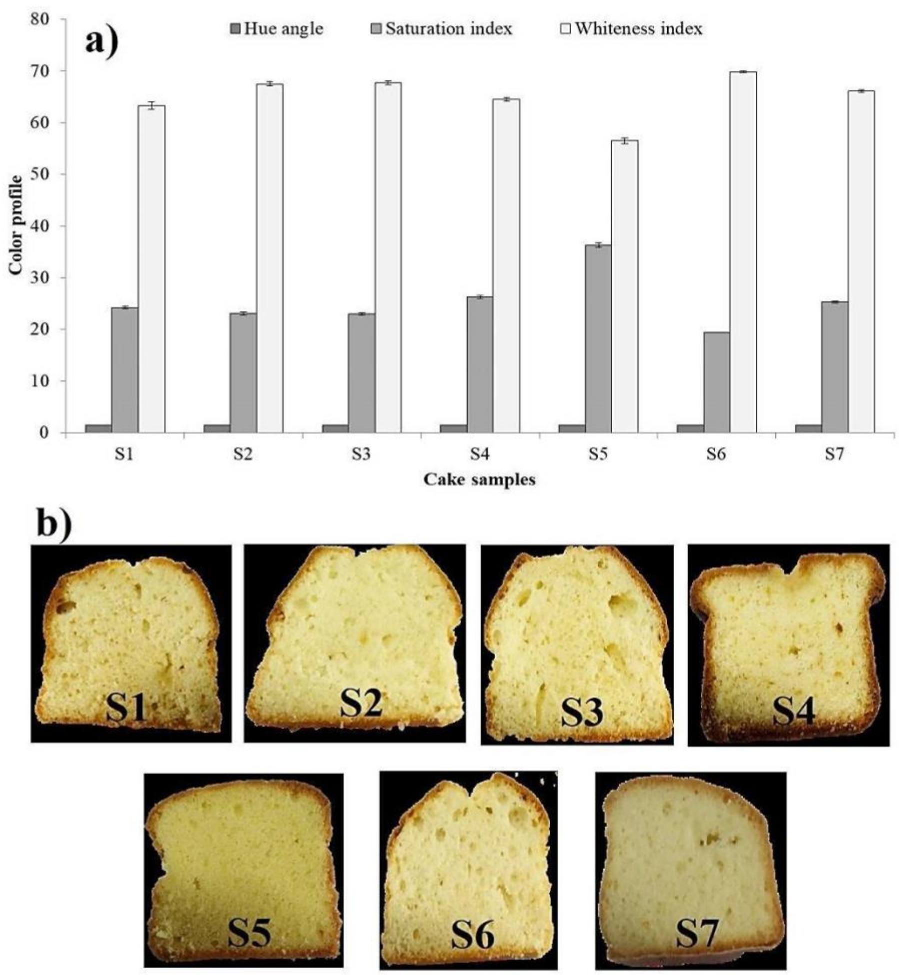

Figure 2. a) Color profiles of cake sample b) photographs of sliced cake samples

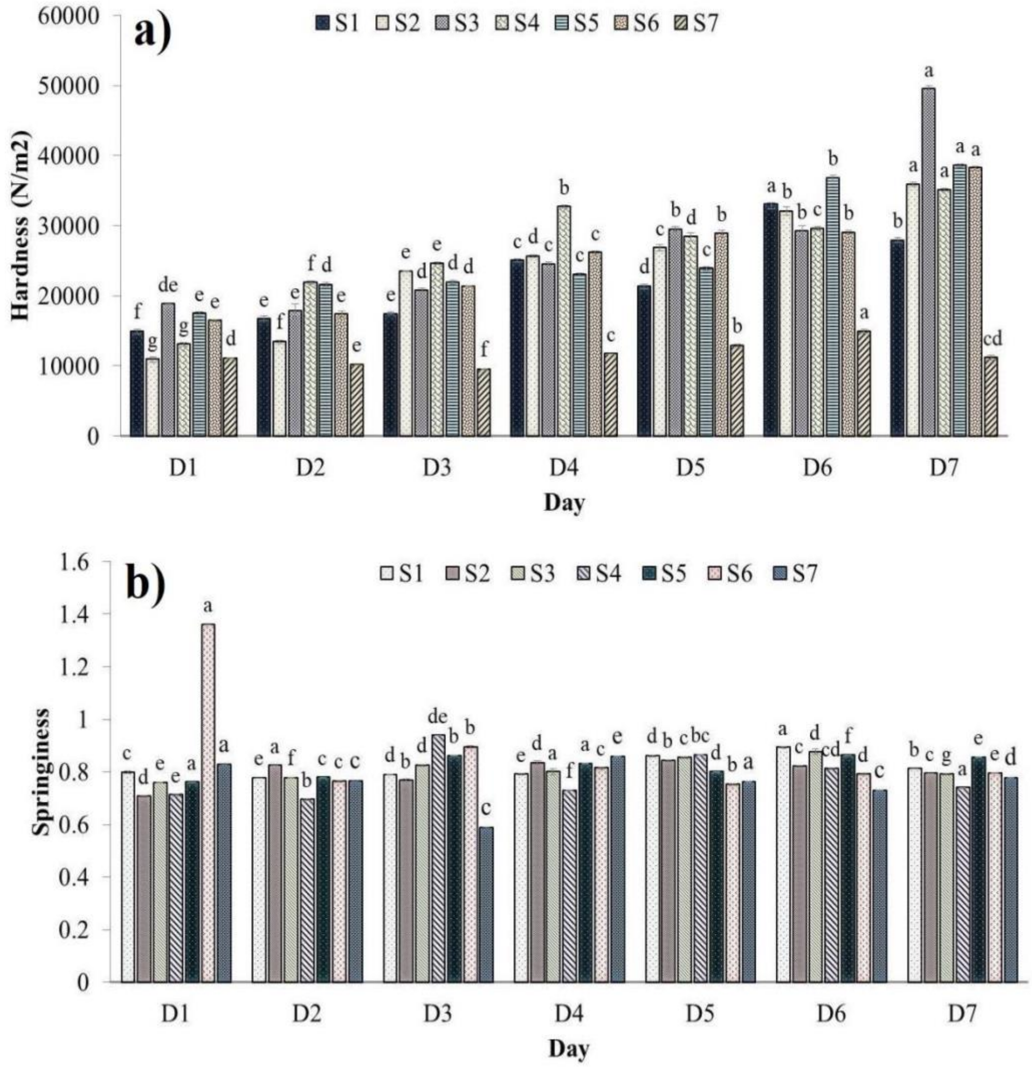

Figure 3. Textural stability of cake; a) Hardness, b) Springiness

3.2.2. Color indices of cake samples

Appearance is considered one of the primary criteria that a consumer usually considered during buying food (Kashim and Kashim, 2015). Among many other indices color has always been a key parameter in food choices, food preference and acceptability, and even effect taste thresholds, pleasantness and perception (Rico *et al.*, 2007).

Table 3 and Fig. 2 jointly showed the color profile of the cake crumb regarding L*, a*, b* value (Table 3) as well as hue angle, saturation index and whiteness index (Fig. 2). It reveals that highest lightness was observe for S7 cake sample whereas darker texture was observed in S1 sample with lowest L* value. No significant difference (p>0.05) was observed among the L* values of cake samples (except S1 sample). S5 cake sample was tend to be more yellowish in appearance than other cake samples with highest a* and b* value. The hue angle is another parameter frequently used to characterize color in food products (Barreiro *et al.,* 1997).

The lowest hue angle may also contributed to this yellowish appearance of S5 sample (Pathare *et al.*, 2012) whereas S1 sample was analyzed with highest hue angle and maximum b* value. Another parameter is the saturation index (SI) or chroma that indicates color saturation and is proportional to its intensity (Barreiro *et al.*, 1997). S5 cake samples showed higher color saturation than other samples. Whiteness index mathematically combines lightness and yellow–blue into a single term (Rodriguez-Aguilera *et al.*, 2011). Overall whiteness of the S6 cake samples showed higher value than other samples indicating the higher extent of discoloration during the baking process (Hsu *et al.*, 2003) with simultaneous lowest color saturation.

3.2.3. Textural properties of cake samples

The quality of bakery items degrades over time due to starch retrogradation, which leads to amylose recrystallization resulting in increased hardness (Hussain *et al.*, 2022). One of the key elements in improving the stiffness of the cake is the moisture migration from the crumbs to the surface (Huang *et al.*, 2020). Thus, in this study the cake quality was evaluated after the first and seven days of storage.

Fig. 3 showed the changes in textural properties of cake samples for seven days storage. It revealed that the hardness of the maximum cake samples (except S1 and S7) was gradually increased with storage time. Highest hardness was recorded in the 7^{th} day of storage and it was significantly different ($p<0.05$) from the initial values. This change was due to the loss of capability of the cake to entrap air that led to the loss of moisture (Schiraldi *et al.*, 1996). However, the increasing hardness of S1 and S7 was not found consistent. Bread-crumb hardness is generally lower in samples with increased moisture content (Hussain *et al.*, 2022). Thus cake samples having higher moisture percentage in the crumbs after 7 days of storage, less hardness might be predicted. Surprisingly, there was no evident link between the moisture content of the cake and its hardness. According to the springiness statistics, the S4 cake samples had the highest springiness values after 7 days of storage. In contrast, the S3 cake sample had the least-springy cake crumb after 7 days. Overall, the springiness of the cake was not affected as much as its hardness when the storage time was changed. Moreover, according to Fig. 3 the seven days of storage exhibited a significant increase in the hardness ($p<0.05$) whereas the springiness decreased.

3.3. Microbial stability of cake samples

The local bakery products which either were wrapped individually and then sealed manually by candle lights or were over-packed in large open or partially sealed poly-packs with more than few pieces together – that increases the chance of those local products to come in contact with airborne microbes, insects, dusts, and hot & humid environment of the vendors outside. This along with the poor post baking handling and storage conditions in the vendors themselves may be one of the major reasons for high microbial count observed in the local bread and cakes.

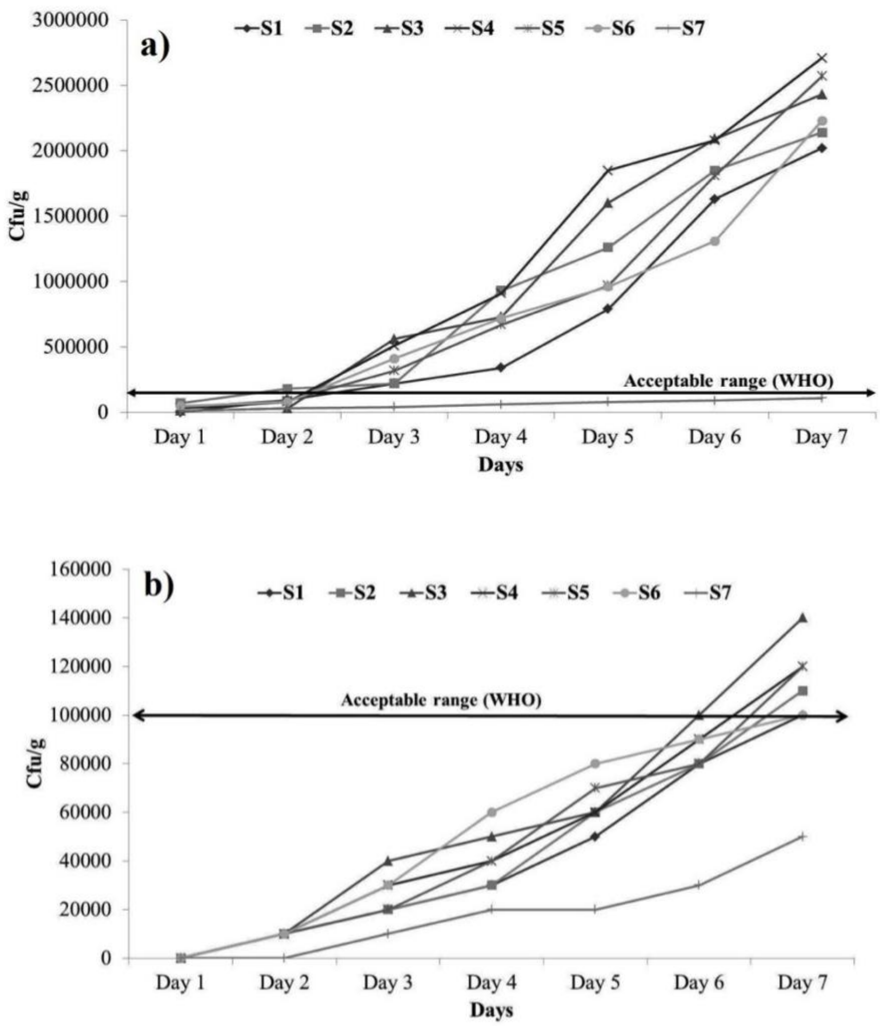

Figure 4. Microbial stability of cake samples; a) Total viable count (TVC), b) Total Fungal count (TFC)

The microbial stability as well as shelf life of bakery products like cake and bread largely depends on packaging materials, technology used, packaging condition and importantly post baking handling and storage conditions (Al-Fuad *et al.,* 2018). The cake samples were stored for seven days where the bacterial and fungal count were analyzed and recorded to assess their shelf.

Fig. 4. (a) revealed the total viable count of different cake samples from day 1 to day 7 at every 24 hours interval. Most of those cake samples contained higher TVC content than the acceptable range of TVC ($2.0x10^5$ cfu/g) suggested by WHO (WHO, 1994), just after the 2^{nd} day of storage. The findings are well in agreement with the TVC values of cake samples observed by Talukder *et al.* (2017). The exception was recorded for the S7 cake sample which was found to contain TVC within the WHO acceptable range even till the last day of analysis. The more stability of S7 cake samples might be due to the low moisture content (Table 2) than other samples. Moreover the packaging quality of this cake sample was comparatively better than others which might contribute to maintaining better microbial resistance. The other cake samples that did not comply with the WHO bacteriological standard just after 2^{nd} days of storage might be manufactured or stored in unhygienic condition or packaged inappropriately. Fig. 4. (b) also showed the total

fungal content (TFC) of the cake samples. At the initial period of analysis no fungal growth was observed for any cake samples. Except for the S7 sample the fungi started to grow just after the very first day. But the growth was limited and within the acceptable range ($1.0x10^5$ cfu/g) of WHO standards (WHO, 1994). At the end of the storage all the cake samples except S7 were reached to the maximum or beyond the limit of TFC suggested by WHO (1994). The cake samples of the current study were found considerably more fungal resistant than the analysis of Talukder *et al.* (2017) where most of the samples started to cross the acceptable range of TFC just after 3 days of storage. Considering both TVC and TFC it was clear and lucid that bacterial contamination may be more prominent in cake than fungal contamination and among the cake sample S7 showed superior microbial stability both in the case of bacterial and fungal contamination than other cake samples.

4. Conclusions

Although the locally produced cake samples showed minimum quality standards for consumption regarding different proximate parameters according to BSTI standards, for manufacturer, care must be taken in reducing moisture content and improving packaging quality to ensure better self-life and storage stability. As most of the cake samples had lower microbial and textural stability during seven days of storage, the storage condition in retail shops also needed to be improved for maintaining better wholesomeness and palatability.

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