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Sensory, nutritional, and shelf-life aspects of corn silk incorporated chapati

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Abstract
Corn silk, a byproduct of maize cultivation, has been traditionally consumed for its therapeutic benefits. This study aimed to reintroduce corn silk into the culinary domain by incorporating it into chapati, a staple flatbread in India, at varying proportions (30%, 35%, and 40%). Chapatis incorporating 30% corn silk flour (SCT1) achieved the highest overall acceptability on a nine-point scale, comparable to control chapatis (SCC), with minimal impact on visual, textural, and taste qualities. SCT1 exhibited a higher moisture content (30.34±0.01% *vs.* 27.71±0.09%, p<0.001) and protein content (9.71±0.06 g *vs.* 8.83±0.04 g, p = 0.015). SCT1 also showed significantly higher total ash (1.92±0.03 g *vs.* 1.13±0.03 g, p = 0.002) and dietary fiber content (10.39±0.06 g *vs.* 9.20±0.07 g, p = 0.001) compared to SCC. However, SCT1 exhibited lower carbohydrate content (46.44±0.10g *vs.* 51.78±0.09 g, p<0.001) and energy content (235.4±0.86 kcal *vs.* 254.59±1.02 kcal, p = 0.001) than SCC. During a 48-hour storage, both SCC and SCT1 experienced significant moisture content decreases (p<0.001). Extended storage resulted in substantial declines in sensory properties for both formulations. Microbial analysis showed increased bacterial counts in both, with SCC more pronounced (11 × 10^2 cfu/g) than SCT1 (8.50 × 10^2 cfu/g), while SCT1 exhibited better resistance to fungal growth. Cost analysis favoured SCT1 due to reduced ingredient costs, establishing corn silk's economic advantage. In conclusion, integrating corn silk into chapati offers nutritional enhancement, sustainability benefits, and economic viability, with opportunities for refining storage techniques and optimizing sensory attributes.

Keywords: Corn silk, chapati, sensory acceptability, nutritional composition, shelf-life studies

1. Introduction
Corn silk, the yellowish thread like strands from the female flower of maize, is a waste material from corn cultivation and is available in abundance. Corn silk, as traditional medicine, has been consumed for a long time as a therapeutic remedy for various illnesses like gout, diabetes, nephrolithiasis and inflammatory diseases.

Corn silk bioactive components provide many benefits that can be tapped as potential natural products for healthcare applications (Hu *et al.*, 2010) [8]. The pharmacological effects of corn silk, such as antioxidant (Liu *et al.*, 2011; Jia *et al.*, 2020) [12, 9], anti-inflammatory (Wang *et al.*, 2012; Sarfare *et al.*, 2022) [22, 19], diuretic activities (Velazquez *et al.*, 2005) [21,], anti-diabetic (Guo *et al.*, 2009; Zhao *et al.*, 2012; Chaudhary *et al.*, 2022) [7, 24, 4], antibacterial activities (Abirami *et al.*, 2021; Azevedo *et al.*, 2022) [1, 2], antifungal (Nessa *et al.*, 2012; Morshed and Islam, 2015) [15, 14], antitumor (Yang *et al.*, 2014; Li *et al.*, 2020) [23, 11] and anti-obesity activities (Chaiittianan *et al.*, 2016; Oh *et al.*, 2021) [3, 16] have been shown to be attributed to the bioactive compounds it contains.

Reintroducing corn silk into the food system is a noteworthy initiative, reviving culinary traditions with its unique flavour and numerous health benefits while aligning with the trend toward sustainable, locally sourced ingredients. Corn silk, being readily available and often a byproduct of corn cultivation, can contribute to reducing food waste and promoting a more environmentally conscious approach to food production.

The revival of traditionally sourced ingredients in culinary practices has brought about a renewed appreciation for staple like chapati. Chapati, a type of unleavened flatbread, has been a dietary staple for centuries in India. Made from whole wheat flour and water, chapati offers revival in modern diets due to its versatility and health benefits. Incorporating corn silk into these traditional foods marks a reintroduction of this valuable natural resource, allowing for a resurgence in their nutritional and functional value. The research therefore aimed to incorporate corn silk into chapati and study the sensory acceptability, nutritional composition, shelf-life stability through changes in moisture content, nutritional composition and microbial population and cost of production.

2. Materials and Methods

The present study was conducted in the Department of Food Science and Nutrition, University of Agricultural Sciences, GKVK, Bengaluru, India during the year 2022-2023.

2.1 Collection of samples

Silk from the corn variety Syngenta 5414 were harvested in silking stage (7 days after the emergence) and collected from processing unit of Namdhari industries, Bengaluru. Corn silk samples were separated from corn stalks and peels and were then washed with potable water. The samples were freeze-dried in VirTis AdVantage Wizard 2.0 benchtop lyophilizer (-40 ºC and 96 mTorr) until constant weight was obtained. Dried corn silk samples were ground, sieved through BSS-72 mesh sieve (210 microns) and stored in airtight pouches until further analysis.

Other raw materials required for product development were procured from local markets of Bengaluru, India.

2.2 Preparation of corn silk incorporated chapati

Three blends were formulated utilising whole wheat flour and corn silk flour in different blend proportions of 30% (SCT1), 35% (SCT 2) and 40% corn silk flour (SCT 3), as shown in Table 1. As a control, 100% wheat flour chapatis were employed.

Whole wheat flour (*atta*) with corn silk as mentioned in the formulation table, was mixed with optimum water (Gujral and Singh, 1999) [6] and kneaded well. The optimum water was subjectively determined till it gave a smooth non-sticky dough, easy to handle and suitable for sheeting without cracking (Gujral *et al.*, 2004) [5]. The dough was rested for half an hour. Pre-weighed quantity of dough was rounded, placed on the rolling board and was sheeted to a thickness of less than 2 mm using a rolling pin. The raw chapati was immediately placed on a hot plate (*tawa*) and heated at 220 °C on each side till properly cooked.

Table 1: Formulation of corn silk *chapatti*

Particulars (g)	SCC	SCT 1	SCT 2	SCT 3
Corn silk powder	0	30	35	40
Wheat flour	100	70	65	60
Salt	1	1	1	1
Oil	2	2	2	2

2.3 Organoleptic evaluation of the developed products

Products developed were evaluated for sensory characteristics by a panel of 21 semi-trained members using nine-point hedonic scale (Preyam and Pilgrim, 1957) [17]. The products were evaluated for their colour, appearance, texture, taste and overall acceptability. The selected panel members were asked to score sensory characters according to their importance in evaluating the acceptability of different treatments. The mean score was obtained for all the characters and the data was statistically analysed.

2.4 Nutritional analysis

The developed products underwent a comprehensive nutritional analysis, encompassing the assessment of moisture, protein, fat, ash, and dietary fiber content. These analyses followed standardized protocols recommended by the Association of Official Agricultural Chemists (AOAC). The carbohydrate content of the samples was determined utilizing the difference method. Additionally, the energy content of the meals was computed using the factorial method.

2.5 Shelf-life study of best accepted products

The product variation best accepted by the sensory panel and the control chapati were considered for shelf-life studies and the changes in moisture content, sensory characteristics and microbial load were studied.

The products were stored in 300-gauge multi layered polypropylene (MPP) and were studied for sensory characteristics, moisture and microbial population every 24 hours.

Microbial analysis of the best accepted products was carried out as per the standard method by using Nutrient Agar (NA) for bacteria, Eosin Methylene Blue Agar (EMBA) for coliforms and Potato Dextrose Agar (PDA) for fungi.

2.6 Calculation of cost of production

The calculation of costs for both control and best-accepted products involved a comprehensive assessment, considering raw ingredient expenses, processing cost, overhead charges encompassing operational and indirect costs, the cost of labour and machinery operation, and the inclusion of a profit margin.

2.7 Statistical analysis

The experiments were carried out in triplicates. The data were analysed statistically using SPSS software (IBM, SPSS Statistics 16.0). Following ANOVA, Duncan's multiple range test was employed for post-hoc analysis.

3. Results and discussion

3.1 Sensory acceptability of corn silk incorporated chapati

The sensory scores presented in figure 1 highlight the impact of corn silk incorporation at various proportions on chapati sensory quality attributes.

Chapatis made with 100% wheat flour (SCC) had significantly higher score in terms of colour (8.59±0.49) and appearance (8.45±0.50) compared to those with corn silk incorporation, signifying that control chapatis made from 100% wheat flour were visually preferred. The slight decrease in colour and appearance scores in the corn silk-incorporated chapatis (SCT1, SCT2, and SCT3) indicates that the addition of corn silk adversely influenced these visual attributes. However, it's important to note that the differences were relatively small, suggesting that chapatis with corn silk still retained appealing visual qualities.

The texture scores followed a similar trend, with SCC receiving the highest score (8.55±0.50), followed by SCT1 and SCT2, and SCT3 scoring the lowest (6.55±0.72). Statistically significant differences in texture (p-value < 0.001) indicate that higher proportions of corn silk may impact the texture of chapatis. While the differences are noteworthy, they still fall within an acceptable range for sensory acceptability.

The taste score for SCT1 (chapatis with 30% corn silk flour incorporation) was slightly higher than that of SCC (8.36±0.48 *vs.* 8.32±0.47), indicating a subtle improvement in taste. However, it's noteworthy that SCT1 maintained an overall acceptability score (8.45±0.50), which was on par with overall acceptability of SCC (8.50±0.50). These findings suggest that the addition of corn silk may have influenced the taste positively without significantly affecting the overall acceptability of the chapatis. Consumers are likely to find these sensory variations acceptable, particularly when considering the potential health benefits associated with corn silk incorporation.

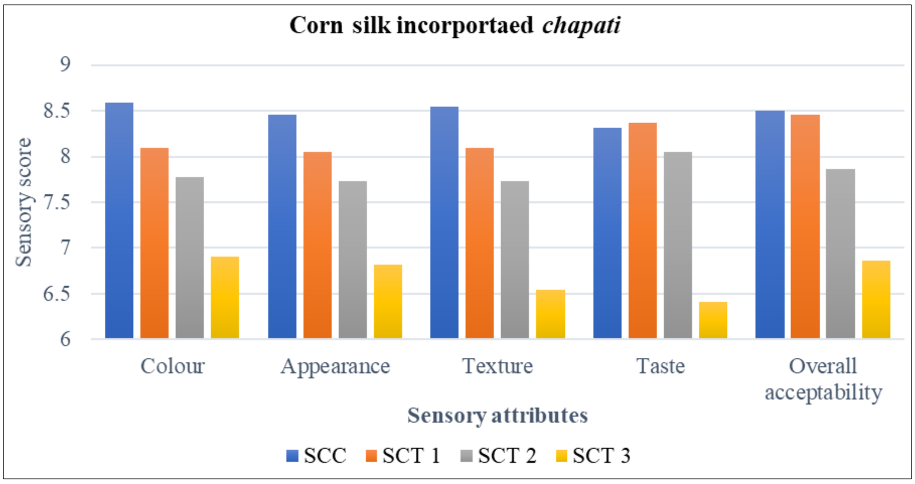

Fig 1: Mean sensory scores of corn silk incorporated chapati

The formulation SCT1, with 30% corn silk flour incorporation, was found to be the best accepted among the three variations in terms of sensory acceptability. Consequently, SCT1, along with the control chapati SCC made from 100% wheat flour, was further considered for nutritional analysis and shelf-life studies.

In line with this, the data presented by Singh and Raghuvanshi (2020) [20] revealed that the addition of corn silk powder to chapati resulted in a gradual decline in organoleptic acceptability, as the percentage of corn silk powder increased from 0% (control) to 10%.

3.2 Proximate composition of corn silk incorporated chapati

Table 2 presents a detailed analysis of the nutritional composition of corn silk-incorporated chapati, particularly comparing control chapati SCC with SCT 1 (chapati with 30% corn silk flour incorporation).

Table 2: Proximate composition of corn silk incorporated *chapatti*

Nutrients per 100 g	SCC	SCT 1	p value	SE (m)	CD
Moisture (%)	27.71±0.09	30.34±0.01	<0.001	0.036	0.236
Fat (g)	1.35±0.08	1.20±0.02	0.208	0.056	NA
Protein (g)	8.83±0.04	9.71±0.06	0.015	0.063	0.413
Total ash (g)	1.13±0.03	1.92±0.03	0.002	0.027	0.175
Dietary fibre (g)	9.20±0.07	10.39±0.06	0.001	0.031	0.201
Carbohydrate (g)	51.78±0.09	46.44±0.10	<0.001	0.078	0.509
Energy (kcal)	254.59±1.02	235.4±0.86	0.001	0.461	3.017

SCC: Control chapati; SCT 1: Chapati incorporated with 30% corn silk; Results are expressed as Mean±SD.

The moisture content of SCT 1 (30.34±0.01%) was significantly higher than that of SCC (27.71±0.09%), indicating that the incorporation of corn silk retained higher moisture content in the chapati. This could potentially affect the texture and shelf life of the product. There was no significant difference in fat content between SCC (1.35±0.08 g) and SCT 1 (1.20±0.02 g), suggesting that corn silk incorporation did not significantly impact the fat content. However, SCT 1 exhibited a higher protein content (9.71±0.06 g) compared to SCC (8.83±0.04 g).

Furthermore, SCT 1 had a significantly higher total ash content (1.92±0.03 g) compared to SCC (1.13±0.03 g), suggesting an increased mineral content with the incorporation of corn silk. Similarly, the dietary fiber content in SCT 1 (10.39±0.06 g) was higher than in SCC (9.20±0.07 g), indicating enhanced fiber content with corn silk incorporation.

SCC contained more carbohydrates (51.78±0.09 g) compared to SCT 1 (46.44±0.10 g), indicating a reduction in carbohydrates due to corn silk inclusion. Similarly, the energy content in SCT 1 (235.4±0.86 kcal) was lower than in SCC (254.59±1.02 kcal), indicating a potential decrease in energy density with corn silk incorporation.

The notable increase in protein, ash, and fiber content in corn silk incorporated chapati can indeed be attributed to the fact that these nutrients are more concentrated in corn silk compared to wheat flour. Corn silk, as a natural source of these nutrients, offers a higher per-gram availability. This suggests that the utilization of corn silk in chapati formulation not only enriches the product's nutritional profile but also aligns with the concept of harnessing the nutritional potential of underutilized resources to enhance the overall quality of food products.

In support of this data, Singh and Raghuvanshi (2020) [20] also reported that, as the percentage of corn silk incorporation increased from 0% (control chapati) to 10%, there was a general trend of increased protein, total ash, dietary fiber (including insoluble and soluble dietary fiber), and a decrease in carbohydrate content of chapati formulations.

3.3 Effect of storage on moisture content of corn silk incorporated chapati

Figure 2 presents the effect of storage duration on the moisture content of corn silk-incorporated chapati, comparing SCC (control chapati) with SCT 1 (chapati with 30% corn silk flour incorporation). On the initial day, SCC had a moisture content of 27.71±0.11%, while SCT 1 had a slightly higher moisture content of 30.34±0.03%. This initial difference suggests that the incorporation of corn silk may have contributed to the increased moisture retention in chapati formulation.

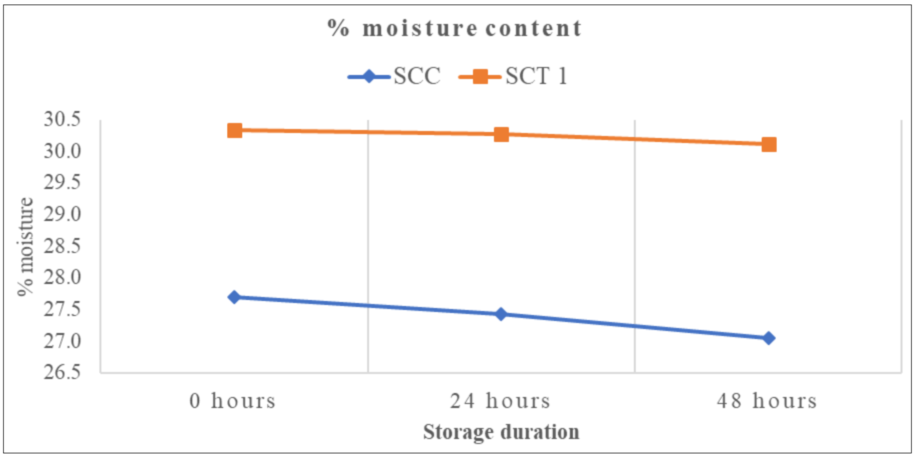

Fig 2: Effect of storage on moisture content of corn silk incorporated chapati

As the storage duration progressed to 48 hours, both SCC and SCT 1 experienced a decrease in moisture content. SCC showed a gradual decline from 27.71% to 27.06%, whereas SCT 1 exhibited a similar pattern, decreasing from 30.34% to 30.12% over the same period. The p-values of 0.001 for SCC and <0.001 for SCT 1 indicate that the changes in moisture content during storage were statistically significant. These findings suggest that storage duration has a measurable impact on the moisture content of both types of chapati.

The observed decrease in moisture content during storage in both SCC and SCT 1 chapati formulations can be attributed, at least in part, to the increasing hardness of the chapati over time. As chapati loses moisture, it tends to become drier and firmer, which can result in a perceptible change in texture and overall quality. These findings are consistent with the research conducted by Khan *et al*. (2011) [10], who also reported a reduction in moisture content as the storage duration increased.

3.4 Effect of storage on sensory properties of corn silk incorporated chapati

Table 3 provides a detailed analysis of the sensory parameters of two chapati formulations, SCC (Control Chapati) and SCT1 (Chapati with 30% corn silk flour incorporation), over storage intervals.

Table 3: Effect of storage on sensory properties of corn silk incorporated *chapatti*

Product	Storage interval	Colour	Appearance	Texture	Taste	Overall acceptability
SCC	0 hours	8.59±0.49ª	8.45±0.50ª	8.55±0.50ª	8.32±0.47ª	8.50±0.50ª
	24 hours	7.86±0.34ᵇ	7.73±0.45ᵇ	6.73±0.75ᵇ	6.86±0.76ᶜ	6.91±0.85ᵇ
	48 hours	6.64±0.83ᶜ	6.68±0.76ᶜ	5.50±0.58ᶜ	-	4.95±0.77
	p value	<0.001	<0.001	<0.001	<0.001	<0.001
	SE(m)	0.132	0.129	0.156	0.152	0.172
	CD at 5%	0.379	0.369	0.220	0.450	0.492
SCT1	0 hours	8.09±0.42ª	8.05±0.21ª	8.09±0.29ª	8.36±0.48ª	8.45±0.50ª
	24 hours	7.64±0.48ᵇ	7.55±0.50ᵇ	6.68±0.87ᵇ	6.73±6.73ᵇ	6.73±0.75ᵇ
	48 hours	6.32±0.55ᶜ	6.23±0.73ᶜ	5.23±0.42ᶜ	-	4.73±0.69ᶜ
	p value	<0.001	<0.001	<0.001	<0.001	<0.001
	SE(m)	0.110	0.116	0.139	0.165	0.162
	CD at 5%	0.315	0.333	0.397	0.488	0.464

SCC: Control chapati; SCT 1: Chapati incorporated with 30% corn silk; Results are expressed as Mean±SD. Values with different alphabetical superscripts within the same column differed significantly.

Over the course of storage period, both SCC (control chapati) and SCT1 (chapati with 30% corn silk flour inclusion) underwent substantial changes in colour perception. On the initial day, both formulations exhibited notably high colour scores, signifying an attractive and visually appealing appearance, with SCC registering 8.59±0.49 and SCT1 scoring 8.09±0.42. However, as the storage duration progressed by 24 hours, a significant decrease in colour scores was observed for both SCC and SCT1, with SCC declining to 7.86±0.34 and SCT1 to 7.64±0.48.

This trend continued on 48 hours of storage, with colour scores further diminishing to 6.64±0.83 for SCC and 6.32±0.55 for SCT1. These findings suggest a noticeable deterioration in colour attributes as the storage period extended, underscoring the importance of monitoring and managing sensory qualities to maintain product appeal and consumer satisfaction.

Comparing the initial and 48-hour values for appearance assessment in both SCC (control chapati) and SCT1 (chapati with 30% corn silk flour incorporation) revealed a notable decline in visual appeal with prolonged storage. On the initial day, both formulations received high appearance scores, reflecting an attractive presentation (SCC: 8.45±0.50, SCT1: 8.05±0.21). However, by 48 hours of storage, these scores had significantly decreased, with SCC at 6.68±0.76 and SCT1 at 6.23±0.73. This decline underscores the impact of extended storage on the perceived visual appeal of the chapati formulations.

On the initial day, texture evaluations of both SCC (control chapati) and SCT1 (chapati with 30% corn silk flour incorporation) indicated favorable scores, with SCC scoring 8.55±0.50 and SCT1 achieving a score of 8.09±0.29. However, as the initial 24 hours of storage passed, there was a notable and significant decrease in texture scores for both formulations, with SCC recording 6.73±0.75 and SCT1 at 6.68±0.87. This decline in texture attributes continued into the 48-hour mark, where scores further decreased, reaching 5.50±0.58 for SCC and 5.23±0.42 for SCT1. These values highlight a noticeable deterioration in texture with prolonged storage, underscoring the impact of time on textural quality. This decline in texture quality can be attributed to hardening of the chapati, depicting the loss of moisture during storage, as indicated by figure 2. The relationship between moisture content and texture deterioration underscores the impact of moisture levels on the textural attributes of chapati during storage.

On the initial day of assessment, both SCC (control chapati) and SCT1 (chapati with 30% corn silk flour incorporation) exhibited high taste scores, SCC scoring 8.32±0.47 and SCT1 scoring 8.36±0.48. However, on 24 hours of storage, both formulations experienced a significant and substantial decrease in taste scores, with SCC recording 6.86±0.76 and SCT1 scoring 6.73±0.75, indicating a prominent decline in taste quality. Notably, the taste scores after 48-hour storage period were not recorded for the products, which was a precaution taken to ensure microbial safety. It's important to note that the decision to withhold the chapati for taste evaluation on the second day was made due to concerns about microbial safety, underscoring the potential impact of storage on taste attributes in food products.

The overall acceptability scores for SCC and SCT1 on the initial day reflected the trends observed in individual sensory parameters. On the initial day, both formulations received high overall acceptability scores, indicating strong initial likability (SCC: 8.50±0.50, SCT1: 8.45±0.50). However, by 48 hours of storage, the overall acceptability scores had substantially decreased, with SCC recording scores of 4.95±0.77 and SCT1 at 4.73±0.69.

Based on the 9-point hedonic scale, where a score of 4 corresponds to 'dislike slightly,' the scores recorded on 48 hours storage period for both SCC and SCT1 (4.95±0.77 and 4.73±0.69, respectively) indicate that the chapati formulations were no longer sensorily acceptable at that stage of prolonged storage.

In line with the findings of this study, Masih *et al.* (2021) [13] and Khan *et al.* (2011) [10] have similarly reported a decrease in the overall acceptability score of chapati as the storage period increased. This consistency in results across studies highlights the common phenomenon of sensory quality deterioration over time and underscores the importance of storage duration impact on consumer acceptability of food products.

3.5 Effect of storage on microbial population of corn silk incorporated chapati

Table 4 provides insights into the effect of storage duration on the microbial population of corn silk incorporated chapati, with specific consideration to Total Bacterial Count (TBC), fungal count, and coliforms.

Table 4: Effect of storage on microbial population of corn silk incorporated *chapatti*

Product	Storage intervals	Population (×10^2 cfu/g)		
		Bacteria	Fungi	Coliforms
SCC	0 hours	0.00 (0.707) ^{b}	0.00 (0.707) ^{b}	0.00 (0.707)
	24 hours	0.50±0.71 (1.000) ^{b}	0.00 (0.707) ^{b}	0.00 (0.707)
	48 hours	11.00±1.41 (3.391) ^{a}	2.50±0.71 (1.732) ^{a}	0.00 (0.707)
	p value	0.006	0.039	-
	S.E(m)	0.500	0.289	-
	CD at 5%	3.276	1.891	-
SCT 1	0 hours	0.00 (0.707) ^{b}	0.00 (0.707)	0.00 (0.707)
	24 hours	0.00 (0.707) ^{b}	0.00 (0.707)	0.00 (0.707)
	48 hours	8.50±0.71 (3.000) ^{a}	0.50±0.71 (1.000)	0.00 (0.707)
	p value	0.004	0.500	-
	S.E(m)	0.289	0.408	-
	CD at 5%	1.891	NA	-

p<0.05; SCC: Control chapati; SCT 1: Chapati incorporated with 30% corn silk; Results are expressed as Mean±SD. Values with different superscripts within the same column differed significantly. Values in parenthesis indicate $\sqrt{(x + 0.5)}$.

The initial day assessments across both SCC (control chapati) and SCT1 (chapati with 30% corn silk flour incorporation) indicate negligible microbial counts, as evidenced by no colony growth, signifying hygienic and uncontaminated products at the start of the study. The lower microbial counts observed on the initial day are likely a result of the heat treatment applied during the preparation of chapati.

As storage progressed to 24 hours, a significant difference emerged in the formulations. SCC recorded a TBC of 0.50 ×10^2 cfu/g, signifying some bacterial proliferation. In contrast, SCT1 maintained a hygienic status with no detectable bacterial growth. This distinction suggests that SCC was more susceptible to bacterial proliferation during the storage period.

By 48 hours of storage period, both SCC and SCT1 exhibited increased bacterial count. SCC recorded a substantial increase, reaching 11×10^2 cfu/g, indicating significant bacterial growth. In comparison, SCT1 also showed an increase but at a lower level, with a total bacterial count of 8.50 ×10^2 cfu/g. These results indicate that both formulations experienced microbial proliferation during the storage period, with SCC displaying a more pronounced increase in bacterial count.

In terms of fungal count, the initial day assessments across both SCC (control chapati) and SCT1 (chapati with 30% corn silk flour incorporation) showed no detectable fungal contamination, affirming the initial quality and cleanliness of the products. On 24 hours of storage, the count remained negligible for both formulations, with no significant difference observed between SCC and SCT1.

However, by 48 hours of storage period, colonies were detected in SCC, with a count of 2.50 $\times10^2$ cfu/g, signifying the presence of fungal growth. In contrast, the count remained low in SCT1 (0.50 $\times10^2$ cfu/g), not significantly differing from the initial day. These findings indicate that prolonged storage led to fungal proliferation in SCC, while SCT1 exhibited better resistance to fungal growth during the same storage period. Notably, coliforms were not detected in the formulation at any storage interval.

A plausible explanation for the observed difference in microbial growth between the formulations could be attributed to the potential antimicrobial properties inherent to corn silk, which were present in SCT1 due to its incorporation. These inherent antimicrobial attributes of corn silk, as reported earlier in the study (Sahana *et al*., 2023) [18], might have played a pivotal role in mitigating bacterial proliferation within SCT1.

In alignment with the results of this study, Masih *et al*. (2021) [13] have similarly noted an increase in microbial proliferation within chapati as the storage period prolonged. This consistency in findings underscores the shared phenomenon of microbial growth with extended storage and highlights the importance of monitoring microbial safety in food products over time.

The comprehensive shelf-life study of chapati formulations incorporating corn silk flour (SCT1) and the control chapati (SCC) provided insights into the product's stability. It was evident that the chapati maintained its sensory quality and microbial safety for a period of up to 24 hours. However, beyond this timeframe, noticeable deteriorations became apparent across various sensory attributes, encompassing colour, appearance, texture, and overall acceptability. Furthermore, the microbial analyses, with a particular focus on total bacterial count (TBC) and fungal count, disclosed a common trend of microbial proliferation in both formulations over time.

3.6 Production cost of corn silk incorporated chapati

Table 5 provides valuable insights into the production cost of corn silk incorporated chapati (SCT1) in comparison to the control chapati (SCC). The table presents a breakdown of the production cost with a detailed analysis of the cost associated with each ingredient and the final product cost. The table highlights the cost of raw materials, processing cost, overhead charges and profit margin considerations.

Table 5: Production cost of corn silk incorporated *chapatti*

Ingredients	Rate ₹ /Kg	SCC		SCT 1	
		Quantity used (g)	**Cost (₹)**	**Quantity used (g)**	**Cost (₹)**
Corn silk flour	0	0	0	35	0
Wheat flour	65	100	6.5	65	4.23
Salt	20	1	0.02	1	0.02
Oil	120	2	0.24	2	0.24
Total		6.76		4.49	
Processing cost (20%)		1.35		0.90	
Overhead charges (30%)		2.03		1.35	
Profit (15%)		1.01		0.67	
Cost of product		11.15		7.41	
Round off to		₹ 12/-		₹ 8/-	

SCC: Control chapati; SCT 1: Chapati incorporated with 30% corn silk

It is evident that the primary cost-contributing factor for both formulations is wheat flour, which is a common ingredient in chapati production. Taking into account the processing cost at 20%, overhead charges at 30% and a profit margin of 15%, the total production cost for SCC is ₹11.15, while SCT1 incurs a cost of ₹7.41. When rounding off these figures, SCC amounts to ₹12, and SCT1 stands at ₹8. These results emphasize the significance of wheat flour in the overall production cost, while also highlighting the cost advantage of SCT1 compared to SCC, making it an economically attractive option for chapati production.

Highlighting the absence of expenses associated with corn silk in the formulations is crucial, as it was sourced from a baby corn processing industry, considering it a byproduct. It is to be taken into account that the costs related to drying and processing of corn silk have been included in the processing costs. The procurement of corn silk as a byproduct from the baby corn processing industry played a substantial role in shaping the cost structure, ultimately leading to a reduced production cost for corn silk incorporated chapati.

4. Conclusion

The incorporation of corn silk into chapati formulations has yielded a multifaceted range of insights. Despite a slight decline in sensory properties, these chapatis offer substantial nutritional advantages, particularly in terms of increased dietary fiber content. The cost-effective use of corn silk as a byproduct adds to their appeal, presenting a multifaceted solution with sensory appeal, nutritional benefits, extended shelf life, and economic viability. This innovative approach not only enhances the nutritional profile of a traditional staple but also addresses sustainability concerns by repurposing agricultural byproducts. Future research could focus on refining storage techniques, optimizing sensory attributes, and exploring corn silk concentrations for an optimal balance between acceptability and nutritional benefits.

5. Author Contributions

Vijayalaxmi, K. G., and Jamuna, K. V. conceived and designed the analysis, and contributed to the data collection and analysis tools. Sahana, H. S. conceptualized and planned the analysis, collected the data, performed the analysis, and prepared the manuscript.

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F-SJSGC-11828).

8. Conflict of interest

Authors Vijayalaxmi, K. G. and Shobha, D. declare they have no financial interests. Author 1 (Sahana, H. S.) has received research support by University Grants Commission India (UGCES-22-GE-KAR-F-SJSGC-11828).

9. Reference

1. Abirami S, Priyalakshmi M, Soundariya A, Samrot AV, Saigeetha S, Emilin RR, *et al*. Antimicrobial activity, antiproliferative activity, amylase inhibitory activity and phytochemical analysis of ethanol extract of corn (*Zea mays* L.) silk. Current Opinion in Green and Sustainable Chemistry. 2021;4:100089.
2. Azevedo ASD, Seibert JB, Amparo TR, Antunes ADS, Sousa LRD, Souza GHB, *et al*. Chemical constituents, antioxidant potential, antibacterial study and photoprotective activity of Brazilian corn silk extract. Food Science & Technology; c2022. p. 42.
3. Chaittianan R, Chayopas P, Rattanathongkom A, Tippayawat P, Sutthanut K. Anti-obesity potential of corn silks: Relationships of phytochemicals and antioxidation, anti-pre-adipocyte proliferation, anti-adipogenesis, and lipolysis induction. Journal of Functional Foods. 2016;23:497-510.
4. Chaudhary RK, Karoli SS, Dwivedi PS, Bhandari R. Anti-diabetic potential of Corn silk (*Stigma maydis*): An in-silico approach. Journal of Diabetes & Metabolic Disorders. 2022;21(1):445-454.
5. Gujral HS, Haros M, Rosell CM. Improving the texture and delaying staling in rice flour chapati with hydrocolloids and α-amylase. Journal of Food Engineering. 2004;65(1):89-94.
6. Gujral HS, Singh N. Effect of additives on dough development, gaseous release and bread making properties. Food Research International. 1999;32(10):691-697.
7. Guo J, Liu T, Han L, Liu Y. The effects of corn silk on glycaemic metabolism. Nutrition & Metabolism. 2009;6:1-6.
8. Hu QL, Zhang LJ, Li YN, Ding YJ, Li FL. Purification and anti-fatigue activity of flavonoids from corn silk. International Journal of Physical Sciences. 2010;5:321-326.
9. Jia Y, Gao X, Xue Z, Wang Y, Lu Y, Zhang M, *et al*. Characterization, antioxidant activities, and inhibition on α-glucosidase activity of corn silk polysaccharides obtained by different extraction methods. International Journal of Biological Macromolecules. 2020;163:1640-1648.
10. Khan MA, Semwal AD, Sharma GK, Mahesh C, Nataraj S, Srihari KA, *et al*. Development and evaluation of long shelf-life ambient stable chapati*es* without the use of chemical preservatives. Journal of Food Processing Technology. 2011;2(1):1-5.
11. Li Y, Hu Z, Wang X, Wu M, Zhou H, Zhang Y. Characterization of a polysaccharide with antioxidant and anti-cervical cancer potentials from the corn silk cultivated in Jilin province. International Journal of Biological Macromolecules. 2020;155:1105-1113.
12. Liu J, Wang C, Wang Z, Zhang C, Lu S, Liu J. The antioxidant and free-radical scavenging activities of extract and fractions from corn silk (*Zea mays* L.) and related flavone glycosides. Food Chemistry. 2011;126(1):261-269.
13. Masih M, Saini S, Mishra RC. Value addition with flours for increased shelf life of Chapati. Pharma Innovation. 2021;10(10):807-816.
14. Morshed S, Islam SM. Antimicrobial activity and phytochemical properties of corn (*Zea mays* L.) silk. SKUAST Journal of Research. 2015;17(1):8-14.
15. Nessa F, Ismail Z, Mohamed N. Antimicrobial activities of extracts and flavonoid glycosides of corn silk (*Zea mays* L). International Journal of Biotechnology and Wellness Industries. 2012;1(2):115-121.
16. Oh KK, Adnan M, Cho DH. Elucidating drug-like compounds and potential mechanisms of corn silk (*Stigma maydis*) against obesity: A network pharmacology study. Current Issues in Molecular Biology. 2021;43(3):1906-1936.
17. Preyam DR, Pilgrim FJ. Hedonic scale method of measuring food preferences. Food Technology. 1957;11:9-14.
18. Sahana HS, Vijayalaxmi KG, Chavan M, Chavannavar SV, Shobha D. Bioactive Potential of Baby Corn Silk: in-vitro Evaluation of Antioxidant, Antimicrobial, Anti-diabetic, and Anti-gout Activities. Pre-print, Research Square; c2023.
19. Sarfare S, Khan SI, Zulfiqar F, Radhakrishnan S, Ali Z, Khan IA. Undescribed C-glycosylflavones from corn silk and potential anti-inflammatory activity evaluation of isolates. Planta Medica. 2022;88(09/10):745-752.
20. Singh A, Raghuvanshi RS. Influence of corn silk powder supplementation on sensory and chemical characteristics of developed food. International Journal of Current Microbiology and Applied Sciences. 2020;11:1072-1081.
21. Velazquez DVO, Xavier HS, Batista JEM, De Castro-Chaves C. *Zea mays* L. extracts modify glomerular function and potassium urinary excretion in conscious rats. Phytomedicine. 2005;12(5):363-369.
22. Wang GQ, Xu T, Bu XM, Liu BY. Anti-inflammation effects of corn silk in a rat model of carrageenin-induced pleurisy. Inflammation. 2012;35:822-827.
23. Yang J, Li X, Xue Y, Wang N, Liu W. Anti-hepatoma activity and mechanism of corn silk polysaccharides in H22 tumor-bearing mice. International Journal of Biological Macromolecules. 2014;64:276-280.
24. Zhao W, Yin Y, Yu Z, Liu J, Chen F. Comparison of anti-diabetic effects of polysaccharides from corn silk on normal and hyperglycemia rats. International Journal of Biological Macromolecules. 2012;50(4):1133-1137.