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Modernisation and shelf life extension of chhana-based traditional sweetmeat by utilising *Theobroma cacao*, *Vaccinia oxycoccos* and different fruit powders

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India is pre-eminent in milk production and according to the estimates of the dairy industry, 50% of the comprehensive milk produced in India is processed into traditional milk products like ghee, paneer, khoa, chhana, dahi and a diverse range of milk sweetmeats. Chhana and chhana-based confections like rasogolla, ras-malai, cham-cham, etc. are highly perishable and limited research efforts have been made to increase their shelf life, resulting in a waning of dairy output in terms of value addition. So, the plenary investigation was based on the development of an improved confection utilising chhana and fruit powders as core materials, *Theobroma cacao* (dark chocolate) as a coating of core material, and *Vaccinia oxycoccos* (cranberry extract) as a natural preservative in the core material. Storage studies were performed on four different formulations marked as control, T1, T2 and T3 (described in the material/methodology section) at a storage interval of 10 days up to day 40 of refrigeration preservation. Total phenolic counts, flavonoid counts, pH and water activity of all the formulations exhibited a substantial decrease, while TBA values, TPC and YMC increased significantly with the advancement of storage interval. All the samples got the microbial counts (TPC and YMC) above the permissible limit between 30 and 40 days of storage, indicating a shelf life of 30 days versus the few days of shelf life of traditional chhana-based confections.

Keywords: Chhana delights, Cranberry extract, Dark chocolate, Storage study

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In concordance with the estimates of Basic Animal Husbandry Statistics (2019)[1], India's milk production stands at 187.75 million tonnes with a compound annual growth rate of 6.5%. Almost half of the country's milk production is diverged to the sector of value addition. Nevertheless, production is highly unorganised, owing to limited shelf life and incompetent packaging of value-added dairy products.

Chhana is one of the value-added dairy products in India, obtained by coagulating hot milk with citric acid. Chhana and chhana-based confections (rasogolla, ras-malai, and cham-cham) are highly perishable and susceptible to surface microbial growth, limiting their shelf life to a few days at refrigeration temperature[2]. An attempt was therefore made to utilise natural ingredients like *Theobroma cacao* and *Vaccinia oxycoccos* for the preparation of chhana-based confections with improved shelf life. *Theobroma cacao* is a potent reservoir of polyphenolics, including catechin, epicatechin and procyanidins[3]. Similarly, *Vaccinia oxycoccos* is a remarkable source of polyphenols, which are consumed as dietary supplements due to its anti-microbial, anti-cancer, and anti-oxidative properties[4]. As a result, a new chhana confection was designed by utlising chhana as the core material, milk powder as the binding material, fruit powders (mango, grape, and pineapple) as flavour enhancers, *Vaccinia oxycoccos* as an antioxidant source and *Theobroma cacao* as the core material's coating. Its storage stability was analysed at refrigeration temperature (4±1°C) in the laboratory of the Division of Livestock Products Technology, SKUAST-Jammu.

Materials and Methods

Source of materials

Cow milk was procured from the dairy farm of SKUAST-Jammu University and standardised to

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4.5% fat and 8.5% SNF as per the Pearson calculation. Crystalline sugar and whole milk powder were procured from the retail market of R. S. Pura. Fruit powders (mango, pineapple and grape) manufactured by Sri Nuthatch Nutricare Technologies Pvt. Ltd., Bengaluru**,** *Vaccinia oxycoccos* (cranberry extract) and *Theobroma cacao* (dark chocolate) manufactured by Bunge India Private Ltd., New Delhi, were obtained via e-marketplace.

Methodology used for preparation of chhana-based confection:

Preparation of chhana

The methodology by Bhattacharya *et al.* (1971)[5] was followed for chhana preparation**.**

Standardised milk (Fat content = 4.5%)
Heated (82°C/ 5 min)
Cooled (70°C)
Acid coagulated (citric acid-1%)
Stirred continuously until curd and clear whey separated
Whey was drained out through a muslin cloth
The coagulum so obtained was collected as chhana

Preparation of chhana balls

All four formulations were standardised on the basis of organoleptic evaluation as per the standard method followed by Pavon *et al.*[6].

Control formulation- Chhana (95 g) + Milk powder (5 g) + *Theobroma cacao* (40 g)

T1- Chhana (91 g) + Milk powder (5 g) + Mango powder (4 g) + *Vaccinia oxycoccos* (1 mL) + *Theobroma cacao* (40 g)

T2- Chhana (91 g) + Milk powder (5 g) + Grape powder (4 g) + *Vaccinia oxycoccos* (1 mL) + *Theobroma cacao* (40 g)

T3- Chhana (91 g) + Milk powder (5 g) + Pineapple powder (4 g) + *Vaccinia oxycoccos* (1 mL) + *Theobroma cacao* (40 g)

The standardised formulations were manually worked for 5-10 min to get smooth, dough-like texture. As shown in Figure 1, chhana dough was moulded into small balls of approximately 12 g in weight by rolling between the palms.

Cooking and coating of chhana balls

On the basis of organoleptic evaluation[6], a sugar solution of 50°Bx strength and a cooking time of 10 min were preferred for the cooking of chhana balls. Sugar syrup was brought to a boil and all four formulations were cooked turn by turn at a simmering temperature to avoid scorching of the chhana balls. As shown in Figure 1, cooked chhana balls were left to cool aside and coated with *T. cacao* using silicon moulds.

Storage and analysis

T. cacao-coated chhana confections were wrapped in aluminium foil and kept in LDPE pouches at a refrigeration temperature of 4±1°C. Storage studies were performed at day 0, 10, 20, 30 and 40 as per the protocols followed by Kaur *et al.*, (2021)[7].

Analytical procedures

The pH of the confection was estimated as per the standard procedure of Keller *et al.*[8]. The Aqua Lab (Model Series 3 TE, Decagon Devices, USA) was used to measure water activity (aw) in the Department of Food Science and Technology at SKUAST-Jammu. Total phenolic and flavonoid contents were estimated as per the spectrophotometric methods by Singleton *et al.*[9] and Quettier *et al.*[10], respectively. The thiobarbituric acid reacting substances (TBARS) value was determined following the method by Witte *et al.*[11]. Total plate count and yeast mould count were determined as per the methods by APHA (1984)[12]. Sensory evaluation was performed for sensory attributes like colour and appearance, texture, aroma, flavour and overall acceptability as per the standard procedure by Pavon *et al.*[6] using a 9-point hedonic scale and statistical analysis was done using the software statistical package for social sciences (SPSS 16.0) as per Snedecor and Cochran[13].

Fig. 1 — Preparation of chhana confection

Result and Discussion

Physico-chemical changes

Changes in physicochemical parameters like pH, water activity, TBARS, total phenolics and flavonoids are summarised in Table 1. A substantial decrease ($p<0.05$) was observed in the pH of control samples from day 0 to 40, in the case of T1 from day 20 to 40, whereas for T2 and T3, a decreasing trend was recorded on day 30 and 40. Rajakumar[14] also witnessed a significant ($p<0.05$) abatement in pH of paneer samples ahead of the 18th week at a refrigeration temperature of 7°C. Similar variations have also been noticed by Sreenivas *et al.*[15] in low-calorie herbal basundi during refrigerated storage. Neha *et al.*[16] also revealed a substantial ($p<0.05$) fall in pH of gluten-free gulab-jamun during refrigeration storage. According to Sindhav[17], progressive increases in microbial counts during storage of milk products resulted in glycolytic changes responsible for the breakdown of lactose, sucrose and minor carbohydrates. Yet, the average pH values of all the variants were significantly ($p<0.05$) lower relative to the control sample, approximately all the days of storage. This might be due to the addition of *Vaccinia oxycoccos* having an acidic pH as stated by Conner and Beuchat[18].

Water activity of control samples as well as T3 decreased substantially ($p<0.05$) ahead of day 20. As for T1 and T2, a substantial ($p<0.05$) decrease was witnessed on days 30 and 40. Accordingly, other scientists also found a significant ($p<0.05$) decrease in the water activity of gluten-free gulab-jamun and

Table 1 — Physico-chemical changes at refrigeration temperature (4±1°C)

pH					
Treatments	0	10	20	30	40
Control	6.67±0.033 ^{aA}	6.33±0.091 ^{aB}	6.20±0.037 ^{aB}	6.07±0.041 ^{aC}	5.80±0.085 ^{aD}
T1	5.96±0.071 ^{bA}	5.83±0.076 ^{bAB}	5.75±0.063 ^{bB}	5.69±0.048 ^{bB}	5.47±0.061 ^{bC}
T2	6.07±0.087 ^{bA}	5.98±0.092 ^{bA}	5.87±0.070 ^{bAB}	5.71±0.057 ^{bB}	5.63±0.086 ^{abB}
T3	6.01±0.097 ^{bA}	5.95±0.074 ^{bA}	5.89±0.026 ^{bAB}	5.74±0.064 ^{bBC}	5.65±0.050 ^{abC}
Water activity (a_w)					
Treatments	0	10	20	30	40
Control	0.878±0.0027 ^{A}	0.869±0.0051 ^{bAB}	0.857±0.0073 ^{BC}	0.850±0.0038 ^{C}	0.817±0.0023 ^{D}
T1	0.888±0.010 ^{A}	0.876±0.0060 ^{abAB}	0.871±0.0054 ^{AB}	0.861±0.0091 ^{B}	0.827±0.0065 ^{C}
T2	0.886±0.0058 ^{A}	0.880±0.0059 ^{abAB}	0.872±0.0042 ^{AB}	0.865±0.0070 ^{B}	0.824±0.0049 ^{C}
T3	0.894±0.0028 ^{A}	0.889±0.0036 ^{aA}	0.869±0.0058 ^{B}	0.863±0.0060 ^{B}	0.829±0.0084 ^{C}
TBA (mg mal./kg)					
Treatments	0	10	20	30	40
Control	0.549±0.0048 ^{E}	0.574±0.0052 ^{D}	0.680±0.0038 ^{C}	0.865±0.0067 ^{aB}	1.51±0.0071 ^{aA}
T1	0.544±0.0111 ^{D}	0.558±0.0039 ^{D}	0.670±0.0027 ^{C}	0.828±0.081 ^{bB}	1.12±0.0033 ^{bA}
T2	0.540±0.0099 ^{D}	0.563±0.0074 ^{D}	0.673±0.0040 ^{C}	0.826±0.0082 ^{bB}	1.10±0.0211 ^{bA}
T3	0.539±0.0080 ^{D}	0.569±0.0064 ^{D}	0.675±0.0028 ^{C}	0.823±0.0069 ^{bB}	1.15±0.0305 ^{bA}
Total phenolic count (mg GAE/100 g)					
Treatments	0	10	20	30	40
Control	562±0.67 ^{A}	393±0.56 ^{B}	263±0.17 ^{BC}	185±0.36 ^{C}	13.5±0.075 ^{D}
T1	620±0.58 ^{A}	409±0.66 ^{B}	291±0.91 ^{BC}	209±0.41 ^{C}	16.3±0.069 ^{D}
T2	606±0.83 ^{A}	405±0.71 ^{B}	284±0.45 ^{BC}	204±0.34 ^{C}	12.8±0.060 ^{D}
T3	615±0.64 ^{A}	416±0.73 ^{B}	296±0.37 ^{BC}	205±0.58 ^{C}	17.5±0.049 ^{D}
Total flavonoid (mg QE/100 g)					
Treatments	0	10	20	30	40
Control	62.4±0.073 ^{A}	58.3±0.091 ^{A}	44.0±0.070 ^{A}	19.4±0.083 ^{B}	3.5±0.012 ^{B}
T1	64.4±0.134 ^{A}	58.7±0.088 ^{A}	45.9±0.0053 ^{AB}	20.3±0.78 ^{BC}	4.0±0.006 ^{C}
T2	64.6±0.152 ^{A}	59.8±0.135 ^{A}	45.0±0.046 ^{AB}	21.4±0.074 ^{BC}	3.8±0.013 ^{C}
T3	63.1±0.179 ^{A}	59.6±0.079 ^{A}	45.7±0.073 ^{AB}	21.8±0.076 ^{BC}	4.0±0.0037 ^{C}

* Mean ± SE with different superscripts in a row wise (upper case alphabet) and column wise (lower case alphabet) differ significantly ($p<0.05$).

$n_1 = 6$ for each treatment

Control (chhana base+ whole milk powder)

T1 (chhana base + whole milk powder + mango powder + *Vaccinia oxycoccos*)

T2 (chhana base + whole milk powder + grape powder + *Vaccinia oxycoccos*)

T3 (chhana base+ whole milk powder + pineapple powder + *Vaccinia oxycoccos*)

bottle gourd burfi at refrigeration conditions[16,19]. In a similar direction, Makhecha[20] stated that the reduction in moisture percentage probably abated the water activity of thabdi samples stored at a refrigeration temperature of 7°C[20]. Although the water activity of all the variants was similar to control samples on almost all the days of storage.

For the TBARS assay, there was a significant rise ($p<0.05$) in control samples from day 0 to 40, whilst each treatment indicated a substantial ($p<0.05$) rise from day 10 to 40. Kaur *et al.*[7] also revealed a substantial ($p<0.05$) hike in the values of the TBARS assay performed on caramel-infused paneer bites in refrigerated storage. However, in the case of all the variants, significantly ($p<0.05$) lower TBARS values were analysed relative to control samples on day 30 of storage. Perhaps the phenolic content of *Vaccinia oxycoccos* responded to free radical chain reactions by stabilising and terminating them. Velasco and Williams[21] also witnessed a positive effect of natural extracts on oxidative stress by diminishing secondary oxidative products generated during the storage period.

A significant decrease ($p<0.05$) was monitored in total phenolic count ahead of day 10, whereas in flavonoid count on days 30 and 40 of storage, in both control and *Vaccinia oxycoccos* added formulations. However, the phenolic and flavonoid counts of all the three treatments corresponded to the control formulation throughout the storage period. Perhaps the *T. cacao* coat on both control and *Vaccinia oxycoccos* added formulations was the reason for this comparison. Genovese and Lannes[22] briefed *T. cacao* as the richest repository of phenolics, formulated with a high percentage of cocoa liquor beans. Yang and Choi (2017) compared different kinds of berries and reported the highest concentration of phenolics in bokbunja, followed by blackberry, mulberry, cranberry, raspberry, wild raspberry and strawberry[23]. Results were also in accordance with the findings by Kaur *et al.*[7] in caramel paneer bites stored in refrigerated conditions.

Changes in the microbial quality

The total plate count and yeast mould count of control and treatment formulations displayed in Table 2 escalated substantially ($p<0.05$) on day 40 of storage. The total plate count for control samples increased from 2.38 log cfu/g (day 0) to 5.89 cfu/g (day 40). Similarly, for treatment formulations, the upsurge was almost identical to control. On days 0 and 10 of storage, the Y&M count was negligible to enumerate. On day 20, however, the counts were 1.33, 1.20, 1.23 and 1.28 log cfu/g for control, T1, T2 and T3, respectively. On day 30, the Y and M counts in treatment formulations were significantly ($p<0.05$) lower than in control samples. The maximum threshold limit for TPC and YMC in chhana and chhana-based sweets is 5.54 log cfu/g and 2.17 log cfu/g, respectively, according to the Food Safety and Standards Regulations (2011)[24]. Taking into account the counts of all the four formulations, the unacceptability in the context of microbial quality had been declared on day 40. Other scientists also reported significant ($p<0.05$) increases in TPC and

Table 2 — Microbial Changes at refrigeration temperature (4±1°C)

Total plate count (log cfu/g)					
Treatments	0	10	20	30	40
Control	2.38 ± 0.052^{D}	2.50 ± 0.070^{D}	2.75 ± 0.075^{C}	3.56 ± 0.094^{B}	5.89 ± 0.049^{aA}
T1	2.30 ± 0.051^{D}	2.45 ± 0.045^{D}	2.63 ± 0.084^{C}	3.42 ± 0.054^{B}	5.58 ± 0.031^{bA}
T2	2.33 ± 0.056^{D}	2.38 ± 0.077^{D}	2.60 ± 0.045^{C}	3.40 ± 0.056^{B}	5.56 ± 0.034^{bA}
T3	2.36 ± 0.070^{D}	2.40 ± 0.103^{D}	2.68 ± 0.075^{C}	3.45 ± 0.090^{B}	5.53 ± 0.092^{bA}
Y&M count (log cfu/g)					
Treatments	0	10	20	30	40
Control	ND	ND	1.33 ± 0.075^{C}	1.94 ± 0.105^{aB}	2.81 ± 0.056^{A}
T1	ND	ND	1.20 ± 0.042^{C}	1.65 ± 0.055^{bB}	2.55 ± 0.082^{A}
T2	ND	ND	1.23 ± 0.047^{C}	1.60 ± 0.053^{bB}	2.57 ± 0.033^{A}
T3	ND	ND	1.28 ± 0.038^{C}	1.58 ± 0.038^{bB}	2.58 ± 0.152^{a}

* Mean ± SE with different superscripts in a row wise (upper case alphabet) and column wise (lower case alphabet) differ significantly ($p<0.05$)

$n_1 = 6$ for each treatment

Control (chhana base+ whole milk powder)

T1 (chhana base + whole milk powder + mango powder + *Vaccinia oxycoccos*)

T2 (chhana base + whole milk powder + grape powder + *Vaccinia oxycoccos*)

T3 (chhana base+ whole milk powder + pineapple powder + *Vaccinia oxycoccos*

YMC in a variety of milk products packed in diverse packages[7,20,25].

Organoleptic changes

Variations in the organoleptic attributes of control and treatment formulations are displayed in Table 3. The colour and appearance scores of all the treatment formulations were significantly higher compared to control samples on day 30 of storage. Perhaps it could be credited to the natural colour pigments of fruit powders. Kulla and Kuraganti (2021) also reported a significant improvement in the colour of foxtail millet biscuits supplemented with papaya fruit pulp[26]. Decrease in organoleptic attributes with progress in the storage period, primarily a consequence of Maillard reaction, oxidative discoloration and moisture vaporisation etc[27]. Results were in agreement with the studies by Tiwari[25] and Sengar[28] on burfi and cham-cham refrigerated at 7±2°C, respectively. Neha *et al.* [16] also revealed a substantial ($p<0.05$) fall in colour and appearance scores of gluten-free gulab-jamun during the entire duration of storage. Texture scores also declined significantly ($p<0.05$) on account of moisture vaporisation and increased hardness in the product[29]. For the entire storage period, flavour scores were comparable between control and treatment formulations. However, aroma scores for all the treatment formulations were substantially ($p<0.05$) superior relative to control on day 10 of storage. It is probably due to the presence of aroma precursors in fruit powders. A significant ($p<0.05$) decline was also witnessed in the overall acceptability scores of all the

Table 3 — Organoleptic changes at refrigeration temperature (4±1°C)

Colour and appearance					
Treatments	0	10	20	30	40
Control	8.54±0.10^{A}	8.23±0.14^{AB}	7.90±0.20^{B}	6.84±0.14^{bC}	5.64±0.17^{C}
T1	8.69±0.11^{A}	8.32±0.16^{AB}	8.12±0.18^{B}	7.38±0.09^{aC}	5.80±0.18^{C}
T2	8.62±0.11^{A}	8.30±0.15^{AB}	8.10±0.17^{B}	7.30±0.11^{aC}	5.86±0.19^{C}
T3	8.63±0.15^{A}	8.35±0.19^{A}	8.18±0.19^{A}	7.34±0.09^{aB}	5.81±0.18^{C}
Texture					
Treatments	0	10	20	30	40
Control	8.30±0.16^{A}	8.24±0.15^{A}	7.90±0.21^{AB}	6.79±0.12^{B}	6.00±0.16^{C}
T1	8.14±0.15^{A}	7.95±0.21^{A}	7.81±0.19^{A}	6.51±0.16^{B}	5.90±0.11^{C}
T2	8.16±0.20^{A}	8.06±0.15^{A}	7.76±0.19^{A}	6.58±0.14^{B}	5.93±0.14^{C}
T3	8.12±0.17^{A}	8.00±0.16^{A}	7.80±0.22^{A}	6.55±0.17^{B}	5.92±0.16^{C}
Flavour					
Treatments	0	10	20	30	40
Control	8.60±0.08^{A}	8.33±0.11^{AB}	7.99±0.13^{B}	6.45±0.14^{C}	-
T1	8.67±0.08^{A}	8.39±0.12^{AB}	8.02±0.14^{B}	6.79±0.20^{C}	-
T2	8.65±0.09^{A}	8.36±0.12^{AB}	8.13±0.15^{B}	6.72±0.22^{C}	-
T3	8.64±0.13^{A}	8.34±0.13^{AB}	8.18±0.14^{B}	6.78±0.17^{C}	-
Aroma					
Treatments	0	10	20	30	40
Control	8.16±0.16^{A}	7.87±0.20^{bAB}	7.40±0.19^{BC}	6.93±0.21^{C}	5.20±0.18^{D}
T1	8.60±0.14^{A}	8.25±0.15^{aA}	7.46±0.21^{B}	7.05±0.19^{B}	5.56±0.24^{C}
T2	8.55±0.14^{A}	8.12±0.16^{aA}	7.43±0.24^{B}	7.08±0.21^{B}	5.58±0.25^{C}
T3	8.58±0.15^{A}	8.15±0.16^{aA}	7.35±0.21^{B}	7.13±0.20^{B}	5.53±0.26^{C}
Overall acceptability					
Treatments	0	10	20	30	40
Control	8.57±0.17^{A}	8.30±0.19^{A}	8.12±0.20^{A}	6.52±0.16^{B}	5.25±0.21^{C}
T1	8.65±0.12^{A}	8.42±0.17^{A}	8.27±0.19^{A}	6.88±0.10^{B}	5.83±0.18^{C}
T2	8.60±0.14^{A}	8.45±0.15^{A}	8.24±0.19^{A}	6.78±0.14^{B}	5.81±0.20^{C}
T3	8.68±0.15^{A}	8.40±0.14^{A}	8.22±0.16^{A}	6.70±0.14^{B}	5.86±0.17^{C}

*Mean ± SE with different superscripts in a row wise (upper case alphabet) and column wise (lower case alphabet) differ significantly ($p<0.05$)

$n_1 = 21$ for each treatment

Control (chhana base+ whole milk powder)

T1 (chhana base + whole milk powder + mango powder + *Vaccinia oxycoccos*)

T2 (chhana base + whole milk powder + grape powder + *Vaccinia oxycoccos*)

T3 (chhana base+ whole milk powder + pineapple powder + *Vaccinia oxycoccos*)

formulations during the entire storage period as a consequence of the decline in other organoleptic attributes[7,28]. The findings were in resemblance with the published research data of other scientists during the storage of a variety of milk products at different temperatures[14,16,26].

Conclusion

On the strength of results obtained, it is potentially concluded that ahead of day 30, microbial quality declined substantially at a temperature of 4±1°C in aerobic packaging. Therefore, *T. cacao* coated chhana confections with and without incorporation of *Vaccinia oxycoccos* have a storage life of 30 days, in contrast to the 7-day shelf life of traditional chhana-based confections. With the aid of all-natural ingredients like *Theobroma cacao* and *Vaccinia oxycoccos, a* new innovative strategy has been exploited to shield chhana-based confections against escalated microbial growth.

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Conflict of Interest

All the authors do not have any conflicts of interest to declare.

Author's Contributions

SK*- Roles/Writing- original draft; SK- Conceptualization; RK-Writing - review & editing; SD-Formal analysis; DM- Formal analysis.

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