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SHORT COMMUNICATION

Physico-sensory and Textural Properties of Composite Millet Palm Jaggery Muffins

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Abstract

Composite millet palm jaggery (CMPJ) muffins were prepared by replacing all-purpose flour with composite millet flour at different level (0:100, 50:50, 30:70) and replacing cane sugar completely with palm jaggery. CMPJ muffins and control muffins with cane sugar (APFS) were analyzed for Physico-sensory and textural properties (TPA). Incorporation of millet flour and wheat flour at the ratio 70:30 resulted in an acceptable product with good sponginess which is one of the desirable properties of muffins. The moisture content of muffins prepared with palm jaggery was found to be higher (21.84±0.01%) than muffins prepared with sugar (19.58 ±0.01%). The lightness of the crumb and crust (37.58±0.08, 28.89±0.11) of CMPJ muffins were found to be lesser than control muffins (58.34±0.20, 35.30±0.99), whereas redness of crumb and crust was found more in CMPJ muffins (9.18±0.07, 12.12±0.22) than APFS muffins (6.56±0.15, 10.61 ±0.15) which is due to the brown colour of palm jaggery. The muffins with jaggery had lower pH and sensory score and higher water activity (aw) than muffins with sugar. TPA results showed that CMPJ (6270±7.2 g) were slightly harder than APFS (4729±4.7). Microbial analysis (Total plate count, Yeast and mold count) for CMPJ muffins was found to be safe for consumption upto 12 days without added preservative. It is concluded that CMPJ muffins (without preservative) can be an alternative to APFS without affecting the quality parameters of the product.

Keywords: All Purpose Flour, All Purpose Flour Sugar Muffins (APFS), Cane Sugar, Composite Millet Flour, Composite Millet Palm Jaggery Muffins (CMPJ), Palm Jaggery

1. Introduction

Millets is one of the 6th cereal crops in terms of world agriculture production, grown under drought condition compare to major cereals. It has resistance to pest and diseases, short growing season and productivity[1]. Millets serve as a major food component and various traditional food and beverages such as bread, porridges and snack foods are made up of millets. Millets are small-seeded with different varieties such as pearl millet (*Pennisetumglaucum* L.), finger millet (*Eleusinecoracana* L.), kodo millet (*Paspalumsetaceum* L.), proso millet (*Penicummiliaceum* L.), foxtail millet (*Setariaitalic* L.) and little millet (*Panicumsumatrense* L.). In addition to nutritive value, millets are having several health benefits viz., preventing cancer and cardiovascular diseases, reducing tumor incidence, lowering blood pressure, reducing risk of heart diseases, cholesterol, rate of fate absorption and also in delaying in gastric emptying. Therefore, millet grains are now receiving specific attention from these developing countries in terms of utilization as food as well as from some developed countries in terms of its good potential in the manufacturing of bioethanol and biofilms[2].

Palm jaggery is traditional, non-centrifugal palm sugar consumed in Asia, Africa and in some countries in the America. It is a concentrated product of palm sap without separation of the molasses and crystals can vary from golden brown to dark brown in colour. It has an intense, reminisced chocolate taste. The colour of palm jaggery after processing turns dark brown and is highly priced due to its medicinal properties. Palm jaggery is most popular in southern India states viz Tamil Nadu

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(*Karupatti, vellamorpanavellam*), Karnataka (*thaatibella*), Kerala and Andhra Pradesh[3]. Palm jaggery contains 90.60% carbohydrate and also it is one of the richest source of iron (2.5mg/gm), thiamin (24mg/100gm) and riboflavin (432mg/100gm).

Bakery products with incorporation of nutritional component are an important part of balancing our diet since thousands of years. The aim of this study is to develop the millet based muffins with palm jaggery as a natural sweetener without addition of preservative.

2. Materials and Methods

2.1 Materials

Commercial all-purpose flour, composite millet flour (kodo, proso, foxtail, little, barnyard, finger millets), palm jaggery, cane sugar, butter and milk were purchased from local market. Vanillaessesnce (BushBoake Allen Ltd., Chennai, India), plate count agar, E. coli agar, potato dextrose agar media were purchased from HiMedia Mumbai, India. All the other chemicals were procured from Merck, Mumbai.

2.2 Muffins Formulation and Processing Conditions

Muffins with the ingredients (Table 1) were prepared according to the method[4,5]. All-purpose flour, composite millet flour, baking powder, salt and powdered sugar were sieved separately thrice for uniform mixing. Palm jaggery was used in the form of a solution by diluting with water in the ratio of 1: 1. Butter and powdered sugar/palm jaggery were mixed using Sinmag planetary mixer (model no: SM- 5L) for 3 min at 120 rpm to get a uniform mixture. Simultaneously, egg white, egg yolk and essence were whipped at 170 rpm for 5 min. The whipped egg mixture was mixed with cream in four parts to avoid curdling of cream. It was then mixed with all-purpose flour and composite millet flour at 120 rpm for 1 min to get a homogeneous mix. Cake batter was transferred into cake pan, baked at 180^0C for 25 min in a OTG oven (Sinmag). The muffins were prepared with various formulations denoted as A, B, C, D, E and F respectively. After baking, the muffins were allowed to cool at room temperature and packed with air polythene pouches and stored at an ambient temperature. The muffins were subjected to physico-chemical, textural and sensory analysis during storage.

2.3 Storage of Muffins

CMPJ muffins and APFS muffins (control sample) were packed in polythene pouches and shelf life studies were conducted. Muffins were stored at room temperature (30 ± 2^0C) for 16 days. The samples were analyzed for colour, water activity, pH, texture, titratable acidity, microbial analysis, sensory evaluation at an interval of 4 days upto the storage period.

3. Methods

Muffins were analysed for physico- chemical parameters for muffins such as pH, colour, volume according to the standard procedures[6]. Colour (crust and crumb) of the muffins were evaluated using Hunter Lab Colour measuring system (Labscan XE system, Reston, USA) and water activity of the product was analyzed using AquaLab

Table 1. Formulations prepare at different level with composite millet flour, all purpose flour and palm jaggery

Ingredient (g)	Composition of all purpose flour with CMF and palm jaggery					
	A	B	C	D	E	F
All purpose flour	100	100	100	-	50	30
Composite millet flour	-	-	-	100	50	70
sugar	100	-	-	-	-	-
palm jaggery		100	150	150	150	150
Butter	65	65	65	65	65	65
Egg white	62	62	62	62	62	62
Egg yolk	30	30	30	30	30	30
Baking powder	1.7	1.7	1.7	1.7	1.7	1.7
Vanilla essence(ml)	1.5	1.5	1.5	1.5	1.5	1.5
Milk (ml)	25	25	25	25	25	25

Bold values are variations of palm jaggery, composite millet flour and all-purpose flour

Pre water activity meter. The pH of muffin samples was measured by using a pH meter (Eutech Instruments pH 510, Ayer Rajah Crescent, Singapore) by dissolving 10 g of sample with 10 ml of distilled water and readings were noted.

3.1 Volume of Muffins

Volume of muffins was determined by using rapeseed displacement. An empty pan was filled with rapeseed and the volume of the pan was observed on the basis of rapeseed volume by graduated cylinder(A_1). Thereafter muffins were placed in the pan. The rest of the volume was filled by rapeseed and the volume of rapeseed was calculated by graduated cylinder (B_2). Muffin volume was determining by A_1- B_2.

3.2 Colour of Muffins

The colour analysis of crust and crumb of the muffins were done using Hunter Lab Colour measuring system (Labscan XE system, Reston, USA). The colour measurement of muffins sample were performed through 6.4 mm diameter of diaphragm containing an optical glass which is placed on the sample holder and reflectance was auto-recorded for the wavelength ranging from 360-800 nm. The parameter determined were L, a, b[8]. Each value represents the means of triplicate readings.

3.3 Texture Profile Analysis

The texture analysis of CMPJ muffin and cane sugar muffin was carried out by using Texture profile analyser-(TPA), (Model TA-XT. plus, Stable Micro Systems, Godalming, UK). Measurement was conducted using a 50kg load cell and cylindrical aluminum probe 36mm diameter. Maximum force required for 25% compression of the muffins were recorded. The results recorded were as an average of three replicates. The texture determination was carried out after removing the crust from the muffin surface. Hardness of the muffins was analyzed.

3.4 Sensory Evaluation of Muffins

Sensory evaluation of muffins was carried out using 9 Point Hedonic scaleby 14 trained panelist (Professors and students, Department of Food Technology, BIT, Tamil Nadu) at 4 days' interval after production. Each panelist was provided with the muffins sample with a randomized code. Sensory evaluation was done at room temperature in between the hours of 10.00 to 11.00 am and the test was conducted under day light illumination. Normal water and mouth refreshing sample (puffed rice) were served in between samples to eliminate the residual test of the previous sample.

3.5 Microbial Analysis of Muffins

Microbial analysis of muffins was done during storage study at 4 days' interval. Total plate count (TPC), Yeast and mold count (Y&M) was done using nutrient agar and potato dextrose agar respectively[9]. The microbial analysis of muffins was carried out using serial dilution agar plate technique, 1g of muffin sample was suspended and agitated in 9ml of water blank (to make volume upto 10ml) to form microbial suspension. Subsequently, samples were diluted decimally and 0.1ml aliquots were inoculated on TPC and Y&M respectively.

3.6 Statistical Analysis

Statistical analysis of all the experiments was carried out in triplicates and analyzed statistically with different experimental group using Duncan's news multiple range test (DMRT) statistica software version 7.0 of Stat Soft Incorporation, Tulsa, OK, USA as per the method[10]. The significance level was established at $p < 0.05$.

4. Results and Discussion

4.1 Optimization of Formulations for Muffins

The composite millet flour used for the study had 10.36% moisture, 11.16% protein, 1.12% fat, 0.86% ash and 0.41% total sugars. The sugar and jaggery powder was found to possess 0.82% and 6.88% moisture, ash (0.18 and 0.74%) and total sugar (96 and 70.13%). These results showed jaggery is rich in minerals. The moisture and total sugar content of jaggery are within the specified limit[11].

The quality characteristics of muffins with sugar and palm jaggery are furnished in Table 2. There is not much variation in weight of muffins (30-35g) with different percentage of composite millet flour, all-purpose flour and palm jaggery which reveals the processing and baking conditions are uniform throughout the experiments. Volume of sample B and C is less compared to sample A which may be due to the replacement of palm jaggery which hinders the raising of the muffins during baking. The volume of muffins, not only depends on the incorporation of air inside the batter but also depends on the capacity of the batter to retain air during baking[12]. Effect of formulated composite millet flour and all-purpose flour with palm jaggery has been evaluated for sensory evaluation (using 9-point hedonic scale). During the sensory analysis, colour of crumb and crust of muffins,

texture, sweetness and overall acceptability parameters were evaluated. From Table. 2, it is observed that Sample A, ie., control muffins prepared using all-purpose flour with cane sugar was preferred by maximum number of panelists. Sample B and C of CMPJ muffins formulated with 100g and 150g of palm jaggery were evaluated for the equivalent sweetness level of CMPJ muffins with APFS muffins. Sample C (150g) was preferred by the panelists who provided equivalent sweetness to cane sugar muffins. Samples, D, E, F contain ratio of composite millet flour: all-purpose flour in proportion to 100:00, 50:50, 70:30 respectively. The sample D tasted floury during eating and also the sample was more hard. Sample E and F provided equivalent OQS which equal to Sample A. Sample F, with the ratio of composite millet flour: all-purpose flourat 70:30, was optimized due to its nutritional importance. On the basis of composite millet flour's nutritional value, we optimized sample F, ratio of its composite millet flour: all-purpose flour (70:30) for further storage study.

Texture profile analysis was carried out for all the formulated muffins. It is observed that the softness of APFS muffins is highest compared to CMPJ muffins. The hardness of all the formulations significantly differ from each other, which is a clear indication that hardness of the muffins depends on the composition as well as the ingredients used for making muffins. The hardness of Sample A is 4729g which is the control sample. Hardness of sample B and C is 4699g and 2436g respectively. From sample B and C, we conclude that Sample C is softer than sample B because of the concentration of palm jaggery. Sample D is having a hardness of 8174g because of its 100% composite flour which doesn't have elasticity which may be due to the absence of gluten which is one of the important ingredient for the bakery products. Replacement of 50% all-purpose flour with 50% composite millet flour reduces the hardness to 6274g. Further replacement of 70% all-purpose flour, though the muffins possess the hardness of 6295g, there is no significant difference in OQS between Samples E and F. Hence, the formulation with the replacement of 70% all-purpose flour with composite millet flour was chosen for further shelf life studies.

4.2 Quality Characteristics of Muffins

Physico-chemical and sensory evaluation of muffins were carried out for both APFS muffins and CMPJ muffins during the storage period. The moisture content of APFS muffins was lesser (19.58%) compared to palm jaggery muffins sample (21.84%) which is due to the presence of higher invert sugar and hygroscopic nature of palm jaggery[13]. As expected, ash content is more in palm jaggery muffins (1.32%) compared to sugar based muffins

Table 2. Effect of CMF and palm jaggery composition on quality of muffins

Sample code	Crust colour			Crumb colour			Hardness (gm)	Volume(ml)	OQS
	L	a	b	L	a	b			
A	$35.30^{bc} \pm 0.99$	$10.60^{c} \pm 0.15$	$12.71^{e} \pm 0.39$	$58.34^{a} \pm 0.20$	$6.56^{e} \pm 0.15$	$14.69^{f} \pm 0.08$	$4729^{a} \pm 4.7$	$130^{c} \pm 0.36$	$8.91^{a} \pm 0.10$
B	$38.36^{a} \pm 0.36$	$9.63^{e} \pm 0.09$	$13.41^{d} \pm 0.13$	$54.13^{b} \pm 0.01$	$7.5^{d} \pm 0.19$	$17.76^{e} \pm 0.67$	$4699^{b} \pm 5.9$	$120^{d} \pm 0.28$	$5.75^{d} \pm 0.23$
C	$37.81^{a} \pm 0.36$	$10.06^{d} \pm 0.01$	$17.02^{a} \pm 0.02$	$55.23^{c} \pm 0.01$	$8.95^{c} \pm 0.03$	$20.41^{d} \pm 0.16$	$2436^{f} \pm 6.7$	$120^{e} \pm 0.10$	$6.83^{c} \pm 0.35$
D	$34.32^{c} \pm 0.12$	$10.52^{c} \pm 0.04$	$17.35^{a} \pm 0.03$	$47.6^{d} \pm 0.05$	$9.98^{a} \pm 0.01$	$19.6^{c} \pm 0.5$	$8174^{a} \pm 5.8$	$134^{b} \pm 0.11$	$6.03^{d} \pm 0.10$
E	$36.39^{b} \pm 0.95$	$10.88^{b} \pm 0.01$	$14.46^{c} \pm 0.17$	$42.42^{e} \pm 0.05$	$9.86^{a} \pm 0.01$	$22.98^{b} \pm 0.51$	$6274^{a} \pm 5.0$	$134^{b} \pm 0.10$	$8.48^{ab} \pm 0.27$
F	$28.89^{d} \pm 0.11$	$12.11^{a} \pm 0.22$	$16.01^{b} \pm 0.09$	$37.57^{f} \pm 0.08$	$9.94^{b} \pm 0.18$	$24.18^{a} \pm 0.20$	$6295^{b} \pm 5.6$	$139^{a} \pm 0.20$	$8.48^{ab} \pm 0.21$

Results are given as the mean value ± standard deviation. Values having different superscripts in the same column are statistically different ($p < 0.05$).

(0.85%). The protein and fat content of palm jaggery muffins are slightly lesser (6.89% and 30.24%) than muffins with sugar (6.98% and 34.56%). The sugar content in CMPJ muffins was found to be 26.41%, which is lower than the APFS muffins (33.21%). Jaggery is a good source of iron, calcium, phosphorous and contains less amount of sucrose than cane sugar which is the cause of higher ash content and lesser sugar content of CMPJ muffins than APFS muffins[14].

4.3 Effect of Storage on the Quality of Muffins

Effect of storage on various quality parameter during the storage study was evaluated for CMPJ muffins for 16 days and compared with sugar muffins and the results are presented in Table 3.

The water activity of CMPJ and cane sugar muffins was increased from 0.70 to 0.88 and 0.71 to 0.80 respectively (Figure 1). CMPJ muffins have higher water activity (aw) compared to cane sugar muffins. Similar result was observed for water activity of muffins prepared using various fiber and natural sweetener Stevia by replacement of cane sugar[15]. The pH activity of CMPJ muffins and cane sugar muffins was observed to decrease slightly during storage from 7.81 to 7.6 and 7.12 to 7.10 respectively. Decrease in water activity and pH of muffins were found to be similar as reported[16]. Titratable acidity of palm jaggery muffins during storage was observed to increase after 4 days, while it reduced in case of APFS muffins at the end of storage period.

From Table 3, it is observed that the CMPJ muffins showed higher moisture content when compared to cane sugar muffins initially as well as during storage period of 16 days. The moisture content decreased extensively in muffins from 0 to 16 days of storage period. It is observed that the moisture content of CMPJ and APFS muffins sample reduced upto 8th day and slightly increased on 12th and 16th days. Reduction in moisture can be attributed to retrogradiation and staling. CMPJ muffins and cane sugar based muffins showed similar reduction in moisture during storage upto 8th day.

Colour analysis of crust and crumb of CMPJ and APFS muffins was done during storage study. The change in colour (Lab value) values of crust and crumb of both muffin samples was very less different during 16 days of storage period. TPA of muffins was analysed during storage for hardness compared to that of sugar muffin sample. Initially, the hardness of CMPJ muffins was found to be more than the control muffin sample, 6270g and 4729 g respectively. The hardness of CMPJ and APFS muffins were increased during storage upto 8 days 13947g

Table 2. Effect of storage on physico-sensory and textural characteristics of CMPJ muffins

Sample code	Days	Crust colour			Crumb colour			Hardness (gm)	Moisture (%)	OQS
		L	a	b	L	a	b			
Sugar muffins (Control)	0	$35.30^{c} \pm 0.99$	$10.61^{b} \pm 0.15$	$12.72^{a} \pm 0.39$	$58.34^{b} \pm 0.20$	$6.56^{b} \pm 0.15$	$14.69^{bc} \pm 0.08$	$4729^{a} \pm 4.7$	$19.58^{a} \pm 0.01$	$8.66^{a} \pm 0.30$
	4	$36.16^{b} \pm 0.59$	$10.62^{b} \pm 0.32$	$12.73^{a} \pm 0.07$	$58.32^{b} \pm 0.32$	$6.59^{b} \pm 0.15$	$14.76^{bc} \pm 0.27$	$5354^{a} \pm 7.3$	$19.22^{c} \pm 0.01$	$8.63^{a} \pm 0.32$
	8	$36.22^{b} \pm 0.08$	$10.67^{b} \pm 0.52$	$12.73^{a} \pm 0.16$	$58.32^{b} \pm 0.45$	$6.53^{b} \pm 0.26$	$14.79^{b} \pm 0.2$	$6534^{a} \pm 5.8$	$18.82^{d} \pm 0.02$	$8.33^{a} \pm 0.11$
	12	$36.35^{b} \pm 0.54$	$10.74^{b} \pm 0.37$	$12.75^{a} \pm 0.20$	$58.83^{ac} \pm 0.48$	$6.70^{b} \pm 0.38$	$14.83^{a} \pm 0.14$	$4189^{a} \pm 7.5$	$19.16^{c} \pm 0.05$	$7.90^{a} \pm 0.10$
	16	$36.72^{a} \pm 0.68$	$10.82^{a} \pm 0.37$	$12.77^{a} \pm 0.11$	$58.95^{ac} \pm 0.46$	$6.88^{a} \pm 0.42$	$14.84^{a} \pm 0.14$	$3972^{a} \pm 6.5$	$19.32^{b} \pm 0.01$	$6.51^{ab} \pm 0.52$
CMPJ muffins	0	$28.89^{b} \pm 0.11$	$12.12^{b} \pm 0.22$	$16.02^{d} \pm 0.09$	$37.58^{b} \pm 0.08$	$9.18^{a} \pm 0.07$	$24.18^{b} \pm 0.2$	$6295^{a} \pm 5.6$	$21.84^{a} \pm 0.01$	$8.43^{a} \pm 0.20$
	4	$29.32^{a} \pm 0.60$	$12.15^{b} \pm 0.07$	$16.16^{c} \pm 0.06$	$37.61^{b} \pm 0.37$	$9.21^{a} \pm 0.09$	$24.22^{b} \pm 0.14$	$8305^{a} \pm 4.5$	$21.12^{c} \pm 0.06$	$8.40^{ab} \pm 0.20$
	8	$29.35^{a} \pm 0.73$	$12.18^{b} \pm 0.07$	$16.27^{abc} \pm 0.07$	$37.73^{b} \pm 0.43$	$9.22^{a} \pm 0.10$	$24.27^{a} \pm 0.09$	$13947^{a} \pm 6.6$	$20.92^{d} \pm 0.03$	$8.16^{ab} \pm 0.15$
	12	$29.42^{a} \pm 0.39$	$12.20^{a} \pm 0.10$	$16.32^{ab} \pm 0.04$	$38.19^{ac} \pm 0.04$	$9.22^{a} \pm 0.10$	$24.35^{ac} \pm 0.09$	$13466^{b} \pm 5.1$	$21.16^{c} \pm 0.06$	$7.63^{c} \pm 0.32$
	16	$29.45^{a} \pm 0.59$	$12.21^{a} \pm 0.09$	$16.33^{a} \pm 0.08$	$38.19^{ac} \pm 0.56$	$9.23^{a} \pm 0.10$	$24.39^{ac} \pm 0.10$	$13452^{c} \pm 5.8$	$21.63^{b} \pm 0.01$	$3.31^{d} \pm 0.30$

Results are given as the mean value ± standard deviation. Values having different superscripts in the same column are statistically different ($p < 0.05$).

and 6534g and reduced on 12th and 16th day upto 13452g and 3972g owing to oxidation as well as microbial growth which softens the muffins. The overall acceptability of both the muffin samples was evaluated and found that the overall acceptability of muffin samples was good upto 8 days.

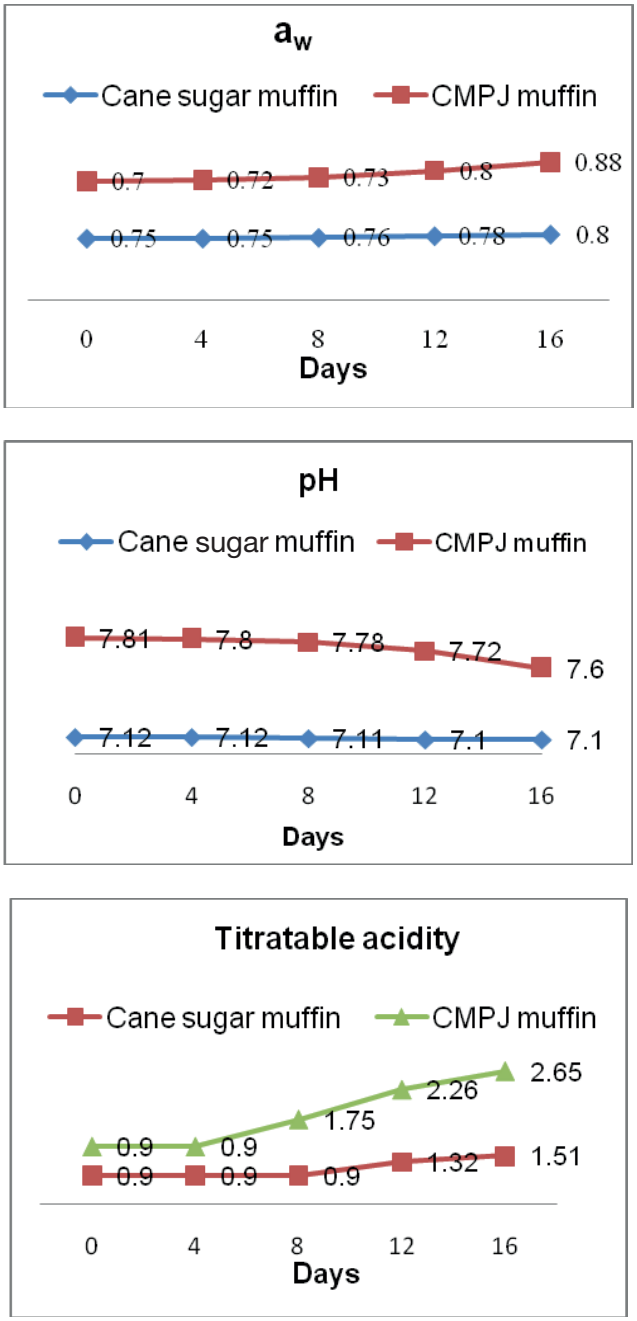

Figure 1. Effect of storage period on water activity (aw), pH and Titrable acidity of CMPJ and cane sugar muffins.

4.4 Microbial Quality of Muffins During Storage

The microbial analysis of muffins was performed during storage studies at room temperature 30±2°C for 16 days. The microbial analysis of muffin samples was performed for TPC and Y&M. During the storage study, *E.coli* and *Salmonella* were not detected in both the muffin samples. The count as well as the proliferation of TPC and Y &M was more in CMPJ muffins compared to APFS muffins. The TPC count was in the range of 2.3 to 3.87 (log CFU/g) and Y & M was in the range of 2.15 to 2.89 log CFU/g with increase in storage period from 0 to 8 days.

Total aerobic microbial count was lower than 4 log CFU/g as specified for bakery product by UK Sodexo Standards and Yeast & Mold was lower than 3 log CFU/g as recommended by Woolworth quality assurance standards Guidelines[17]. With the recommended limits, CMPJ muffins sample is safe for consumption upto 8 days because on 12th and 16th days, the Y& M growth of CMPJ muffins (3.87 log CFU/g) and TPC (4.32 log CFU/g) exceeded the recommended limit and hence the shelf-life is concluded as 8 days.

5. Conclusion

Composite millet flour based muffins with palm jaggery as a natural sweetener was optimized using different formulation of composite millet flour: all purpose flour (100:0, 50:50, 70:30) and Palm jaggery (100g and 150g). From physico-sensorial properties, it is observed that the composite millet flour: all-purpose flour at the ratio of 70:30 with 150g palm jaggery provided equivalent sweetness and overall acceptability. The CMPJ muffins showed lower pH and increase in titratable acidity. CMPJ muffins had higher moisture content, ash, protein and carbohydrate as compared to APFS muffins. CMPJ muffins showed lower value for lightness, higher value for redness and yellowness compared to cane sugar muffins. TPA and OQS was analyzed during the 16 days storage. Microbial analysis of muffin sample was carried out for TPC and Y&M and it was observed that the product was acceptable for consumption upto 8 days without addition of any preservatives.

6. References

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