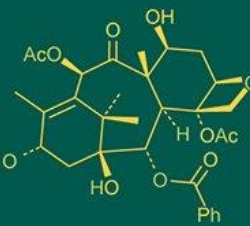
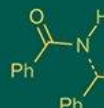
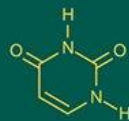


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Standardization and assessment of blended cookies for nutritional quality

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Abstract

This study on standardization and assessment of blended cookies for nutritional quality was conducted during 2022–23 to develop nutritional & value-added functional cookies enriched with custard apple pulp powder and fruit peel powders. Ten different cookies were prepared using varying levels of custard apple pulp powder, wheat flour, while orange peel powder and pomegranate peel powder were incorporated at a fixed level of 6%. The experiment was laid out in a Factorial Completely Randomised Design (FCRD) with three replications, and cookies were evaluated under ambient storage conditions for 90 days. The treatment T₅ (80% wheat flour + 14% custard apple pulp powder + 6% pomegranate peel powder) recorded the highest sensory acceptability and maintained satisfactory quality throughout 90 days of storage. The study demonstrated that incorporation of custard apple pulp powder and fruit peel powders significantly improves the nutritional and functional quality of cookies. Storage studies revealed that starch, protein, antioxidant activity, dietary fibre, and ascorbic acid contents declined over time.

Keywords: Functional foods, under-utilized fruits, custard apple powder, pomegranate peel powder, orange peel powder, by-product utilization, blended cookies, shelf-life.

Introduction

Cookies are widely consumed due to their affordability, convenience, ready-to-eat nature, and long shelf life. However, conventional cookies are mainly prepared from refined wheat flour, sugar, and fat, making them energy-dense but relatively low in dietary fibre and micronutrients. Growing awareness of the relationship between diet and health has increased interest in developing functional bakery products enriched with natural ingredients. Custard apple (*Annona squamosa*), commonly known as sitaphal or sugar apple, is a nutrient-rich fruit containing carbohydrates, vitamins, and minerals and is beneficial for energy and nervous system function (Gopalan *et al.*, 1989) [5].

Processing custard apple into value-added products such as pulp powder can extend shelf life and improve utilization while retaining its nutritional and functional properties (Khodifad *et al.*, 2016) [9]. Cookies provide a suitable medium for incorporating custard apple pulp powder because of their wide consumer acceptance and storage stability. Additionally, fruit by-products such as pomegranate peel powder and orange peel powder are rich in dietary fibre, phenolic compounds, flavonoids, antioxidants, and minerals, making them valuable ingredients for enhancing the nutritional quality of bakery products while promoting sustainable utilization of agro-waste (Braddock, 1999; Gorinstein *et al.*, 2001; Ismail *et al.*, 2014) [4, 6, 7].

However, the incorporation of such non-traditional ingredients may influence dough characteristics, baking quality, texture, colour, flavour, and overall acceptability. Therefore, standardization of formulation levels and evaluation of physico-chemical and sensory attributes are essential for developing acceptable and nutritious functional cookies.

Materials and Methods

The experiment was conducted during 2022-23 at the Postharvest Laboratory, College of Horticulture, Mojerla, Wanaparthy, Telangana and laid out in a factorial completely randomized design (FCRD) with three replications comprising ten treatments consisting of

different proportions of wheat flour, custard apple pulp powder (cv. Balanagar), pomegranate peel powder (var. Bhagwa) and orange peel powder as following.

The treatments consisted of wheat flour at 100% (control) and at 80%, 60%, and 40% levels in the formulated cookies. Custard apple pulp powder was incorporated at 20%, 40%, and 60% levels, while in peel-supplemented formulations, it was used at 14%, 34%, and 54% to accommodate a fixed inclusion of 6% peel powder. Pomegranate peel powder and orange peel powder were each added separately at a constant level of 6%.

Cookies were prepared using food-grade wheat flour, custard apple pulp powder, pomegranate peel powder, orange peel powder, sugar, unsalted butter, baking powder, and baking soda in the required proportions. Sugar powder and butter (1:1) were creamed, followed by the addition of baking soda and baking powder (1:2). These were incorporated into the flour and powder blends and formed into dough, which was shaped into cookies and baked in a preheated oven (INALSA Master Chef 24RSS OTG) at 120°C for 20 min after preheating for 5 min. The baked cookies were cooled to room temperature and packed in sealed bags. No essence or artificial flavouring agents were added to avoid interference with ingredient analysis and sensory evaluation.

The prepared cookies were analyzed for starch, protein, total dietary fiber, antioxidants and ascorbic acid.

Results and Discussion

The properties of the raw material used like wheat flour, custard apple pulp powder, pomegranate peel powder, orange peel powder were analyzed and presented in Table 1.

Starch (%)

The analysis for starch (%) during storage (Table 2) revealed that cookies made with 100% wheat flour (T₁) had the highest starch content (43.40%), followed by T₈ (38.05%), while the lowest (24.81%) was observed in T₄ (40% wheat flour + 60% custard apple pulp powder). The starch content decreased significantly during storage, from 34.58% at day 0 to 30.86% at 90th day. Among interactions, the highest starch content (45.00%) was recorded in T₁ at day 0, whereas the lowest (22.72%) was found in T₇ at 90 days. Starch content in wheat flour used as raw material is highest among the ingredients (Table 1), hence it might have led to higher starch content in the treatment T₁ containing 100% wheat flour. The reduction in starch content during storage may be due to gelatinization and conversion into reducing sugars, consistent with earlier findings (Ndife *et al.* 2014; Le-Bail *et al.* 2018) ^[11, 10].

Protein (%)

The results revealed that combination of different flours had significantly affected protein content during storage of cookies (Table 3). The highest protein content was observed in T₁ (100% wheat flour, 19.61%), followed by T₅ (80% wheat flour+14% custard apple pulp+6% pomegranate peel, 17.86%), while the lowest was recorded in T₁₀ (40% wheat flour+54% custard apple pulp+6% orange peel, 13.29%), which was on par to T₄ (13.36%). Protein content gradually decreased during storage from 16.53% on the 0th day to 15.83% on the 90th day. Interaction effects revealed that

maximum protein (19.88%) was recorded in T₁ on the 0th day and the minimum (12.96%) in T₁₀ on the 90th day. The higher protein in T₁ is attributed to 100% wheat flour, which had the highest protein content among the raw materials used (Table 1). The decline in protein during storage may be due to denaturation and aggregation of proteins under temperature and humidity, reducing solubility and digestibility, consistent with observations by Sobhan *et al.* (2014) ^[15] and Sujirtha and Mahendran (2015) ^[16].

Antioxidant activity by DPPH method (%)

The data on antioxidant activity during storage was presented in Table 4, which indicated significant differences between treatments. The highest was observed in T₇ (40% wheat flour+54% custard apple pulp+6% pomegranate peel, 32.03%), followed by T₁₀ (30.35%), while the lowest was in T₁ (100% wheat flour, 20.31%). Antioxidant activity gradually decreased during storage from 27.26% on the 0th day to 26.99% on the 90th day, with the values on the 30th (27.17%) and 60th day (27.06%) being comparable. Interaction effects showed maximum activity (32.11%) in T₇ on the 0th day and minimum (20.17%) in T₁ on the 90th day. The higher activity in T₇ is attributed to custard apple pulp and pomegranate peel, consistent with Abd-Allah *et al.* (2016). The gradual decline during storage is likely due to oxidation of antioxidant compounds from exposure to oxygen and light (Ismail *et al.* 2014) ^[17].

Dietary fiber (%)

The data on dietary fiber percentage (Table 5) indicated there was a significant difference between treatments. The highest dietary fibre (11.44%) was observed in T₁₀ (40% wheat flour+54% custard apple pulp powder+6% orange peel powder), followed by T₉ (10.34%), while the lowest (5.94%) was in T₁. During storage, maximum dietary fibre (9.47%) was recorded on the 0th day, which was on par with the 30th day (9.30%), whereas minimum (8.99%) was observed on the 90th day, comparable with the 60th day (9.12%), indicating a gradual decrease over storage. Interaction effects showed that the highest dietary fibre (11.67%) was in T₁₀ on the 0th day and the lowest (5.57%) in T₁ on the 90th day. These findings agree with Belose *et al.* (2021) ^[2] and Zaker *et al.* (2016) ^[17], who reported that orange peel incorporation enhances dietary fibre and improves the nutritional quality of cookies.

Ascorbic acid (mg/100 g)

Various and different percentages of flours for cookies during storage influenced the ascorbic acid (Table 6). The highest ascorbic acid was recorded in T₁₀ (40% wheat flour+54% custard apple pulp+6% orange peel, 18.42 mg/100 g) followed by T₉ (16.20 mg/100 g), while the lowest was in T₁ (100% wheat flour, 4.34 mg/100 g). Ascorbic acid content gradually declined during storage from 10.79 mg/100 g on the 0th day to 9.67 mg/100 g on the 90th day. Interaction effects showed maximum content (19.03 mg/100 g) in T₁₀ on the 0th day and minimum (3.70 mg/100 g) in T₁ on the 90th day. Maximum ascorbic acid (vitamin C) in T₁₀ is attributed to orange peel powder, which naturally enriches cookies with ascorbic acid, consistent with Ojha and Thapa (2017).

Table 1: Properties of different flours used as raw material for cookie preparation

Parameters	Wheat flour	Custard apple pulp powder	Pomegranate peel powder	Orange peel powder
Starch (%)	71.13	0.61	2.16	0.70
Protein (%)	12.13	1.76	5.93	3.60
Antioxidant (DPPH method) (%)	3.90	31.20	67.96	39.10
Dietary fibre (%)	1.23	5.36	9.16	12.30
Ascorbic acid (mg/100 g)	4.20	16.23	11.40	48.16

Table 2: Effect of different treatments on Starch (%) of cookies during storage

Treatments (T)	Starch (%)				
	0 th day	30 th day	60 th day	90 th day	Mean T
T ₁ -Wheat flour 100%	45.00	43.85	42.93	41.84	43.40 ^a
T ₂ -Wheat flour 80%+Custard apple pulp powder 20%	39.30	38.40	37.16	35.96	37.70 ^b
T ₃ -Wheat flour 60%+Custard apple pulp powder 40%	33.36	32.25	30.92	29.49	31.51 ^c
T ₄ -Wheat flour 40%+Custard apple pulp powder 60%	26.76	25.45	24.30	22.73	24.81 ^d
T ₅ -Wheat flour 80%+Custard apple pulp powder 14%+PPP 6%	39.49	38.30	37.32	36.14	37.81 ^b
T ₆ -Wheat flour 60%+Custard apple pulp powder 34%+ PPP 6%	33.84	32.66	31.43	30.15	32.02 ^c
T ₇ -Wheat flour 40%+Custard apple pulp powder 54%+PPP 6%	26.88	25.63	24.43	22.72	24.92 ^d
T ₈ -Wheat flour 80%+Custard apple pulp powder 14%+OPP 6%	39.79	38.60	37.50	36.30	38.05 ^b
T ₉ -Wheat flour 60%+Custard apple pulp powder 34%+ OPP 6%	33.78	32.55	31.30	29.99	31.91 ^c
T ₁₀ -Wheat flour 40%+Custard apple pulp powder 54%+ OPP 6%	27.56	26.22	24.72	23.25	25.44 ^d
Mean S	34.58	33.39	32.20	30.86	
	T		S		T x S
SE(m)±	0.30		0.19		0.60
CD at 5%	0.84		0.53		1.69

PPP- Pomegranate peel powder; OPP- Orange peel powder

Table 3: Effect of different treatments on the protein (%) of cookies during storage

Treatments (T)	protein (%)				
	0 th day	30 th day	60 th day	90 th day	Mean T
T ₁ -Wheat flour 100%	19.88	19.73	19.49	19.34	19.61 ^a
T ₂ -Wheat flour 80%+Custard apple pulp powder 20%	17.46	17.29	16.95	16.70	17.10 ^d
T ₃ -Wheat flour 60%+Custard apple pulp powder 40%	16.61	16.50	16.14	15.96	16.30 ^f
T ₄ -Wheat flour 40%+Custard apple pulp powder 60%	13.73	13.52	13.18	13.00	13.36 ^h
T ₅ -Wheat flour 80%+Custard apple pulp powder 14%+PPP 6%	18.11	18.01	17.82	17.52	17.86 ^b
T ₆ -Wheat flour 60%+Custard apple pulp powder 34%+ PPP 6%	16.78	16.63	16.25	16.04	16.42 ^{ef}
T ₇ -Wheat flour 40%+Custard apple pulp powder 54%+PPP 6%	14.26	14.01	13.60	13.35	13.80 ^g
T ₈ -Wheat flour 80%+Custard apple pulp powder 14%+OPP 6%	18.01	17.85	17.42	17.22	17.62 ^c
T ₉ -Wheat flour 60%+Custard apple pulp powder 34%+ OPP 6%	16.91	16.67	16.42	16.25	16.56 ^e
T ₁₀ -Wheat flour 40%+Custard apple pulp powder 54%+ OPP 6%	13.60	13.43	13.18	12.96	13.29 ^h
Mean S	16.53 ^a	16.36 ^b	16.04 ^c	15.83 ^d	
	T		S		T x S
SE(m)±	0.07		0.04		0.14
CD at 5%	0.20		0.13		0.41

PPP- Pomegranate peel powder; OPP- Orange peel powder

Table 4: Effect of different treatments on antioxidant acidity (DPPH method%) of cookies during storage

Treatments (T)	antioxidant acidity (DPPH method%)				
	0 th day	30 th day	60 th day	90 th day	Mean T
T ₁ -Wheat flour 100%	20.44	20.38	20.25	20.17	20.31 ^j
T ₂ -Wheat flour 80%+Custard apple pulp powder 20%	23.91	23.81	23.67	23.60	23.75 ⁱ
T ₃ -Wheat flour 60%+Custard apple pulp powder 40%	26.89	26.78	26.70	26.59	26.74 ^g
T ₄ -Wheat flour 40%+Custard apple pulp powder 60%	28.97	28.87	28.79	28.73	28.84 ^d
T ₅ -Wheat flour 80%+Custard apple pulp powder 14%+PPP 6%	27.15	27.05	26.96	26.90	27.01 ^f
T ₆ -Wheat flour 60%+Custard apple pulp powder 34%+ PPP 6%	29.73	29.65	29.44	29.35	29.54 ^c
T ₇ -Wheat flour 40%+Custard apple pulp powder 54%+PPP 6%	32.11	32.05	32.01	31.96	32.03 ^a
T ₈ -Wheat flour 80%+Custard apple pulp powder 14%+OPP 6%	25.22	25.07	25.01	24.95	25.06 ^h
T ₉ -Wheat flour 60%+Custard apple pulp powder 34%+ OPP 6%	27.71	27.62	27.51	27.44	27.57 ^e
T ₁₀ -Wheat flour 40%+Custard apple pulp powder 54%+ OPP 6%	30.50	30.39	30.29	30.24	30.35 ^b
Mean S	27.26 ^a	27.17 ^b	27.06 ^{bc}	26.99 ^c	
	T		S		T x S
SE(m)±	0.06		0.04		0.13
CD at 5%	0.18		0.11		0.37

PPP- Pomegranate peel powder; OPP- Orange peel powder

Table 5: Effect of different treatments on dietary fibre (%) of cookies during storage

Treatments (T)	dietary fibre (%)				
	0 th day	30 th day	60 th day	90 th day	Mean T
T ₁ -Wheat flour 100%	6.25	6.05	5.91	5.57	5.94 ^g
T ₂ -Wheat flour 80%+Custard apple pulp powder 20%	7.41	7.18	6.87	6.46	6.98 ^f
T ₃ -Wheat flour 60%+Custard apple pulp powder 40%	9.21	9.03	8.84	8.46	8.88 ^d
T ₄ -Wheat flour 40%+Custard apple pulp powder 60%	10.73	10.62	10.46	10.21	10.50 ^b
T ₅ -Wheat flour 80%+Custard apple pulp powder 14%+PPP 6%	8.54	8.51	8.31	8.17	8.38 ^e
T ₆ -Wheat flour 60%+Custard apple pulp powder 34%+ PPP 6%	10.08	10.00	9.80	9.68	9.89 ^c
T ₇ -Wheat flour 40%+Custard apple pulp powder 54%+PPP 6%	11.57	11.42	11.21	10.97	11.29 ^a
T ₈ -Wheat flour 80%+Custard apple pulp powder 14%+OPP 6%	8.88	8.70	8.51	8.20	8.57 ^e
T ₉ -Wheat flour 60%+Custard apple pulp powder 34%+ OPP 6%	10.50	10.34	10.33	10.19	10.34 ^b
T ₁₀ -Wheat flour 40%+Custard apple pulp powder 54%+ OPP 6%	11.67	11.54	11.41	11.14	11.44 ^a
Mean S	9.47 ^a	9.30 ^{ab}	9.12 ^{bc}	8.99 ^c	
	T		S		T x S
SE(m)±	0.10		0.06		0.20
CD at 5%	0.29		0.18		0.58

PPP- Pomegranate peel powder; OPP- Orange peel powder

Table 6: Effect of different treatments on the ascorbic acid (%) of cookies during storage

Treatments (T)	ascorbic acid (%)				
	0 th day	30 th day	60 th day	90 th day	Mean T
T ₁ -Wheat flour 100%	4.83	4.56	4.26	3.70	4.34 ⁱ
T ₂ -Wheat flour 80%+Custard apple pulp powder 20%	6.73	6.40	6.13	5.66	6.23 ^h
T ₃ -Wheat flour 60%+Custard apple pulp powder 40%	8.80	8.40	7.93	7.66	8.20 ^g
T ₄ -Wheat flour 40%+Custard apple pulp powder 60%	10.30	9.73	9.43	8.93	9.60 ^e
T ₅ -Wheat flour 80%+Custard apple pulp powder 14%+PPP 6%	6.63	6.20	6.00	5.63	6.11 ^h
T ₆ -Wheat flour 60%+Custard apple pulp powder 34%+ PPP 6%	9.13	8.83	8.56	8.46	8.75 ^f
T ₇ -Wheat flour 40%+Custard apple pulp powder 54%+PPP 6%	11.13	10.73	10.26	9.86	10.50 ^d
T ₈ -Wheat flour 80%+Custard apple pulp powder 14%+OPP 6%	14.46	14.00	13.80	13.43	13.92 ^c
T ₉ -Wheat flour 60%+Custard apple pulp powder 34%+ OPP 6%	16.90	16.40	15.96	15.53	16.20 ^b
T ₁₀ -Wheat flour 40%+Custard apple pulp powder 54%+ OPP 6%	19.03	18.63	18.23	17.80	18.42 ^a
Mean S	10.79 ^a	10.36 ^b	10.08 ^c	9.67 ^d	
	T		S		T x S
SE(m)±	0.10		0.06		0.21
CD at 5%	0.29		0.18		0.59

PPP- Pomegranate peel powder; OPP- Orange peel powder

Conclusion

Based on the results of the study, it can be concluded that the incorporation of pomegranate and orange peels can improve the antioxidant activity and dietary fibre content of cookies. The prepared cookies had good overall acceptability with good sensory quality and storability. Further, the cookies from the treatment T₅ (wheat flour 80%+custard apple pulp powder 14%+pomegranate peel powder 6%) had good storability upto 90 days at ambient conditions.

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