ANSF APPLIED AND NATURAL SCIENCE FOUNDATION

Journal of Applied and Natural Science
17(2), 783 - 792 (2025)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Development of nutritional Spread (ready-to-serve food) from *Cucumis callosus*: Impact on physicochemical, nutritional, and sensory attributes during storage

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Article Info
https://doi.org/10.31018/jans.v17i2.6537
Received: January 03, 2025
Revised: May 29, 2025
Accepted: June 04, 2025

How to Cite
Deepika, *et al.* (2025). Development of nutritional Spread (ready-to-serve food) from *Cucumis callosus*: Impact on physicochemical, nutritional, and sensory attributes during storage. *Journal of Applied and Natural Science*, 17(2), 783 - 792. https://doi.org/10.31018/jans.v17i2.6537

Abstract
Nutrient deficiency disorders due to malnutrition are rapidly increasing and are associated with numerous co-morbidities. In such a scenario, developing functional food and value-added products from pharmacologically, nutritionally, and therapeutically rich plants is essential. Hence, the present study aimed to develop a nutritionally rich and healthier functional food, i.e., spread from *Cucumis callosus (CA)* by blending with *Malus domestica (MD)*. Various blends were prepared manually for *MD: CA,* i.e., C (100:0), T_1 (50:50), T_2 (25:75), and T_3 (0:100). The developed Spread was stored at room temperature and further evaluated for nutritional, sensory, and shelf-life attributes for three months. The developed product indicated that the blending and storage period had a significant ($p<0.05$) impact on nutritional parameters. The TSS (68.22±0.06 to 69.83±0.05^{0}Bx), pH (3.24±0.13 to 4.97±0.00), titrable acidity (1.18±0.08 to 1.66±0.12%), pectin (0.28±0.02 to 0.83±0.03%), β-carotene (2.07±0.02 to 3.00±0.02mg/100gm), vitamin A (3.45±0.03 to 4.98±0.06 I.U.), anthocyanin (1.29±0.38 to 1.71±0.08mg/100gm), reducing sugar (19.88±0.18 to 27.73±0.24%), total sugar (55.01±0.10 to 60.14±0.07%), non-reducing sugar (30.30±0.63 to 34.44±0.15%), moisture (45.17±0.03 to 57.05±0.11%), and ash (0.50±0.02 to 0.56±0.01%) varied significantly. In terms of sensory evaluation, all the blends showed non-significant differences. However, the spread T_3 (100% CA pulp) received the highest score, indicating its high sensory acceptability. This indicates that CA can be utilized to develop intermediate moisture food products, i.e., spread with nutritional richness and sensory acceptability.

Keywords: *Cucumis callosus*, Spread, Proximate composition, Shelf-life, Sensory evaluation

INTRODUCTION

Healthy fruits and vegetables are essential to dietary balance (Bursać Kovačević *et al.*, 2020). Various studies have proven that the consumption of adequate amounts of fruits and vegetables aids in maintaining the health of individuals and, as a result, prevents various illnesses (Aziz *et al.*, 2024; Samuel *et al.*, 2024). The reason behind this claim is the hidden chemistry of these foods. They are rich in various phytochemicals, bioactive compounds, trace elements, and nutritional compounds, which possess therapeutic effects (Deepika *et al.*, 2024; Kannaujiya *et al.*, 2018). They compounds are essential parts of various metabolic pathways and act through various mechanisms to boost an individual's health status. *Cucumis callosus* is one such crop rich in various phytochemicals such as cucurbitacin-B, phenols, and flavonoids, which aids them to act as a combatant against non-communicable disorders (Kapoor *et al.*, 2021). The extracts of fruit of this crop have been shown to possess antidiabetic, anti-inflammatory, antioxidant, anti-cancerous, and anti-microbial activity (Choudhary *et al.*, 2023; Deepika *et al.*, 2023; Panda, 2016; Yadav *et al.*, 2022). Traditionally the fruit was consumed for its various health benefits in its raw and processed form. It has been document to act as a coolant during summer. Utilization of this crop for the treatment of constipation, diarrhoea, and bowel complaints is also well-known (Kumar, 2008; Panwar *et al.*, 2014). However, the fruit of this crop, widely consumed for its health benefits, is perishable in nature; therefore, a large portion of its production is wasted in tons. Furthermore, the crop is restricted to summer/ kharif season, making its availability difficult in other parts of the world despite its numerous health benefits (Deepika *et al.*, 2023). Apparently, the lack of healthier food options on shelves has led to a shift in consumers' preferences from Mediterranean to Western dietary habits, causing the onset of various lifestyle-associated non-communicable diseases, including mental health disorders and malnutrition-associated growth challenges such as wasting and stunting among individuals of low-income strata (Chowdhury *et al.*, 2021; Deepika, *et al.*, 2023). According to World Health Organization (WHO), "Child wasting refers to a child who is too thin for his or her height and is the result of recent rapid weight loss or the failure to gain weight" (Https://Www.Who.Int/Data/Gho/Indicator-Metadata-Registry/Imr-Details/302, n.d.). According to recent statistical data from the global health observatory, WHO, 45.0 million children were suffering from the condition of wasting in 2022 (Https://Www.Who.Int/Data/Gho/Data/Themes/Topics/Joint-Child-Malnutrition-Estimates-Unicef-Who-Wb, n.d.). Wasting is a reversible phenomenon when an individual initiates consumption of a nutritionally balanced diet rich in macronutrients, macronutrients, and phytochemicals associated with growth (Mishra *et al.*, 2024). However, when socioeconomic status comes into light, the target becomes challenging. In such a scenario, developing low-cost food options with adequate nutritional quality becomes essential. *C. callosus* is perishable yet nutritionally rich (Patel and Panwar, 2022; Zulfiqar *et al.*, 2024); however, it is a feral crop and does not require economic input, therefore making it an ideal option for the development of low-cost and nutritionally rich value-added food products. Intermediate moisture food products such as jam, ready-to-serve beverages, spreads, and jellies are one way of preserving perishable food items (Bekele *et al.*, 2020). Previous efforts to develop intermittent moisture food, i.e., syrup in a study, were also considered where the product was found to be nutritional and sensory acceptability (Deepika *et al.*, 2023). However, to the best of present knowledge, no study has been reported yet to develop spread from *C. callosus*. Thus, considering the knowledge gap, a study was conducted to develop a food product that has low cost, nutritional richness, therapeutic benefits, and popularity among the target group. The prepared product was analysed for its nutritional value and sensory/ organoleptic acceptability. The current study focused on developing the Spread (ready-to-eat food) of *C. callosus* due to its rich nutritional and therapeutic profile. Most of the spreads these days are fat-based, such as mayonnaise and cheese, which are nutritionally unhealthy. Therefore, the development of fruit-based sweet Spread with health benefits was necessary for the target population.

MATERIALS AND METHODS

The research work was performed in the research laboratories of the Department of Nutrition Biology, Central University of Haryana, Mahendergarh, Haryana. The details about the procurement of raw materials, chemicals, and methodologies utilized for analysing various parameters are given in this section.

Procurement and processing of raw material

Cucumis callosus and *Malus domestica* were purchased from the regional *mandi* (market)/fruit and vegetable market of Mahendergarh, Haryana, India. After collection, the fruits were sorted and washed thoroughly under running tap water. The fruits were then allowed to air dry and chopped into smaller pieces. *M. domestica* was, however, peeled and destoned before being chopped. The fruits were then subjected to hot pulping separately in the pressure cooker for 10-12 minutes on a medium flame with 150mL water/kg fruit. Later, the pressure-cooked fruit was allowed to cool down, followed by grinding separately in the Electronic mixer grinder. The ground pulp was then sieved using muslin cloth to avoid lumps and uneven pulp. The pulp was

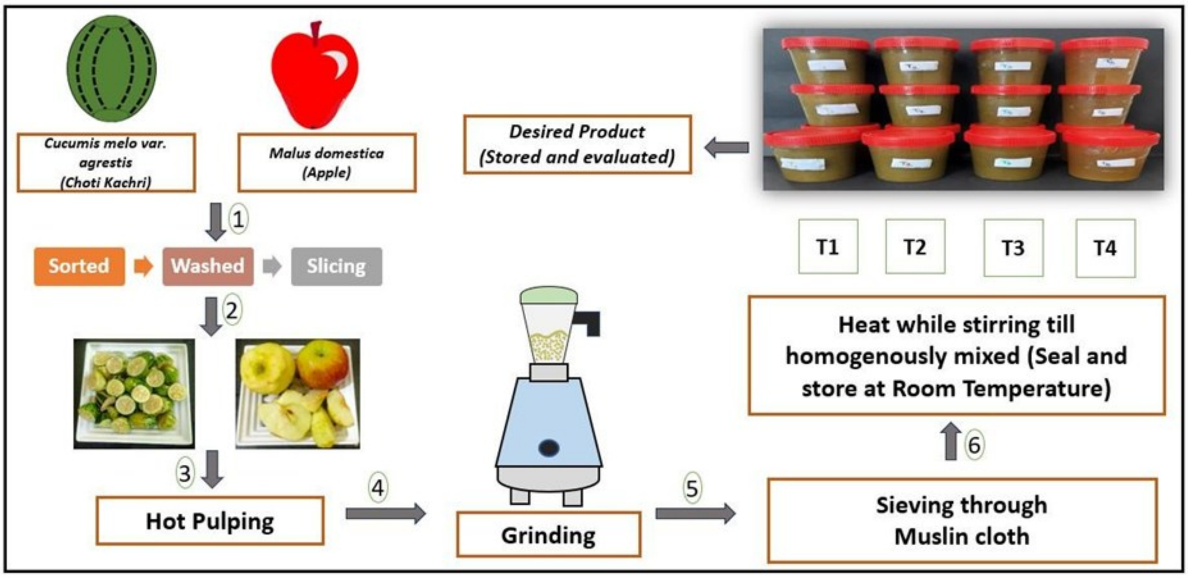

Fig. 1. *Process illustration for development of spread*

then stored in sterilized/autoclaved glass jars at 4^0C until further processing. Sugar used to prepare the Spread was also procured from a local shop in Mahendergarh.

Chemicals and machinery

Chemicals used for analysing the developed product were of analytical grade and were purchased from Central Drug House (CDH) (P) Ltd, HiMedia, and Sisco Research Laboratories (SRL) Pvt. ltd.

Procedure of Spread development

To obtain the desired product, the blending of pulp obtained from CA and MD was performed in four different ratios, i.e., C (100:0), T_1 (75:25), T_2 (50:50), and T_3 (0:100). The pulp and sugar were cooked in a skillet on medium flame along with other ingredients as mentioned in Table 1 until the desired consistency was reached (65-68^{0}Bx). Later, upon cooling, a small amount of the generated product was added to a bowl and mixed with a defined amount of potassium metabisulphite (KMS) (Table 1). The mixture with KMS was then readded to the entire cooking material and stirred uniformly. The prepared spreads were then stored in sterilized, airtight sample storage plastic containers in the dark, followed by nutritional, shelf-life, and sensory evaluation at the fresh, first, second, and third months of storage. An illustration of the procedure for spread development is given in Fig. 1.

Analysed nutritional parameters

The prepared Spread was evaluated for nutritional parameters (total soluble solids (TSS), pH, titrable acidity (%), pectin (%) as calcium pectate, total anthocyanin (mg/100gm), β-carotene (mg/100gm), vitamin A (I.U)), proximate analysis (moisture (%), ash (%)), and sensory evaluation at fresh, first, second, and third month of storage interval.

Total soluble solids (TSS)

The prepared spreads' total soluble solids (0Bx) were analysed using a hand refractometer (Shivani *et al.*, 2022). The cooled spread sample was placed on the prism of a calibrated refractometer and held near a light source to observe the readings from the eyepiece. The readings were recorded as TSS in ^{0}Brix.

pH

A digital pH meter (Biocon Pvt. Ltd.) was used to record the pH. A calibrated pH meter rod was immersed in a beaker containing the spread sample, and the readings were recorded (Wasihun *et al.*, 2023).

Titrable acidity (%)

To determine the titrable acidity (TA) (%), 5 gm of sample was taken from the prepared product and transferred into a flask to make a final volume of 50 mL with distilled water. An aliquot of 5 mL was taken from this and was titrated against 0.1N NaOH with phenolphthalein as an indicator. The development of a faint pink colour that persisted for 15 seconds was noted as an end-point (Rafique *et al.*, 2023).

Pectin (%) as calcium pectate

For pectin content determination, 15 gm of sample was added to 400 mL distilled water and heated for one hour. The volume of the obtained solution was made 500 mL once it reached room temperature. The solution was then filtered and kept overnight after adding 10 mL of NaOH solution for neutralizing. The step was followed by adding 50 mL acetic acid and 25 mL 1N $CaCl_2$. The solution was then allowed to rest for one hour, followed by filtering the solution and washing the residue with hot water. The residue was then dried overnight in a hot air oven at 100^0C and its weight was recorded. The results were calculated according to *Eq.* 1 mentioned below and were expressed in (%) (Ranganna, 2017).

$$Pectin\,(\%) = \frac{Weight\ of\ calcium\ pectate\ (gm) * Volume\ made (mL)}{Weight\ of\ sample\ taken\ (gm)} * 100$$

Eq. 1

Total anthocyanin

For determination of total anthocyanin (mg/100gm) content, 10 gm of prepared sample was taken and blended with 10 mL ethanolic HCL (85:15). The prepared solution was then poured into a volumetric flask and the volume was then made 100 mL using ethanolic HCL. The solution was then stored overnight at 4^0 Celsius. Later, the solution was filtered through Whatman filter paper no. 1 and the optical density of the filtrate was recorded at 535 nm using ethanolic HCL as blank. The results were calculated according to the formulas mentioned in *Eq.* 2 and 3 (Srivastava and Kumar, 2003).

$$OD/100\ gm = \frac{OD * Volume\ made (mL)}{Weight\ of\ sample\ taken\ (gm)} * 100$$

Eq. 2

$$Total\ anthocyanin\ (mg/100\ gm) = \frac{OD\ /\ 100\ gm}{98.2}$$

Eq. 3

β-carotene

The sample (5 gm) of prepared product was grounded with 10-15 mL of acetone. The prepared solution was then filtered and 10-15 mL of petroleum ether was added to it. Addition of petroleum ether led to the separation of the solution into two different layers (supernatant and β-carotene). The obtained solution was then put into a separatory funnel and the layer of β-carotene was collected. The collected layer was then transferred into a volumetric flask, and its volume was 100 mL, using petroleum ether. The OD of the prepared sample was then recorded at 452 nm with petroleum ether as blank. The content of β-carotene (mg/100gm) was calculated using the given formula in *Eq.* 4 (Srivastava and Kumar, 2003).

$$\beta - carotene\ (mg/100\ gm) = \frac{OD * 13.9 * 10^4 * 100}{weight\ of\ sample\ (gm) * 560 * 1000}$$

Eq. 4

Vitamin A

The vitamin A content was determined on calculation basis using the following formula in *Eq.* 5.

$$Vitamin\ A\ (I.U.) = \frac{\beta{-}carotene\ \left(\frac{mg}{100gm}\right)}{0.6}$$

Eq. 5

Sugars

The sugars (%) were estimated according to the methodology of Ranganna (2017). For sample preparation, a sample of 25 gm was taken and crushed in water to make a volume of 250 mL . 2 mL of neutral lead acetate (45%) was added to the solution, followed by keeping the solution aside for 10 minutes. Further, the necessary amount of potassium oxalate solution (22%) was added to remove the trace of lead from the solution. The mixture was then filtered through Whatman filter paper no. 1. The filtrate obtained was used for the estimation of reducing and total sugars.

To determine the amount of reducing sugars (%), sugar extract was filled in a burette and titrated against the boiling solution of Fehling mixture (Fehling A: Fehling B as 1:1) using methylene blue as an indicator. The appearance of a brick-red precipitate was observed as the end point of titration. For total sugars (%), 1 mL of concentrated HCL was added to 50 mL sugar extract and kept for hydrolyzation overnight at room temperature. The sugar solution was then neutralized using saturated NaOH solution followed by the addition of 2-3 drops of phenolphthalein indicator. The solution was then titrated similarly as reducing sugars against boiling Fehling mixture until the end point of brick red precipitate was reached. The non-reducing sugars (%) were calculated using the following formula in Eq. 6.

Non reducing sugar (%) = Total sugar (%) - Reducing sugar (%) * 0.95 Eq. 6

Proximate analysis

The proximate analysis was determined using AOAC (2000) methodology. The moisture (%) was determined by drying the sample at 105^0C until constant weight was achieved. For determination of total ash (%), the moisture-free sample was kept in a muffle furnace at 500 ± 5^0C for 5 hours.

Organoleptic evaluation

In order to analyse the sensory attributes, the prepared spreads were subjected to a panel of 15 semi-trained panellists aged 22-45 years. The panellists evaluated the products using (Larmond, 1977) scale varying from extremely liked (9) to extremely disliked (0). While selecting the panellists, the exclusion-inclusion criteria were maintained, i.e., care was taken to check that the panellists were free from cough, cold, or any diseased condition that could interfere with the sensory judgement. It was also checked that the panellists were neither too hungry nor too fed. The sensory attributes scored by the panellists were colour, aroma, flavour, consistency, and overall acceptability. Other parameters, such as identical serving containers, light brightness, and Spread temperature, were also considered.

Ethical consideration

Research protocols related to organoleptic evaluation were approved by the Departmental Research Committee and Research Advisory Committee, Department of

Table 1. Different ingredients and their required amount for preparation of various treatments of Spread.

Set of treatments	Blending ratio (MD:CA)	MD pulp (gm)	CA pulp (gm)	Sugar (gm)	Citric acid (gm)	KMS (gm)
C	100:0	1000	0	800	3	1
T_1	25:75	250	750	800	3	1
T_2	50:50	500	500	800	3	1
T_3	0:100	0	1000	800	3	1

MD : *Malus domestica*, CA: *Cucumis callosus*, KMS: Potassium metabisulphite

Nutrition Biology, Central University of Haryana. The informed consent was also obtained from the panellists.

Statistical analysis

The data recorded (n=3) for various parameters of all the treatments at different storage intervals was subjected to statistical analysis using two-way ANOVA for multiple comparisons to observe significant and non-significant differences using Graph Pad Prism 10 software at a p-value of 0.05.

RESULTS AND DISCUSSION

Analysed nutritional parameters

The results of nutritional evaluation are mentioned in Table 2. Data for TSS revealed that the blending has a non-significant effect on TSS. However, the value for TSS decreased with an increase in blending concentration with the pulp of CA with values ranging from lowest (68.22±0.06) for T_3 and highest (69.33±0.11) for control, i.e., treatment C. With the increase in storage interval, TSS did not show a significant effect up to the first month of storage; however, TSS increased significantly for the second and third months of storage for all the blends (C, T_1, T_2, and T_3). This increase in storage might be due to the hydrolysis of polysaccharides, which resulted in the formation of mono and polysaccharides (Shivani *et al.*, 2022). Furthermore, increased concentration of ionised acids and their salts might be another reason for its increase (Wan-Mohtar *et al.*, 2021). Spread or an intermediate moisture food product should also be in a reasonably thick consistency to hold the fruit tissues in place (Bekele *et al.*, 2020). TSS acts as a contributing factor for maintaining consistency and hence should not decrease and increase too much. Similar results were observed in the research study conducted by (Wan-Mohtar *et al.*, 2021) and (Shivani *et al.*, 2022), wherein they developed the nectarine and banana jam, respectively. For pH, a significant effect was seen with an increase in the pulp of CA. Storage also impacted the pH and led to a significant decrease for all the treatments, with values ranging from 3.92±0.08 to 3.24±0.13, 4.54±0.09 to 3.81±0.04, 4.88±0.02 to 3.99±0.01, and 4.97±0.00 to 4.21±0.08 for C, T_1, T_2, T_3, and T_4 respectively. When observed for TA(%) of all the blends, a non-significant effect was observed from blending as well as storage interval on reported values. The highest TA (%) was reported for C (1.41±0.17 to 1.66±0.12), while the lowest TA (%) was reported for T_3 (1.18±0.08 to 1.36±0.29). A decrease in pH might be attributed to an increase in acidity during storage (Wan-Mohtar *et al.*, 2021). Chemical reactions leading to organic acid production might have contributed to this decrease in pH (Shivani *et al.*, 2022).

The utilization of sugars for forming organic acids and inherited acidity in the pulp of CA and MD might have contributed to an increase in TA (%). Crab apple jam developed by (Kumari and Dhaliwal, 2017) also exhibited similar trends in their research study wherein pH decreased and TA (%) increased. A sufficient amount of acidity is required for gel formation. Hence, in intermittent moisture foods with gel formation, acidity is crucial in maintaining product acceptability during shelf-life (Wan-Mohtar *et al.*, 2021).With respect to pectin (%) a significant decrease was observed with the increase of CA pulp with values 0.83±0.03 for C, 0.63±0.02 for T_1, 0.43±0.31 for T_2, and 0.31±0.01 for T_3. However, a non-significant increase in pectin (%) was observed for all blends, with an increase in shelf life up to two months of storage. C and T_1, however, showed a significant decrease after two months of storage. Breakdown of pectin into pectinic acid might be the reason for the decrease in pectin content over storage (Wan-Mohtar *et al.*, 2021).

Surprisingly, no pectin was added during spread development; yet, the presence of pectin, although in very few amounts, indicated that fruits utilized for pulp production had endo-storage of pectin components. Data about the amount of β-carotene (mg/100gm) revealed that blending significantly affects the parameter, with values increasing from 2.26±0.04 to 3.00±0.02 for C and T_3, respectively. However, storage led to a significant decrease in values after the second and third months. Vitamin A (I.U) also showed trends similar to β-carotene with values ranging from 3.77±0.07 to 3.45±0.03 for C, 3.84±0.11 to 3.67±0.15 for T_1, 4.41±0.09 to 4.18±0.03 for T_2, and 4.98±0.06 to 4.70±0.09 for T_3. Vitamin A is present in fruits through carotenes, which are converted into vitamins inside the body. In the absence of vitamin A, conditions like immune system impairment and ocular effects such as night blindness and haematopoiesis occur. In such a

Table 2. Nutritional evaluation of various blends of Spread at fresh, first, second, and third month of storage interval

Parameters	Treatments	Storage (months)			
		Fresh	1	2	3
TSS (^{0}Brix)	C	69.33±0.11^{ad}	69.46±0.09^{ad}	69.66±0.18^{bd}	69.83±0.05^{cd}
	T_1	69.20±0.20^{ad}	69.43±0.09^{ad}	69.58±0.08^{bd}	69.93±0.05^{cd}
	T_2	68.73±0.11^{ae}	68.93±0.04^{ae}	69.04±0.04^{be}	69.36±0.05^{ce}
	T_3	68.22±0.06^{af}	68.42±0.16^{af}	68.56±0.04^{bf}	68.96±0.05^{cf}
pH	C	3.92±0.08^{ae}	3.56±0.21^{be}	3.34±0.13^{ce}	3.24±0.13^{de}
	T_1	4.54±0.09^{af}	4.28±0.04^{bf}	4.07±0.15^{cf}	3.81±0.04^{df}
	T_2	4.88±0.02^{ag}	4.53±0.01^{bg}	4.13±0.15^{cg}	3.99±0.01^{dg}
	T_3	4.97±0.00^{ah}	4.77±0.05^{ah}	4.48±0.13^{bh}	4.21±0.08^{ch}
Titrable Acidity (% Citric acid)	C	1.41±0.17^{ab}	1.48±0.14 ^{ab}	1.54±0.21 ^{ab}	1.66±0.12 ^{ab}
	T_1	1.35±0.22 ^{ab}	1.38±0.18 ^{ab}	1.43±0.23 ^{ab}	1.49±0.21 ^{ab}
	T_2	1.26±0.13 ^{ab}	1.33±0.07 ^{ab}	1.46±0.16 ^{ab}	1.54±0.03 ^{ab}
	T_3	1.18±0.08 ^{ab}	1.24±0.12 ^{ab}	1.28±0.19 ^{ab}	1.36±0.29^{ab}
Pectin (% as calcium pectate)	C	0.83±0.03^{ac}	0.80±0.02^{ac}	0.77±0.01^{ac}	0.73±0.02^{bc}
	T_1	0.63±0.02^{ad}	0.60±0.02^{ad}	0.58±0.03^{ad}	0.55±0.02^{bd}
	T_2	0.43±0.31^{ae}	0.40±0.00^{ae}	0.40±0.01^{ae}	0.38±0.01^{ae}
	T_3	0.31±0.01^{af}	0.27±0.04^{af}	0.30±0.08^{af}	0.28±0.02^{af}
β- carotene (mg/100gm)	C	2.26±0.04^{ad}	2.24±0.04^{ad}	2.14±0.04^{bd}	2.07±0.02^{cd}
	T_1	2.30±0.07^{ad}	2.32±0.02^{ad}	2.26±0.04^{ae}	2.20±0.09^{ae}
	T_2	2.65±0.05^{ae}	2.63±0.03^{ae}	2.58±0.04^{af}	2.51±0.02^{bf}
	T_3	3.00±0.02^{af}	2.97±0.04^{af}	2.92±0.05^{ag}	2.82±0.05^{bg}
Vitamin A (I.U)	C	3.77±0.07^{ac}	3.74±0.05^{ac}	3.68±0.03^{ac}	3.45±0.03^{bc}
	T_1	3.84±0.11^{ac}	3.77±0.03^{ac}	3.69±0.08^{ac}	3.67±0.15^{ac}
	T_2	4.41±0.09^{ad}	4.25±0.18^{ad}	4.24±0.13^{ad}	4.18±0.03^{bd}
	T_3	4.98±0.06^{ae}	4.94±0.07^{ae}	4.86±0.14^{ae}	4.70±0.09^{be}
Anthocyanin (mg/100gm)	C	1.29±0.40^{ab}	1.29±0.38^{ab}	1.30±0.20^{ab}	1.30±0.16^{ab}
	T_1	1.32±0.17^{ab}	1.32±0.13^{ab}	1.32±0.18^{ab}	1.32±0.11^{ab}
	T_2	1.46±0.02^{ab}	1.46±0.04^{ab}	1.46±0.03^{ab}	1.45±0.04^{ab}
	T_3	1.71±0.08^{ac}	1.70±0.07^{ac}	1.70±0.08^{ac}	1.70±0.01^{ac}
Reducing sugars (%)	C	26.94±0.89^{ac}	27.11±0.77^{ac}	27.36±0.53^{ac}	27.73±0.24^{ac}
	T_1	24.51±0.06^{ad}	24.66±0.11^{ad}	24.78±0.23^{ad}	25.31±0.40^{ad}
	T_2	21.21±0.12^{ae}	21.32±0.20^{ae}	21.95±0.05^{ae}	22.00±0.01^{ae}
	T_3	19.88±0.18^{af}	19.98±0.09^{af}	20.29±0.42^{af}	20.79±0.12^{bf}
Total sugars (%)	C	60.14±0.07^{ac}	60.03±0.05^{ac}	59.71±0.59^{ac}	59.62±0.43^{ac}
	T_1	58.35±0.37^{ad}	58.11±0.10^{ad}	58.03±0.05^{ad}	57.93±0.21^{ad}
	T_2	57.36±0.53^{ae}	56.95±0.44^{ae}	56.60±0.55^{ae}	56.17±0.34^{be}
	T_3	56.14±0.08^{af}	55.90±0.36^{af}	55.39±0.52^{af}	55.01±0.10^{bf}
Non-reducing sugars (%)	C	31.53±0.82^{ad}	31.26±0.75^{ad}	30.75±1.10^{ad}	30.30±0.63^{bd}
	T_1	32.14±0.32^{ad}	31.77±0.18^{ad}	31.58±0.26^{ad}	30.98±0.58^{ad}
	T_2	34.33±0.50^{ae}	33.84±0.22^{ae}	32.91±0.57^{be}	32.46±0.33^{ce}
	T_3	34.44±0.15^{af}	34.12±0.26^{af}	33.33±0.81^{af}	32.51±0.14^{bf}
Moisture (%)	C	45.17±0.03^{ae}	46.43±0.42^{be}	46.89±0.09^{ce}	47.22±0.57^{de}
	T_1	47.01±0.01^{af}	48.11±0.08^{bf}	48.86±0.14^{cf}	48.98±0.08^{df}
	T_2	53.56±0.04^{ag}	54.12±0.08^{bg}	54.51±0.26^{cg}	54.84±0.13^{dg}
	T_3	55.73±0.01^{ah}	56.10±0.09^{bh}	57.13±0.06^{ch}	57.05±0.11^{dh}
Ash (%)	C	0.51±0.01ac	0.54±0.01^{ac}	0.55±0.02^{ac}	0.56±0.01^{ac}
	T_1	0.50±0.01^{ac}	0.55±0.02^{bc}	0.53±0.03^{ac}	0.54±0.02^{ac}
	T_2	0.50±0.02^{ac}	0.52±0.03^{ac}	0.53±0.02^{ac}	0.53±0.01^{ac}
	T_3	0.50±0.02^{ac}	0.51±0.01^{ac}	0.51±0.01^{ac}	0.52±0.00^{ac}

* Values are mean ± standard deviation of triplicate observations; Letters in superscript depict the significant and non-significant differences in the recorded values at p<0.05.

Table 3. Sensory evaluation of various blends of Spread at the fresh, first, second, and third month of storage interval

Parameters	Treatments	Storage (months)			
		Fresh	1	2	3
Colour	C	$8.6±0.51^{ac}$	$8±0.66^{ac}$	$7.8±0.78^{ac}$	$7.1±0.73^{bc}$
	T_1	$7.9±0.56^{ac}$	$7.3±0.48^{ac}$	$7.1±0.73^{ac}$	$7.3±0.48^{ac}$
	T_2	$7.7±0.48^{ac}$	$7.3±0.48^{ac}$	$7.4±0.51^{ac}$	$7.4±0.51^{ac}$
	T_3	$8.8±0.42^{ac}$	$8.6±0.51^{ac}$	$8.3±0.48^{ac}$	$8.5±0.52^{ad}$
Flavour	C	$8.4±0.51^{ab}$	$8.4±0.51^{ab}$	$8.0±0.66^{ab}$	$7.7±0.67^{ab}$
	T_1	$7.7±0.48^{ab}$	$7.3±0.48^{ab}$	$7.4±0.51^{ab}$	$7.3±0.48^{ab}$
	T_2	$7.7±0.48^{ab}$	$7.6±0.69^{ab}$	$7.4±0.51^{ab}$	$7.4±0.51^{ab}$
	T_3	$8.6±0.51^{ab}$	$8.6±0.51^{ab}$	$8.2±0.63^{ab}$	$8.2±0.78^{ab}$
Texture	C	$8.4±0.51^{ab}$	$8.2±0.63^{ab}$	$7.9±0.73^{ab}$	$7.6±0.69^{ab}$
	T_1	$7.6±0.51^{ab}$	$7.5±0.52^{ab}$	$7.3±0.48^{ab}$	$7.4±0.51^{ab}$
	T_2	$7.9±0.56^{ab}$	$7.4±0.51^{ab}$	$7.5±0.52^{ab}$	$7.4±0.51^{ab}$
	T_3	$8.8±0.42^{ab}$	$8.7±0.48^{ab}$	$8.5±0.52^{ab}$	$8.5±0.52^{ab}$
Consistency	C	$8.2±0.63^{ab}$	$8.1±0.73^{ab}$	$7.0±0.66^{ab}$	$7.8±0.78^{ab}$
	T_1	$7.5±0.51^{ab}$	$7.5±0.52^{ab}$	$7.4±0.51^{ab}$	$7.3±0.48^{ab}$
	T_2	$7.5±0.52^{ab}$	$7.4±0.51^{ab}$	$7.4±0.51^{ab}$	$7.4±0.51^{ab}$
	T_3	$8.6±0.51^{ab}$	$8.7±0.04^{ab}$	$8.2±0.78^{ab}$	$8.3±0.67^{ab}$
Overall acceptability	C	$8.3±0.82^{ab}$	$8.0±0.81^{ab}$	$7.8±0.78^{ab}$	$7.5±0.70^{ab}$
	T_1	$7.7±0.67^{ab}$	$7.5±0.52^{ab}$	$7.4±0.51^{ab}$	$7.3±0.48^{ab}$
	T_2	$7.5±0.52^{ab}$	$7.4±0.51^{ab}$	$7.4±0.51^{ab}$	$7.4±0.51^{ab}$
	T_3	$8.7±0.48^{ab}$	$8.7±0.48^{ab}$	$8.7±0.48^{ab}$	$8.2±0.78^{ab}$

* Values are mean ± standard deviation of triplicate observations; Letters in superscript depict the significant and non-significant differences in the recorded values at $p<0.05$

scenario, consuming these dietary components directly or indirectly becomes essential for the body's normal functioning. The presence of β-carotene was also found in papaya-gooseberry jam for treatment T_0 (195 μg/100gm) and T_4 (156 μg/100gm) (Gupta *et al.*, 2016). For anthocyanin (mg/100gm) content, blending had a non-significant effect up to T_2. A significant increase in anthocyanin content was observed for T_3 (1.71±0.08) developed solely from CA pulp. However, storage showed a non-significant effect for all the blends during the fresh, first, second, and third months of storage. To the best of present knowledge, no research has been done on the anthocyanin content of gel-based intermediate moisture food. However, the efforts to study the parameters in this study were made as anthocyanin, a polyphenol compound that plays a significant role in the pharmaceutical and food industry (Alappat and Alappat, 2020).

Therapeutic effects associated with the consumption of anthocyanin-rich foods, namely antidiabetic, anti-cancer, neuroprotective, and anti-microbial activity, have been documented in numerous studies (Tena *et al.*, 2020). Hence, the presence of anthocyanin in the developed Spread indicated its therapeutic benefits. When observed for sugars, reducing sugar (%) decreased significantly with the increase of blending with values as 26.94±0.89 for C, 24.51±0.06 for T_1, 21.21±0.12 for T_2, and 19.88±0.18 for T_3. However, a non-significant increase was observed in reducing sugar (%) with increased storage interval. The amount of total sugar (%) also decreased significantly with increased blending with CA pulp. Storage did not impact the total sugar (%) content for C and T_1; however, a significant decrease was observed in values for T_2 (57.36±0.53 to 56.17±0.34) and T_3 (56.14±0.08 to 55.01±0.10) for third-month storage study. Non-reducing sugar (%) content was affected non-significantly for C (31.53±0.82) and T_1 (32.14±0.32) blend; however, the amount increased significantly for T_2 (34.33±0.50) and T_3 (34.44±0.15) blend. Storage led to a non-significant decrease in non-reducing sugar (%) content for C and T_1. However, the T_2 and T_3 blends showed a significant decrease after the second and third months of storage, respectively. Blending affected the sugar contents due to different pulp compositions used for spread development. The decrease in non-reducing sugars during storage might be attributed to the hydrolysis of non-reducing sugars to reducing sugars. A similar effect on sugars was observed by (Shivani *et al.*, 2022) during the 90 days of nectarine jam and jelly storage. Sugars are essential to intermediate food product development as they act as a preservative by dehydrating micro-organisms, making them incapable of causing spoilage of processed products. They also act as a sweetener and enhance the end product's consistency and texture, aiding gel formation (Wan-Mohtar *et al.*, 2021). Data concerning proximate analysis revealed that moisture (%) increased significantly with increase in CA pulp blending as well as storage period with values ranging from 45.17±0.03 to 47.22±0.57, 47.01±0.01 to 48.98±0.08, 53.56±0.04 to 54.84±0.13, and 55.73±0.01 to 57.05±0.11 for C, T_1, T_2, and T_3 respectively. Ash (%) content was affected non-significantly with blending as well as storage for all the treatments, i.e., C (0.51±0.01), T_1 (0.50±0.01), T_2 (0.50±0.02), and T_3 (0.50±0.02). Moisture content in the product increased slightly due to various ongoing conversion reactions during storage. Moisture in the atmosphere might have also been attributed to increased moisture content during storage (Sarita *et al.*, 2024). Ash content indicated the presence of inorganic content in the prepared product.

Organoleptic evaluation

The results for organoleptic evaluation (table 3) revealed that colour was impacted non-significantly with blending. However, the third-month storage study observed a significant decrease for C (8.6±0.51 to 7.1±0.73). T_1 (7.9±0.56 to 7.3±0.48), T_2 (7.7±0.48 to 7.4±0.51), and T_3 (8.8±0.42 to 8.5±0.52) exhibited a non-significant decrease in values during storage. The decrease in colour might be due to browning occurring during storage (Shivani *et al.*, 2022). Flavour, texture, consistency, and overall acceptability exhibited similar trend of non-significant difference on scoring due to blending and storage with values ranging from 7.3±0.48 to 8.6±0.51 for flavour, 7.4±0.51 to 8.8±0.42 for texture, 7.3±0.48 to 8.7±0.04 for consistency, and 7.3±0.48 to 8.77±0.48 for overall acceptability. Moreover, the data revealed that T_3 with CA pulp (100%) was most acceptable among consumers as it received the highest score. Furthermore, a non-significant difference was observed for all parameters of T_3 when compared with C, i.e., control, indicating its acceptability similar to the already popular base among consumers. Thus, the development of intermittent moisture food products, specifically spread from CA pulp (100%), can be considered as per organoleptic evaluation results. Similar methodologies and results were obtained when syrup development from CA pulp was done (Deepika *et al.*, 2023). A decrease in the organoleptic score during storage was also observed in gooseberry jam (Banaś *et al.*, 2018).

Conclusion

The present study on developing intermittent moisture food products rich in nutritional value and having organoleptic acceptability revealed that *C. callosus* is an acceptable base for the development of intermediate moisture food products, i.e., Spread which might turn out to be popular among children and other individuals and can aid to mitigate issues like wasting associated with inadequate and unhealthy dietary intake. The results indicated that the developed Spread was rich in nutritional content (%) regarding sugars (reducing sugar, total sugar, non-reducing sugar), moisture, and ash. Physico-chemical attributes related parameters such as TSS (^{0}Bx), pH, and TA (%) were also satisfactory. Functional attributes such as the presence of pectin (%), β-carotene (mg/100gm), vitamin A (I.U.), and anthocyanin (mg/100gm) were also revealed, indicating the therapeutic richness of the developed product. The study for a storage period of three months showed a non-significant difference for organoleptic scoring of developed Spread. The highest score was obtained by T_3, followed by C. However, the difference in mean scoring of both treatments was non-significant. This indicated the similarity in scoring this novel product with an already popular base product. Hence, the development of a nutritionally rich, therapeutically beneficial, and sensory acceptable product (Spread) from the fruit of an underutilized, perishable, and therapeutically important crop, i.e., *C. callosus* can be taken into consideration to uplift the health status of lower and middle economic groups.

ACKNOWLEDGEMENTS

The authors thank the Central University of Haryana, Mahendergarh-123031, for providing research facilities and infrastructure for conducting the study. The authors are also thankful to Dr. Balkar Singh for identifying the crop.

Conflict of interest

The authors declare that they have no conflict of interest.

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