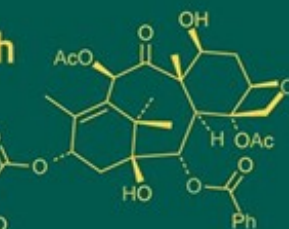
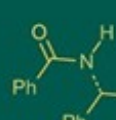


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Development and quality evaluation of toffee prepared from coconut testa, a by-product of coconut milk extraction

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ABSTRACT

The brown testa pared from coconut kernel before milk extraction is normally discarded. This study used it as the principal ingredient of a toffee. Finely grated testa (30 g), fresh coconut milk extracted at a kernel-to-water ratio of 60:40 (30 g) and refined sugar (40 g) were cooked with continuous stirring to the soft-ball stage (112-115 °C). The toffee was analysed for proximate and mineral composition and physicochemical properties, evaluated by 30 semi-trained panellists on a nine-point hedonic scale, and stored at 25 ± 2 °C for 9 days with sensory quality, free fatty acids and total viable count measured at 3-day intervals. Yield was 80% and the raw-material cost was ₹6.50 per 100 g. Per 100 g, the toffee contained 6.12 g moisture, 19.64 g fat, 3.28 g protein, 10.46 g crude fibre, 2.08 g ash and 58.42 g carbohydrate (423.56 kcal), with 92.36 mg calcium, 98.54 mg magnesium and 118.72 mg sodium. Total soluble solids were 82.45 °Brix and pH was 6.42. Fresh toffee scored 8.55-8.65 for all attributes (overall acceptability 8.60). Scores did not differ significantly from day 0 on day 3, declined significantly by day 6 and reached 7.72 for overall acceptability on day 9. Free fatty acids increased from 0.18% to 0.32% (as lauric acid) and total viable count from 2.26 to 3.52 log₁₀ CFU/g. Coconut testa can be converted into an acceptable toffee with appreciable crude fibre; longer storage trials and oxidative-stability measurements are needed to define its shelf life.

Keywords: Coconut parings, By-product valorisation, Sugar confectionery, Hedonic evaluation, Free fatty acids, Storage stability

Introduction

Coconut (*Cocos nucifera* L.) is one of the principal plantation crops of the humid tropics, and India is currently the largest producer, harvesting about 20,301 million nuts from 2.19 million ha in 2024-25 (PIB, 2026) [17]. Beyond copra and oil, a growing share of the kernel is processed wet into coconut milk, desiccated coconut and virgin coconut oil. Each of these routes requires the thin brown seed coat, or testa, to be pared from the white kernel so that the product keeps its light colour.

Paring is not a trivial loss. Roughly 10-15% of the kernel is removed as testa during desiccated-coconut manufacture (Ramesh *et al.*, 2023) [18], and one estimate places the quantity generated at about 6.5 t per 100,000 nuts (Ulpathakumbura *et al.*, 2025) [22]. The material is usually pressed for low-grade oil, with the residue diverted to animal feed (Ramesh *et al.*, 2023; Ulpathakumbura *et al.*, 2025) [18, 22]. Compositionally, testa is lipid-rich, with fat contents of 34-63% reported for wet and dried testa and kernel fractions (Appaiah *et al.*, 2014) [4]. Its oil carries more mono- and polyunsaturated fatty acids than kernel oil (Appaiah *et al.*, 2014) [4], and the tissue contains phenolic acids and flavonoids with measurable antioxidant activity (Arivalagan *et al.*, 2018; Ramesh *et al.*, 2023) [5, 18].

These properties have prompted several food applications. Defatted testa flour has been substituted for up to 30% of wheat flour in cookies without loss of overall acceptability (Marikkar *et al.*, 2020) [15], incorporated into string hopppers and flat breads (Rushdha *et al.*, 2022) [20], and ground into a cream proposed as a substitute for coconut milk in cooking (Kumari *et al.*, 2024) [14]. Testa extracts have also been examined as a natural colourant (Ramesh *et al.*, 2024) [19]. Almost all of this work uses dried or defatted testa, which adds drying and extraction steps. Using freshly pared testa directly, at the point where it is generated alongside coconut milk, has received little attention.

Sugar-boiled confectionery offers a simple vehicle for such use. Indian food standards define toffee within sugar-boiled confectionery and explicitly allow nut products and desiccated coconut among its ingredients (FSSAI, 2023) [10]. In these products the cooking endpoint fixes the final water content, which in turn governs texture, water activity and much of the storage behaviour (Ergun *et al.*, 2010) [9]. A toffee built from testa, coconut milk and sucrose would therefore combine a low-moisture sugar matrix with a lipid phase that

includes the more unsaturated testa oil, making lipid hydrolysis and sensory change during storage a practical concern.

No published study appears to have characterised a toffee in which fresh coconut testa is the principal non-sugar ingredient. The objective of this work was to prepare such a toffee from testa generated during coconut milk extraction, together with coconut milk and sucrose, and to describe its yield, raw-material cost, proximate and mineral composition, physicochemical properties and sensory acceptability, as well as the changes in sensory scores, free fatty acids and total viable count during 9 days of ambient storage.

Materials and methods

Raw materials

Mature, sound coconuts, refined sugar and other food-grade materials were purchased in a single lot from the local market of Udaipur, Rajasthan, India, to limit variation in cultivar, maturity and storage history. The work was carried out in the Food and Nutrition Laboratory, Department of Food Science and Nutrition, and the Dairy Technology Laboratory, Department of Dairy and Food Technology, Maharana Pratap University of Agriculture and Technology, Udaipur. Nuts were washed under running water, dehusked and de-shelled by hand. The brown testa was pared from the kernel with a stainless-steel knife, and the white kernel was used for coconut milk.

Coconut milk

Pared kernel was sliced to 2-3 mm in a food processor (Sujata Powermatic Plus, 1440 rpm, 45-60 s) and wet-ground with potable water at a kernel-to-water ratio of 60:40 (w/v) in a mixer-grinder (Sujata Supermix, 1.5 L stainless-steel jar, about 3000 rpm, 90-120 s). The slurry was filtered through sterile double-layered muslin and pressed by hand for 3-4 min. The 60:40 ratio had been selected in preliminary trials from ratios of 50:50, 60:40 and 70:30 on the basis of yield and sensory acceptability; the milk was used fresh.

Preparation of the testa and the toffee

The pared testa was sorted by eye to remove spoiled or mouldy pieces, washed under running potable water, drained on a stainless-steel sieve and finely grated. Where bitterness or surface contamination was a concern, the grated testa was blanched in hot water for 2-3 min and cooled.

Each 100 g batch comprised 30 g grated testa, 30 g coconut milk and 40 g refined sugar (Table 1). The ingredients were cooked in a heavy-bottomed stainless-steel pan (or steam-jacketed kettle) over medium heat with continuous stirring until the mass thickened, turned glossy and left the sides of the pan. The endpoint was the soft-ball stage (112-115 °C), confirmed by dropping a small portion into cold water, where it formed a soft, cohesive ball].

The hot mass was poured onto a greased food-grade tray, spread to a uniform thickness, cooled undisturbed at ambient temperature, and cut into pieces with a greased knife [Pieces were wrapped individually in butter paper or food-grade film and held in airtight containers. No colours, flavours or preservatives were added. Three independent batches were prepared. The process is summarised in Fig. 1.

Yield was calculated as the mass of toffee obtained divided by the total mass of ingredients $\times 100$. The raw-material cost was calculated from the ingredient prices at the time of the study; overheads (labour, fuel, packaging, equipment) were excluded, and testa was costed at nil because it is a by-product.

Proximate and mineral composition

Moisture was determined by oven drying at 105 °C to constant mass. Ash was determined by dry ashing in a muffle furnace at 500 °C (AOAC, 1984) [1]. Crude protein was determined by the micro-Kjeldahl method ($N \times 6.25$) (AOAC, 2000) [2]. Crude fibre was determined by sequential digestion with 0.25 M H₂SO₄ and 0.31 M NaOH on a fat-free sample, followed by drying and incineration at 550 °C (AOAC, 2006) [3]. Fat was determined by the Gerber method (ISO

488:2008 [12]. Carbohydrate was calculated by difference [100 - (moisture + protein + fat + crude fibre + ash)], and energy with factors of 4, 9 and 4 kcal/g for protein, fat and carbohydrate (Gopalan *et al.*, 2007) [11].

For minerals, samples were wet-digested. Calcium was titrated with 0.01 N EDTA using ammonium purpurate as indicator (Cheng *et al.*, 1951) [7]; magnesium was titrated with 0.1 M EDTA at pH 10 using Eriochrome Black T; and sodium was measured by flame photometry against 0-10 ppm standards.

Physicochemical properties

Total soluble solids were read on a hand refractometer calibrated with distilled water; a weighed portion of toffee was dissolved in distilled water and the reading was corrected for dilution. pH was measured with a calibrated digital pH meter. Titratable acidity was determined by titration with 0.1 N NaOH to a phenolphthalein endpoint (ISO 6091:2010) [13]. The apparent viscosity of the hot toffee mass was measured with a Brookfield viscometer.

Sensory evaluation

Thirty semi-trained panellists drawn from staff and students of the two departments evaluated colour, appearance, flavour, taste, texture and overall acceptability on a nine-point hedonic scale (9 = like extremely, 1 = dislike extremely) (Peryam *et al.*, 1957) [16]. The same panel was used at every storage interval.

Storage study

Wrapped toffees in airtight containers were stored at ambient temperature (25 $\pm$ 2 °C) and sampled on days 0, 3, 6 and 9 for sensory evaluation, free fatty acids and total viable count.

Free fatty acids were determined by the titrimetric method of Cox *et al.* (1962) [8]. About 10 g sample was extracted with 100 mL of a 1:1 (v/v) ethanol-diethyl ether mixture, filtered (Whatman No. 1) and titrated with 0.1 N KOH to a phenolphthalein endpoint; results were expressed as % lauric acid.

Total viable count was determined by the pour-plate method on tryptone glucose yeast extract agar (tryptone 5.0 g, yeast extract 3.0 g, D-glucose 1.0 g, agar 15.0 g per litre; 121 °C, 15 min). Serial decimal dilutions were prepared in sterile 0.9% NaCl, plated in triplicate, and incubated at 37 °C for 48 $\pm$ 2 h; counts were expressed as log₁₀ CFU/g.

Statistical analysis

Compositional and physicochemical results are reported as mean $\pm$ standard deviation. Because a single formulation was studied, no between-formulation comparison was made. Sensory scores across storage intervals were analysed by two-way analysis of variance (storage interval $\times$ replication); the standard error of difference ($SE_d = \sqrt{2MSE/r}$) and critical difference at $p \leq 0.05$ ($CD = SE_d \times t_{0.05, \text{error df}}$) were calculated, and a mean was taken to differ from day 0 when the difference exceeded the Free fatty acid and total viable count data are reported descriptively as mean $\pm$ SD; no inferential test was reported for them in the thesis.

Results and Discussion

Yield and raw-material cost

Each 100 g batch gave 80 g of toffee, a yield of 80% (Table 1). The 20 g loss was attributed to evaporation during concentration to the soft-ball stage. Raw-material cost was ₹5.20 per batch, or ₹6.50 per 100 g of toffee; the testa carried no cost because it is a residue of coconut milk extraction, and overheads were excluded.

The yield should be read together with the composition data. With the thesis's own composition of the coconut milk (76.20 g moisture/100 g), an 80 g yield at 6.12% moisture requires the 30 g of testa to have contributed about 28 g of dry matter, i.e. to have been close to dry. Freshly pared, disintegrated testa typically holds 40-47% moisture (Ulpathakumbura *et al.*, 2025) [22].

Proximate and mineral composition

Carbohydrate was the largest component (58.42 g/100 g), followed by fat (19.64 g/100 g) and crude fibre (10.46 g/100 g); moisture was 6.12 g/100 g and energy 423.56 kcal/100 g (Table 2). Because 40 g of sucrose ended up in 80 g of toffee, added sugar alone accounts for about 50 g/100 g of product, so most of the carbohydrate fraction is formulation sucrose rather than testa-derived material.

The fat content reflects two lipid sources. The coconut milk used here contained 17.80 g fat/100 g, supplying about 5.3 g of fat per batch, and coconut testa is itself lipid-rich, with 34-63% fat reported across testa and kernel fractions (Appaiah *et al.*, 2014) [4]. The testa contribution matters for storage, because testa oil contains more mono- and polyunsaturated fatty acids than kernel oil (Appaiah *et al.*, 2014) [4].

The testa was the only substantial source of crude fibre in the formulation. Published crude-fibre values for dried testa are about 11.6-16% (Ulpathakumbura *et al.*, 2025) [22], and the value found here is higher than those figures would predict for a 30% inclusion of fresh testa [Crude fibre, measured after acid and alkali digestion, recovers only part of the plant cell wall; defatted testa flour contains 68.7-72.9% total dietary fibre (Rushdha *et al.*, 2022) [20]. Any fibre-related description of the product would therefore need total dietary fibre data, which were not determined.

Moisture was lower than the 8.73% reported for a guava-strawberry toffee cooked to a similar soluble-solids level (Chavan *et al.*, 2015) [6]. Low water content is the main compositional reason for the product's microbial stability discussed below (Ergun *et al.*, 2010) [9].

Among the three minerals determined, sodium was highest (118.72 mg/100 g), followed by magnesium (98.54 mg/100 g) and calcium (92.36 mg/100 g). No salt was added; wet testa contains about 30 mg Na/100 g (Appaiah *et al.* 2014, as summarised by Ulpathakumbura *et al.* 2025) [4] and the coconut milk 15.2 mg/100 g, so the sodium value is several times higher than the ingredients would supply. The mineral values are reported as measured and are not interpreted nutritionally.

The FSSAI standard for sugar-boiled confectionery, which includes toffee, sets limits on sulphated ash ($\leq 2.5\%$, salt-free basis) and ash insoluble in dilute HCl ($\leq 0.2\%$), with additional protein and fat minima only for products sold as milk or butter toffee (FSSAI, 2023) [10]. The standard has no moisture or total-sugar criterion. Total ash (2.08%) was measured here, but sulphated and acid-insoluble ash were not, so conformity with the standard cannot be stated from these data.

Physicochemical properties

The toffee had a total soluble solids content of 82.45 °Brix, a pH of 6.42 and a titratable acidity of 0.18% (Table 3). The soluble-solids value is close to the 83.21 °Brix reported for guava-strawberry toffee (Chavan *et al.*, 2015) [6], consistent with a similar degree of sugar concentration at the soft-ball endpoint. The near-neutral pH is expected for a formulation without fruit or added acid, since both coconut milk and sucrose are close to neutral. The apparent viscosity of the hot mass was 6840 cP; because the measurement temperature was not recorded, this value is useful only as a process record and cannot be compared with other studies.

Sensory quality and its change during storage

Freshly prepared toffee scored 8.55-8.65 for all six attributes, between "like very much" and "like extremely" (Table 4, day 0). Texture scored highest (8.65) and colour lowest (8.55). The thesis

records that panellists reported no bitterness or off-flavour, indicating that washing (and, where used, blanching) of the testa was sufficient to avoid the astringency that phenolic-rich testa might otherwise impart (Arivalagan *et al.*, 2018) [5].

These scores come from a semi-trained in-house panel evaluating a single product without a reference sample. Such panels are familiar with the product and the laboratory, and their hedonic scores are not a substitute for consumer acceptance testing. The absence of a comparison product also means that the scores cannot show whether testa improves or detracts from a conventional coconut toffee.

During storage at $25 \pm 2^\circ\text{C}$, no attribute differed significantly from day 0 on day 3, although the day⁻³ reduction in texture (0.25) equalled its critical difference (0.25) (Table 4). All six attributes were significantly lower than on day 0 by day 6. On day 9, overall acceptability was 7.72, still above "like moderately" (7). Flavour showed the largest fall (from 8.58 to 7.58), followed by taste (8.62 to 7.70) and texture (8.65 to 7.75); appearance changed least (8.60 to 7.85).

The larger decline in flavour than in appearance points to chemical rather than visual change as the first sign of deterioration. In sugar confections, moisture exchange with the surroundings drives textural change and graining, and is often the limiting factor in shelf life (Ergun *et al.*, 2010) [9]. Moisture content and water activity were not followed during storage, so this mechanism could not be confirmed. The lipid phase is a second likely contributor, given the unsaturated fraction of testa oil (Appaiah *et al.*, 2014) [4]; the absence of oxidation measurements leaves this untested. For comparison, a guava-strawberry toffee with far less fat remained acceptable after 90 days at $27 \pm 2^\circ\text{C}$ (Chavan *et al.*, 2015) [6].

Free fatty acids and microbial load during storage

Free fatty acids rose from 0.18% on day 0 to 0.22, 0.27 and 0.32% (as lauric acid) on days 3, 6 and 9 (Fig. 2b). No inferential test was applied to these values. Coconut lipids are prone to hydrolysis by lipases released when the kernel is disrupted (Seow *et al.*, 1997) [21], but the soft-ball cooking step should inactivate endogenous enzymes. The continued rise therefore suggests another source, such as microbial lipase activity at the surface or, for a titrimetric method applied to a sugar-rich matrix, co-extracted acidic compounds formed during cooking. A lipid-extract acid value, together with peroxide value or volatile aldehydes, would separate hydrolysis from oxidation in future work.

The total viable count was 2.26 log₁₀ CFU/g on day 0 and increased to 2.65, 3.10 and 3.52 log₁₀ CFU/g on days 3, 6 and 9 (Fig. 2c). The low initial count is consistent with the lethality of cooking to 112-115 °C, and the slow increase with the low water content of the product (Ergun *et al.*, 2010) [9]. Two limits apply. The count was made on a general-purpose medium at 37 °C, whereas yeasts and moulds, the usual spoilage organisms of low-moisture sugar products, were not enumerated. Water activity, which governs which organisms can grow, was also not measured.

Taken together, sensory scores, free fatty acids and total viable count all changed gradually and the toffee remained acceptable throughout the 9 days examined. Because no attribute approached rejection within that period, the data establish acceptability for at least 9 days at $25 \pm 2^\circ\text{C}$ but do not define the end of shelf life.

Tables

Table 1. Formulation, processing endpoint, yield and raw-material cost of coconut testa toffee

Component	Amount per batch	Share of batch (%)	Remarks
Coconut testa (parings), washed and finely grated	30 g	30	By-product of kernel paring; blanched 2-3 min where required
Fresh coconut milk	30 g	30	Kernel-to-water ratio 60:40 (w/v)
Refined sugar	40 g	40	—
Total ingredients	100 g	100	—
Cooking endpoint	Soft-ball stage, 112-115 °C	—	Continuous stirring, open pan
Toffee obtained	80 g	—	Yield 80%
Raw-material cost	₹5.20 per batch; ₹6.50 per 100 g toffee	—	Testa costed at nil; overheads excluded

Table 2. Proximate and mineral composition of coconut testa toffee (per 100 g, as is)

Constituent	Unit	Mean ± SD
Moisture	g	6.12 ± 0.10
Crude protein ($N \times 6.25$)	g	3.28 ± 0.09
Fat	g	19.64 ± 0.28
Crude fibre	g	10.46 ± 0.22
Total ash	g	2.08 ± 0.06
Carbohydrate (by difference)	g	58.42 ± 0.34
Energy	kcal	423.56 ± 1.50
Calcium	mg	92.36 ± 2.44
Magnesium	mg	98.54 ± 2.62
Sodium	mg	118.72 ± 3.18

Values are mean ± standard deviation of [DATA REQUIRED FROM THESIS/RAW DATA: number of analytical replicates]. Carbohydrate = 100 – (moisture + protein + fat + crude fibre + ash). Energy = 4 × protein + 9 × fat + 4 × carbohydrate.

Table 3. Physicochemical properties of coconut testa toffee

Property	Unit	Mean ± SD
Total soluble solids	°Brix	82.45 ± 0.38
pH	—	6.42 ± 0.05
Titrateable acidity	% [AUTHOR TO CONFIRM: acid basis]	0.18 ± 0.01
Apparent viscosity of hot mass	cP (mPa·s)	6840 ± 120

Values are mean ± standard deviation of [DATA REQUIRED FROM THESIS/RAW DATA: number of replicates]. TSS measured on an aqueous solution and corrected for dilution. Viscosity measured on the cooked mass before setting [DATA REQUIRED FROM THESIS/RAW DATA: temperature, spindle and speed].

Table 4. Hedonic scores of coconut testa toffee during storage at 25 ± 2 °C

Storage (days)	Colour	Appearance	Flavour	Taste	Texture	Overall acceptability
0	8.55 ± 0.08	8.60 ± 0.07	8.58 ± 0.09	8.62 ± 0.08	8.65 ± 0.07	8.60 ± 0.08
3	8.35 ± 0.18	8.42 ± 0.16	8.32 ± 0.20	8.38 ± 0.18	8.40 ± 0.17	8.38 ± 0.18
6	8.08 ± 0.24*	8.18 ± 0.22*	7.95 ± 0.28*	8.05 ± 0.26*	8.10 ± 0.24*	8.05 ± 0.24*
9	7.72 ± 0.30*	7.85 ± 0.28*	7.58 ± 0.34*	7.70 ± 0.32*	7.75 ± 0.30*	7.72 ± 0.30*
SE_d	0.12	0.11	0.14	0.13	0.11	0.12
CD ($p \leq 0.05$)	0.27	0.25	0.31	0.29	0.25	0.27

Nine-point hedonic scale (9 = like extremely; 1 = dislike extremely); 30 semi-trained panellists. Values are mean ± SD as reported [AUTHOR TO CONFIRM: see Quality-control report, item 1]. *Significantly different from day 0 (difference > CD, $p \leq 0.05$). SE_d , standard error of difference; CD, critical difference, from two-way ANOVA (storage × replication).

List of figures

Figure 2. Changes in coconut testa toffee during storage at 25 ± 2 °C. (a) Hedonic scores for six attributes (9-point scale; 30 panellists); points are offset horizontally for legibility, and the dotted line marks

“like moderately” (7). All attributes differed significantly from day 0 on days 6 and 9 (Table 4). (b) Free fatty acids, % as lauric acid. (c) Total viable count, log₁₀ CFU/g (TGYA pour plate, 37 °C, 48 h). Values in (b) and (c): day 0, 0.18 ± 0.03% and 2.26 ± 0.05; day 3, 0.22 ± 0.04% and 2.65 ± 0.07; day 6, 0.27 ± 0.04% and 3.10 ± 0.09; day 9, 0.32 ± 0.05% and 3.52 ± 0.10 [DATA REQUIRED FROM THESIS/RAW DATA: replicates per point]. Points are means; error bars are ± SD as reported in the thesis [AUTHOR TO CONFIRM: whether the sensory error values are SD or SE; see Quality-control report, item 1]

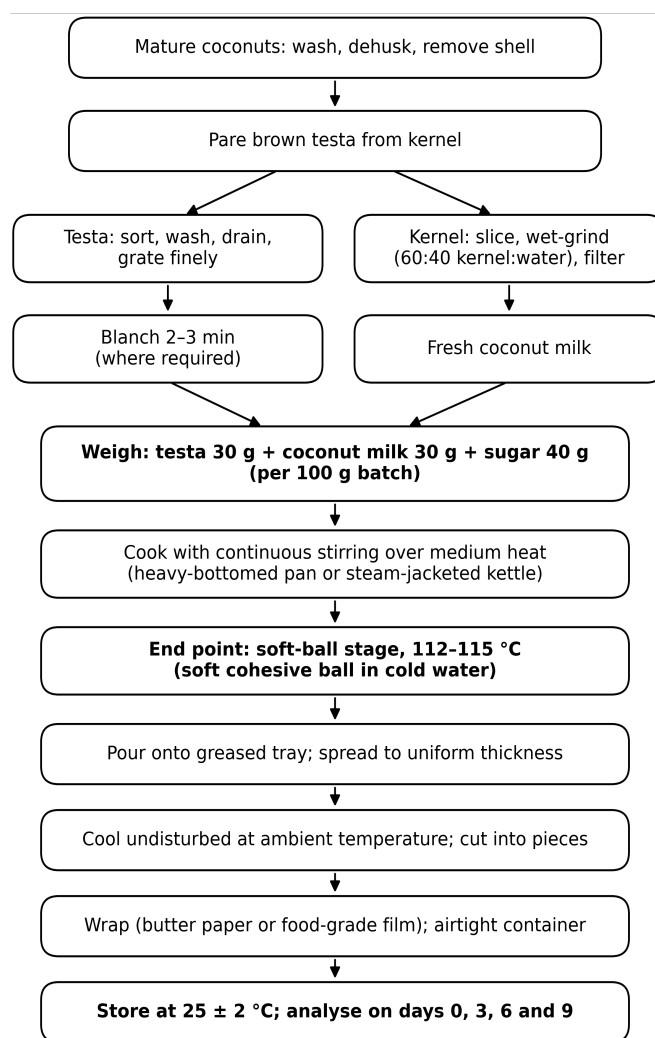


Figure 1. Process flow for the preparation of coconut testa toffee from testa and milk obtained from the same coconuts

Figure 1.

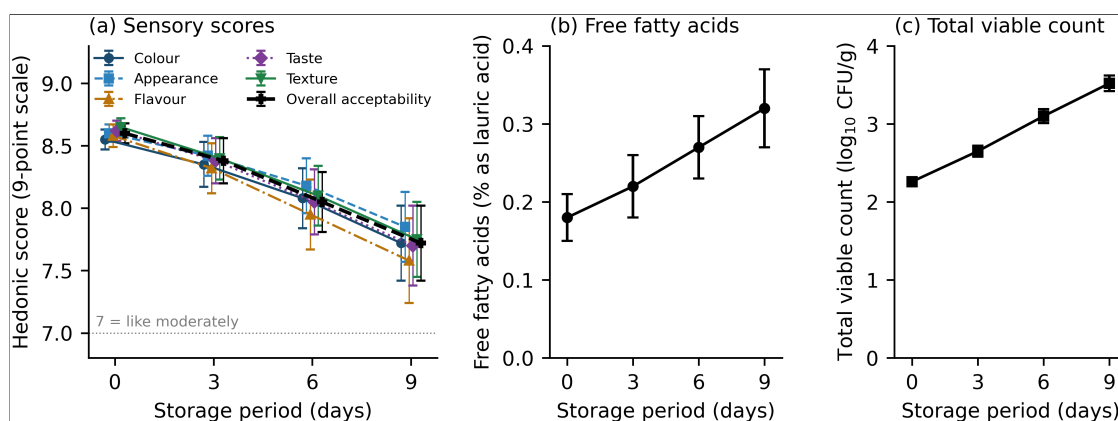


Figure 2. Highlights

- Fresh coconut testa from milk extraction was used as the main toffee ingredient
- Toffee yield was 80% at a raw-material cost of ₹6.50 per 100 g
- Fresh toffee scored 8.55-8.65 for all attributes on a nine-point hedonic scale
- Sensory scores fell significantly by day 6; overall acceptability was 7.72 on day 9
- Free fatty acids rose from 0.18% to 0.32%; viable count stayed below 4 log CFU/g

Conclusions

Coconut testa pared during coconut milk extraction was converted, with coconut milk and sucrose, into a toffee with an 80% yield and a raw-material cost of ₹6.50 per 100 g. The product contained 6.12 g moisture, 19.64 g fat and 10.46 g crude fibre per 100 g, had 82.45 °Brix soluble solids and a near-neutral pH, and was rated between “like very much” and “like extremely” when fresh. Over 9 days at 25 ± 2 °C, sensory scores declined significantly from day 6 but overall acceptability remained 7.72 on day 9, while free fatty acids rose from 0.18% to 0.32% and total viable count from 2.26 to 3.52 log₁₀ CFU/g. These results show that fresh testa can be used directly in a sugar-

boiled confection that is acceptable to a semi-trained in-house panel and stable for at least 9 days.

Practical implications

For units that already extract coconut milk, the process uses a residue generated on site, requires only open-pan cooking, and adds no ingredient beyond sugar and part of the milk stream. This makes it suitable for small-scale value addition. Whether it offers an advantage over existing coconut confections, and at what test level, remains to be established; formulation trials, consumer testing and longer storage studies are needed before commercial use.

Limitations

Only one formulation was prepared, without a control toffee lacking test, so the specific contribution of test to sensory quality and composition cannot be isolated. Sensory data came from a 30-member semi-trained in-house panel rather than consumers. Storage lasted 9 days, which is short for a low-moisture confection, and moisture, water activity, texture, colour and lipid oxidation were not followed. Yeasts and moulds were not enumerated, total dietary fibre and total sugar were not determined, and all work was at laboratory scale with coconuts from one market lot.

Declarations

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Competing interests.

Author contributions Aascharya Srivastav: investigation, formal analysis, data curation, writing - original draft. Nikita Wadhawan: conceptualisation, supervision, resources, writing - review and editing. All authors read and approved the final manuscript.

Ethics approval and consent to participate.

Data availability. The datasets generated during the study are available from the corresponding author on reasonable request.

Use of writing-assistance tools

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