DOI: 10.37833/cord.v40i.483
Coconut Research & Development, 2024, 40, 31-39)

Creamed Coconut Testa and Creamed Coconut as Substitutes for Coconut Milk in Culinary Uses

K. G. S. N. Kumari[1], B. S. K. Ulpathakumbura[1], K. M. R. U. Gunarathna[1], O. M. Lai[2] and J. M. N. Marikkar[1*]

[1] National Institute of Fundamental Studies, Hanthana Road, Kandy, Sri Lanka
[2] Department of Bioprocess Technology, Universiti Putra Malaysia 43400 UPM Serdang, Selangor D.E., Malaysia

* Corresponding author. Email: nazrim.ma@nifs.ac.lk

Abstract

Coconut milk plays a crucial role in preparation of curries and other savoury dishes in Sri Lanka. While squeezing grated coconut manually, there is a wastage of coconut as well as coconut testa which is a significant by-product of coconut processing industries. This study aimed to evaluate the potential of utilizing creamed coconut (CC) and creamed coconut testa (CCT) as a viable substitute for coconut milk in culinary uses. To attain this objective, the nutritional composition of CC and CCT was determined and sensory evaluation was undertaken to test the suitability of these two products as cooking medium on a potato curry using a group of thirty semi-trained panelists. Four formulations of CCT incorporated potato curry were prepared coded as F1 (CCT:water = 1:9), F2 (CCT:water =1:4), F3 (CCT:water = 3:7) and F4 (CCT:water = 2:3). Besides, P1 (CC:water = 1:9), P2 (CC:water = 1:4), P3 (CC:water = 3:7), P4 (CC:water = 2:3) were coded as the four formulations of potato curry, incorporating CC. The analysis revealed that fat, crude protein and carbohydrate in CC was higher than CCT except crude fiber content. However, there was no significant ($p > 0.05$) difference in ash and moisture contents. According to sensory evaluation, F1 (CC: water = 1:9) and P2 (CC:water = 1:4) were identified as the most preferred potato curry formulations incorporating CCT and CC respectively. In conclusion, there was a potential of utilizing and maximizing coconut meat and testa as a viable substitute for coconut milk in culinary applications.

Key words: Creamed coconut, creamed coconut testa, proximate composition, potato curry formulations, sensory attributes

Introduction

Coconut (*Cocos nucifera* L.) is a perennial crop of the tropics grown in more than 80 countries (Arunachalam, 2012). For the past several decades, it has held a significant position within the plantation sector of Sri Lanka. At present, it represents roughly about 12% of the country's overall agricultural production. Apart from a food commodity, coconut fruit also has numerous medical benefits; the tender coconut nut water being naturally sterile could be source of an oral rehydration medium to keep the body cool. Likewise, the bulk of the matter in coconut oil is triacylycerols (> 98%) (TAG) that are composed of medium chain fatty acids in high proportions. When hydrolyzed by pancreatic lipase, TAG molecules are converted to monolaurin, which are known to impart health benefits, including anti-bacterial, anti-viral, and anti-HIV activities (Deen et al., 2020). The flesh of the coconut fruit called coconut kernel, is rich in fat, protein, fiber, and carbohydrate (Appaiah et al., 2014). Generally, coconut kernel is used to make various products such as coconut oil, desiccated coconut, virgin coconut oil, coconut milk powder and coconut milk (Marasinghe et al., 2019). Coconut milk extracted from coconut kernel is a common ingredient in daily culinary preparations that include vegetables, meats, fishes, and various baked products. Traditionally, coconut milk is prepared at home by adding water to grated coconut meat and squeezing it out to extracting milk (Suyitno, 2003). Squeezing grated coconut for milk is a common practice even among small householder industries (Dewi et al., 2019). In fact, this method of milk extraction leads to considerable amount of nutrients of coconut remaining in the residue portion being lost and discarded as waste. Owing to the escalation of the demand for coconut in the local market, this kind of losses and wastage during the house hold consumption have to be stopped using an alternative product.

The white kernel of the coconut fruit has a thin brown colour outer-covering which is called coconut testa (CT). As the coconut reaches the maturity, the thickness of the testa also increases to give it a brown colour. The testa of coconut is removed by paring the coconut flesh during the preparation of products such as desiccated coconut, coconut milk and virgin coconut oil. Thus, CT becomes a by-product of the coconut processing industry (Appaiah et al., 2021). Previous investigations showed that approximately 18% (w/w, on a wet basis) of the entire coconut kernel lost during removal of testa (Gunarathne et al., 2021). According to some prior estimates, approximately 6,500 kilograms of wet CT are generated from 100,000 nuts of the Sri Lankan tall variety (Perera et al., 2014). Despite the edible nature of CT, its complete utilization as a food has not yet been fully realized. Currently, CT is only used for low-grade oil extraction and the residue is left as a feedstock for animals. In order to augment the commercial use of CT, research initiatives were recently undertaken, which showed the presence of beneficial active compounds such as polyphenols, flavonoids with antioxidant properties along with dietary fiber and essential minerals (Fareed et al., 2022; Gunarathne et al., 2021).

Nowadays, Sri Lanka has experienced a significant surge in coconut prices in the local market due to various challenges. Hence, the cost of fresh coconut in the form of milk is escalating day by day. The aim of this research is to minimize the wastage during squeezing of grated coconut for milk extraction through utilizing the CT in coconut processing industries. In this study, preparation of creamed coconut and creamed coconut testa was undertaken to use them as viable alternatives for coconut milk in culinary applications. According to a previous report, CC is found to have 65% fat, 8% protein, 4% crude fiber and 17.5% other carbohydrates (Marikkar & Madurapperuma, 2012) and as such using it directly for culinary purposes is not feasible. Hence, this study focused on a sensory evaluation to work out a way to use these two products as alternative cooking medium for a potato curry.

Materials and Methods

Materials and Sampling

Samples of mature coconuts were collected from Kandy market, Sri Lanka and de-husked.

Methods

Preparation of CC and CCT: De-husked coconuts were split-opened to recover coconut kernel and the testa separately. These were disintegrated into small particles and subjected to oven drying at 80°C temperature for 8 hours to reduce their moisture contents to below 5% using a forced air-drying oven (Biobase, model - BOV-V230F, China). The dried samples were removed from the oven and grounded using a grinding mixer (Model MG 2053, India) until a thick cream was formed.

A proximate compositional analysis was performed to assess the nutritional values of CC and CCT in terms of nutrients such as moisture, ash, fat, proteins, carbohydrates etc.

Proximate compositional analysis: Determinations of the moisture, ash, protein and fat contents related to proximate composition were performed in accordance with the procedures described in AOAC International (2000) manual. The carbohydrate content of the flour was calculated by difference [100 - (crude protein + crude fat + ash + moisture+ crude fiber)]. The results of the proximate composition are given in Table 2.

Moisture: The moisture contents of samples were determined according to AOAC International (2000) Specification (method 934.01). An empty petri dish set was dried in hot air oven at 105°C for 3 hours and transferred to a desiccator to cool. The empty petri dish set was weighted. About 3g of sample was weighed into each petri dish and sample was spread uniformly. The Petri dish with sample was placed in the hot air oven for 3 hours at 105°C. It was transferred to a desiccator to cool and the whole weight of petri dish and its dried sample were measured, following formula was used to calculate the moisture content:

$$\text{Moisture content} = \frac{\text{Initial weight of sample - Final weight of sample}}{\text{Initial weight of sample}} \times 100$$

Table 1. Different potato curry formulations of creamed coconut testa

Curry Variant	CCT (ml)	Water (ml)	Potato (g)	Salt (g)	Turmeric Powder (g)	Chili Powder (g)	Curry Powder (g)	Cardamom (g)	Curry Leaves
F1	50	450	150	7	1	3	2	2	5
F2	100	400	150	7	1	3	2	2	5
F3	150	350	150	7	1	3	2	2	5
F4	200	300	150	7	1	3	2	2	5

Abbreviations: CCT, creamed coconut testa; F1, formulation of CCT with water in 1:9 ratio; F2, formulation of CCT with water in 1:4 ratio; F3, formulation of CCT with water in 3:7 ratio; F4, formulation of CCT with water in 2:4 ratio

Table 2. Different potato curry formulations of creamed coconut

Curry Variant	CC (ml)	Water (ml)	Potato (g)	Salt (g)	Turmeric Powder (g)	Chili Powder (g)	Curry Powder (g)	Cardamom (g)	Curry Leaves
P1	50	450	150	7	1	3	2	2	5
P2	100	400	150	7	1	3	2	2	5
P3	150	350	150	7	1	3	2	2	5
P4	200	300	150	7	1	3	2	2	5

Abbreviations: CC, creamed coconut; P1, formulation of CC with water in 1:9 ratio; P2, formulation of CC with water in 1:4 ratio; P3, formulation of CC with water in 3:7 ratio; P4, formulation of CC with water in 2:4 ratio

Fat: Crude fat contents of samples were determined by Soxhlet method according to the specifications of AOAC International (2000) (method 963.15). About 1.00 g of sample was weighted to paper filter and was wrapped. Sample was taken into extraction thimble and transferred into Soxhlet. Dichloromethane was filled to about 50 ml into the round bottom flask and it was taken on the heating mantle. Soxhlet apparatus (FAT-06A) was connected, and the water was turned on to cool them and then the heating mantle was switched on. The sample was heated for about 14 hours (heat rate of 150 drop/min).

The solvent was evaporated by using the same heating mantel. The round bottom flask was transferred to the desiccator to cool. The flask and its dried content were reweighted. Fat content was determined according to the following formula:

$$\text{Fat content} = \frac{\text{Weight of the flask with fat - Initial weight of the flask}}{\text{Weight of the sample}} \times 100$$

Ash: Total ash contents of samples were determined according to the specifications of AOAC International (2000) (method 923.03). The crucible was placed in furnace at 550°C. It was cooled in a desiccator for 30 minutes. Crucible was weighed and about 5 g of sample was added. Crucible was placed in muffle furnace (S/N FH128120900) at 550°C for 24 hours. Crucibles were removed from muffle furnace and were placed in the desiccator to cool. Final weights of the crucibles were weighed. The following formula was used in the determination of ash content:

$$\text{Ash content} = \frac{\text{Weight of crucible with ash - Weight of crucible}}{\text{Initial weight of sample}} \times 100$$

Protein: Crude protein contents of samples were determined by Kjeldahl method according to AOAC International (2000) (method 960.52). About 1 g of sample was weighed and its weight was recorded. The weighed sample was placed in a digestion tube. Five grams of Kjeldahl catalyst and 200 ml of concentrated sulphuric acid were added to each tube containing the sample. The flasks were placed in inclined position and gently heated until the frothing ceases. It was boiled briskly until the solution cleared. The solution was cooled, and added 60 ml distilled water. Flask was connected immediately to digestion bulb through the condenser with the tip of the condenser immersed in a standard solution of boric acid. When NH3 reacting with boric acid, the solution in the receiver turned from red-violet color to green color due to boric acid turning to borate anion (basic medium). The borate anion formed was titrated with a standard solution of HCl. A reagent blank was run separately to subtract the reagent nitrogen from the sample nitrogen. The following formula were used in determining the protein content:

Table 3. Proximate composition of creamed coconut and creamed coconut testa

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude fiber (%)	Carbohydrate (%)
CC	0.84 ± 0.01[a]	1.46 ± 0.02[a]	68.32 ± 0.29[b]	8.21 ± 0.00[b]	12.05 ± 0.00[a]	9.12 ± 0.00[b]
CCT	0.83 ± 0.01[a]	1.54 ± 0.05[a]	65.63 ± 0.51[a]	8.11 ± 0.00[a]	16.00 ± 0.00[b]	7.89 ± 0.00[a]
CL	NS	NS	*	*	*	*

Each data in the table represents mean of triplicate analyses. Means in the same column bearing different superscripts are significantly ($p<0.05$) different from each other. Abbreviations: CL, confidence level; NS, not significant; *, ($p<0.05$); CC, creamed coconut; CCT, creamed coconut testa.

$$\text{Total nitrogen percentage} = \frac{\text{(Simple titrate − blank titrate)} \times \text{Molarity of HCL} \times 14 \times 100}{\text{Weight of sample} \times 1{,}000} \times 100$$

$$\text{Protein percentage} = \text{Total nitrogen percentage} \times 6.25$$

Crude Fiber: Crude fiber contents of samples were determined according to the AOAC International (2000) specification (method 962.09). One gravimetric approach, the crude fiber method, measures the organic food residue that is left after sequential digestion with 0.255N sulfuric acid and 0.313N sodium hydroxide solution, followed by overnight oven drying at 104°C and lastly exposed to 3 hours igniting at 600°C in a muffle furnace. The following formula was used in determination of crude fiber content.

$$\text{Crude fiber content} = \frac{\text{(Weight of sample before ashing − Weight of sample after ashing)} \times 100}{\text{Weight of sample}} \times 100$$

Carbohydrate: The following formula was used in determination of carbohydrate contents of samples.

$$\text{Carbohydrate content (\%)} = 100 - \%\ \text{(Moisture + Ash + Protein + Fat + Crude Fiber)}$$

Formulation of potato curry incorporating creamed coconut and creamed coconut testa: Creamed coconut and creamed coconut testa samples were diluted with water to find the best acceptable formulations of CCT/CC: water. Initially, four formulations were prepared by diluting CCT/CC with water at 1:9, 1:4, 3:7 and 2:3 ratios using both products separately. As shown in Table 1 and 2, four distinct formulations of potato curry were prepared by altering the ratios of CC/CCT to water in separate cooking pans while maintaining consistency in other ingredients. Initially, potatoes were boiled in a pressure cooker for about 5 minutes. The boiled potatoes were peeled and diced into small cubes and set aside. Subsequently, formulation which prepared by diluting CCT with water at 1:9 ratio was added into cooking pan and mixed well under low heat. After that, turmeric powder, chili powder, curry powder, salt and cardamom were added to the pan according to amounts as mentioned in Table 1 and 2, and stirred well for about 3 minutes. The boiled, diced potatoes were introduced to the mixture in the cooking pan. After adding the curry leaves, the dish was cooked for 15 minutes until the curry become thicken. As shown in Table 1 and 2, the same procedure was repeated for 1:9, 1:4, 3:7 and 2:3 ratios of other formulations of both CCT and CC product.

Sample size: 100 ml of CC and CCT were produced using 100g of dried coconut kernel and dried coconut testa separately. For the sensory evaluation purpose, 900 g of dried coconut kernel or dried coconut testa was required to preparation of 900 ml of either CC or CCT. The serving size of the curry per panelist was 30 ml. Based on this, the total requirement of CC/CCT for the formulated recipes for 30 panelists was determined as follows: (a) For creamed coconut testa curry series: F1 - 90 ml; F2 - 180 ml; F3 - 270 ml; F4 - 360 ml, (b) For creamed coconut curry series P1 - 90 ml; P2 - 180 ml; P3 - 270 ml; P4 - 360 ml.

Sensory Serving the sample: The samples were coded with three digits random numbers and served to the panelists in random order with serving size of 30 ml per sample with bread pieces. Curry samples were microwaved and freshly served among the panelists in each session of sensory evaluation.

Sensory Testing criteria: A preference ranking tests were performed using a group of thirty semi-trained panelists to select the most preferred formulation out of the potato curries incorporated with either creamed coconut or creamed coconut testa. The panelists were instructed to assign preference rank according to the ranking scale: 1: extremely preferred sample; 2: moderately preferred sample; 3: slightly preferred sample; 4: least preferred sample based on individual sensory attribute.

Statistical analysis: The data obtained from the sensory evaluation was statistically analyzed using Minitab 17.1 software package. Friedman test was performed to determine if there is a significant difference ($p < 0.05$) among median values obtained for each sensory attribute of the four formulations. When a significant difference ($p < 0.05$) was detected in Friedman test, the Mann-Whitney test was performed to identify the significant difference ($p < 0.05$) between all possible combinations of formulations based on each sensory attribute.

Results and Discussions

Proximate composition of products

The proximate compositional analysis data of the creamed coconut and creamed coconut testa are given in Table 3. Except the ash and moisture contents, all the other parameters exhibited significant ($p < 0.05$) differences. Moisture content of food product is crucially important in determining its quality and shelf-life stability. In this study, the moisture contents of creamed coconut and creamed coconut testa were 0.84% and 0.83%, respectively (Table 3) but no significant ($p > 0.05$) difference was found between the two products. Though the fresh coconut flesh generally possesses high moisture content, the moisture of creamed coconut products was shown to drop drastically, resulting in the final products possessing a low moisture content. According to a previous study by Appaiah et al. (2014), the moisture contents of the whole copra, white copra kernel, copra testa, wet whole coconut, wet coconut white kernel, wet coconut testa were 4.30%, 3.80%, 4.00%, 42.20%, 43.50%, and 32.90%, respectively. Based on the studies of Belewu et al. (2014) and Beegum et al. (2022), the moisture contents of fresh coconut milk were 88.65% and 57.32%, respectively.

Lipid, sometimes referred to as dietary fat, is a key macronutrient that offers energy and essential fatty acids vital for numerous body functions (Raihana et al., 2015). Cushioning the organs, maintaining control of body temperature, and aiding in the absorption of fat-soluble vitamins are some of the functions of lipids. Apart from these, they act as building materials for cell structure as the majority of the cell membrane are phospholipids. Apart from these, various other functional attributes of coconut oil have already been discussed elsewhere in the literature (Deen et al., 2020). The fat content was found as the largest component of both creamed coconut testa (65.63%) and creamed coconut (68.32%). In fact, there was a notable variance in the fat content between creamed coconut and creamed coconut testa, showing significant difference ($p < 0.05$). According to Appaiah et al. (2014), the oil content of coconut testa was comparatively lower than that of the coconut kernel, in conformity with the findings of fat content of CC and CCT of this study (Table 3). The study by Appaiah et al. (2014) further reported that the fat contents of the copra as a whole, copra white kernel, copra testa, wet coconut whole, wet coconut white kernel, wet coconut testa were 59.80%, 63.60%, 59.00%, 37.00%, 38.80%, and 34.70%, respectively. Moreover, (Beegum et al., 2022) assessed the composition of coconut milk, revealing a fat content of 27.69% on a wet basis. On a comparative basis, the fat contents of CC, CCT and coconut milk were found to be in the ranking order of CC > CCT > Coconut milk. The high fat content of these products makes it necessary to go for a dilution while preparing coconut milk-based foods.

Ash is the inorganic residue that remains in food systems after the organic substance has either completely oxidized or ignited. Determination of the ash content of foods holds importance for various reasons. Apart from providing vital information towards the nutritional quality of foods, ash content might have helped to identify the distribution of major and trace minerals (deMan et al., 2018). The findings by (Marasinghe et al., 2019) already showed that Mn was the most prevalent mineral in coconut testa, followed by Zn and Cu. As shown in Table 3, the ash contents of creamed coconut and creamed coconut testa were 1.46% and 1.54%, respectively, but their difference was not significant ($p > 0.05$). The literature data regarding the composition of ash present either in CC or CCT remains scarce; previous research has explored only the ash content of both fresh coconut flesh and fresh testa. Appaiah et al. (2014) reported the ash contents of the copra whole, copra white kernel, copra testa, wet coconut whole, wet coconut white kernel, wet coconut testa were 1.40%, 2.10%, 1.40%, 1.00%, 0.90%, 0.70% respectively. Previously Dendy & Timmins (1974) and Chakraborty (1985) also conducted multiple studies, reporting the ash contents for mature coconut kernel as 1.30% and 1.10%, respectively. According to Beegum et al. (2022), the ash content of coconut milk was 2.84%. Upon analyzing the current and previous data, the ash content sequence observed among CC, CCT, and coconut milk remains consistent, with CC and CCT possessing similar amounts which are lower than that of coconut milk.

Protein represents the third essential macromolecule within food systems and is crucial to many biological functions of the human body. Determination of the protein contents of coconut-based products is significant as they play a vital role of fostering the body growth, upkeep of cells and tissues, acting as enzymes, transporters and regulators of diverse biological processes (deMan et al., 2018). The data depicted in

Table 4. Results of Friedman test along with the rank median of sensory attributes of different formulations of potato curry incorporated with creamed coconut testa

Formulation	Appearance	Aroma	Colour	Creaminess	Flavor	Overall acceptability
F1	1.12^{a}	1.00^{a}	1.00^{a}	2.00^{a}	1.75^{a}	1.25^{a}
F2	1.87^{a}	2.00^{a}	2.00^{b}	1.00^{a}	1.25^{a}	1.75^{a}
F3	3.12^{b}	3.00^{b}	3.00^{c}	3.00^{b}	3.50^{b}	3.25^{b}
F4	3.87^{c}	4.00^{c}	4.00^{d}	3.00^{b}	3.50^{b}	3.75^{b}
CL	***	***	***	***	***	***

Rank median bearing different superscriptions are significantly different from each other at 99% confident interval level ($\alpha = 0.01$). Abbreviations: F1 potato curry prepared with 50 ml of creamed coconut testa with 450 ml of water; F2 potato curry prepared with 100 ml of creamed coconut testa with 400 ml of water; F3 potato curry prepared with 150 ml of creamed coconut testa with 350 ml of water; F4 potato curry prepared with 200 ml of creamed coconut testa with 300 ml of water.

Table 5. Results of Friedman test along with the rank median of sensory attributes of different formulations of potato curry incorporated with creamed coconut

Formulation	Appearance	Aroma	Colour	Creaminess	Flavour	Overall acceptability
P1	3.75^{c}	3.25^{b}	3.75^{c}	3.50^{c}	4.00^{b}	4.00^{b}
P2	1.25^{a}	1.75^{b}	1.25^{a}	2.25^{a}	2.00^{a}	2.00^{a}
P3	2.00^{a}	2.25^{a}	2.00^{a}	2.25^{a}	2.00^{a}	2.00^{a}
P4	3.00^{b}	2.75^{b}	3.00^{b}	3.00^{b}	3.00^{b}	3.00^{b}
CL	***	***	***	***	***	***

Rank median bearing different superscriptions are significantly different from each other at 99% confident interval level ($\alpha = 0.01$). Abbreviations: P^1, potato curry prepared with 50 ml of creamed coconut with 45 ml of water; P^2 potato curry prepared with 100 ml of creamed coconut with 400 ml of water; P^3 potato curry prepared with 150 ml of creamed coconut with 350 ml of water; P^4 potato curry prepared with 200 ml of creamed coconut with 300 ml of water.

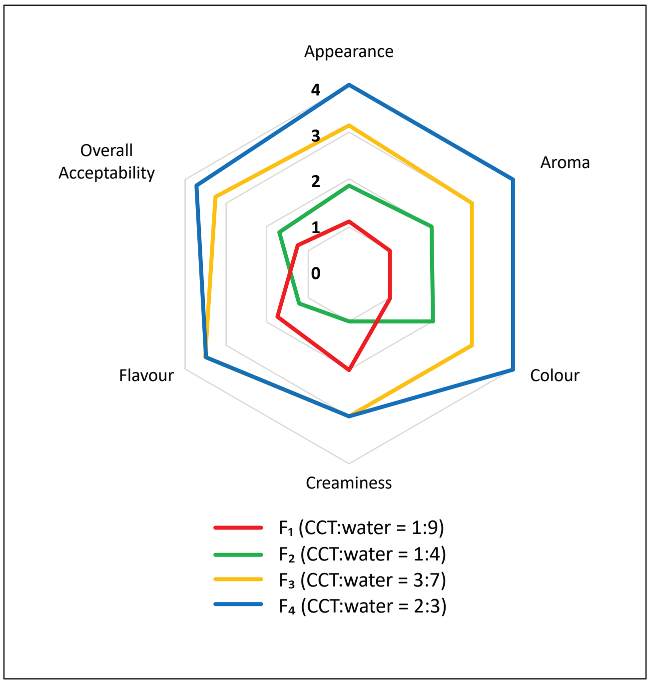

Figure 1. Radar chart depicting the sensory attributes of various potato curry formulations incorporating CCT

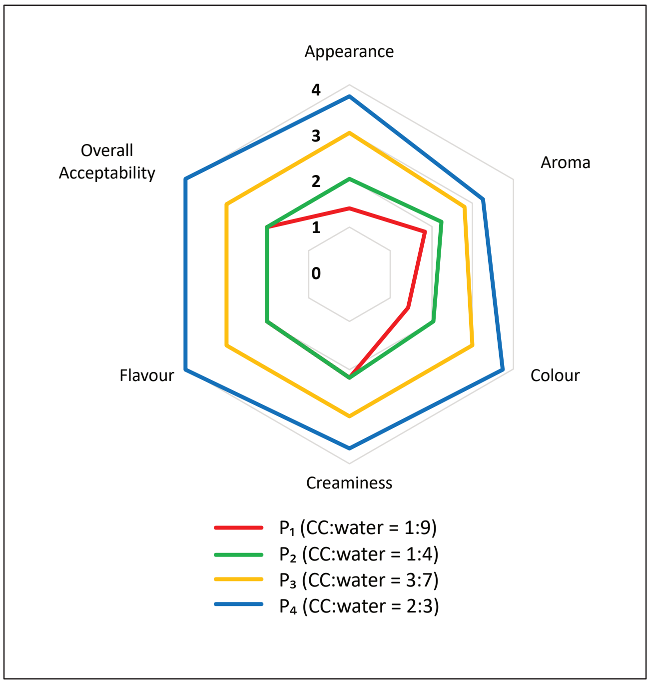

Figure 2. Radar graph for the sensory analysis median score values for various potato curry formulations incorporating creamed coconut

Table 3 indicates that the crude protein content of CC was 8.21%, while that of CCT was 8.11%. There was a statistically significant ($p < 0.05$) difference between the two products, with CC having the highest value. While literature data specific to the protein contents of creamed coconut testa are scarce, the availability of data on the protein content of the fresh coconut flesh and coconut testa exists. As evaluated by Appaiah et al. (2014), the protein content of the copra whole, copra white kernel, copra testa, wet coconut whole, wet coconut white kernel, wet coconut testa were 10.20%, 8.10%, 9.30%, 7.50%, 6.20%, 7.10%, respectively. In a separate study, Beegum et al. (2022) stated that coconut milk had a portion content of 6.79%, which was lower than those of CC and CCT.

The fiber in foods is actually a form of carbohydrate, which includes dietary fibers that are both soluble and insoluble. As a matter of fact, they provide a variety of health benefits. According to Table 3, the amounts of crude fiber in CC and CCT were 12.05% and 16.00%, respectively. There was a significant ($p < 0.05$) difference between them with CCT having the greatest value. There is hardly any literature data on the crude fiber content of creamed coconut or creamed coconut testa to compare the results of this study. In a previous study, Appaiah et al. (2014) showed that the cruder fiber contents of the whole copra, copra white kernel, copra testa, wet coconut whole, wet coconut white kernel, wet coconut testa were 7.00%, 6.60%, 11.60%, 14.30%, 11.70%, and 17.20%, respectively. Apart from this, Belewu et al. (2014) previously showed that fiber content of coconut milk was 3.35%.

The determination of carbohydrate contents of creamed coconut and creamed coconut testa is highly important as carbohydrate is one of the macronutrients essential for human body. Not only they act as a source of energy, they also provide support for blood clotting, brain functioning, and growth of cells and tissues (deMan et al., 2018). According to data presented in Table 3, CC had a significantly ($p < 0.05$) higher carbohydrate content (9.12%) than CCT (7.89%). Nevertheless, there is a scarcity of literature data concerning the carbohydrate contents of creamed coconut testa. Appaiah et al. (2014) previously reported that the carbohydrate content of the whole copra, copra white kernel, copra testa, wet coconut whole, wet coconut white kernel, wet coconut testa were 24.30%, 22.40%, 26.30%, 12.30%, 10.60%, and 24.60%, respectively. Dendy & Timmins (1974) and Chakraborty (1985) previously reported that the carbohydrate content for mature coconut kernel as 9.9% and 16.9%, respectively. With regard to the composition of coconut milk, Belewu et al. (2014) reported that it had 14.30% of carbohydrate content. When examining CC, CCT and coconut milk, it's evident that coconut milk possesses a notably higher carbohydrate percentage.

Selection of the best creamed coconut testa dilution for potato curry

For culinary uses, the direct application of creamed coconut testa is not feasible and hence it can be reconstituted with an appropriate amount of warm water to make into either thick milk or thin milk. Identification of the correct dilution factor of creamed-paste for its use in potato curry is necessary. The data in Table 4 displays the sensory evaluation results of the Friedman test for the four different potato curry formulations. According to Table 4, significant ($p < 0.05$) differences were observed among the four formulations, regarding all sensorry attributes. In the ranking test, the lowest median is an indicator of the highest level of preference. According to Table 4, F1 had the highest preference rank level (lowest median) for appearance, aroma, colour and overall acceptability except for creaminess and flavor attributes. For creaminess and flavor, F2 formulation scored the highest preference level (lowest median). Furthermore, data showed that the preference of the panelists regarding appearance, aroma, colour and overall acceptability attributes seemed to declining with increasing level of CCT incorporation. However, the panelists' choice for the appearance, aroma, flavor, creaminess, and overall acceptability of F1 and F2 did not differ significantly ($p > 0.05$) except for colour. When compared to F3 and F4 formulation for creaminess, the flavor and overall acceptability did not differ significantly ($p > 0.05$) except for appearance, aroma and colour. F1, which was the potato curry prepared with 50 ml of creamed coconut testa with 450 ml of water formulation (CC:water = 1:9) was selected as the most preferred formulation based on all sensory attributes.

As shown in Figure 1, the radar chart illustrates the examination of the four formulations using the preference ranking test. The lowest median in a ranking test is a sign of the strongest level of preference. The maximum preference level is indicated by lines close to zero on the radar chart while the lines go away from zero indicate the gradually decreases in preference level. Based on Figure 1, it is observed that the lines denoting the medians pertaining to all sensory characteristics of the F4 formulation remained predominantly within the vicinity of near 4, with the exception of flavor and creaminess, where the median was noted near at 3. The entirety of sensory attributes within the F3 formulation were specifically localized to area 3. The median values representing the flavor and creaminess of the F2 formulation have notably shifted toward the vicinity of 1, while other associated attributes lie within the range of 2. In contrast, the medians pertaining to sensory attributes of appearance, aroma, color, and overall acceptability in the F1 formulation have demonstrated a discernible movement closer to zero on the radar chart. Hence, F1 formulation which was prepared with 50 ml of creamed coconut testa with 450 ml of water (CC:water = 1:9) formulation was selected as the most preferred formulation.

Selection of the best creamed coconut dilution for potato curry

The sensory evaluation results of the Friedman test performed for different potato curry formulations, incoparated with creamed coconut are shown in Table 5. According to Table 5, significant ($p < 0.0001$) differences were noticed regarding all sensorry attributes. In terms of appearance, aroma, colour, P2 had the greatest preference rank level (lowest median) while P1 had the lowest preference rank level (highest median). For creaminess, flavor, and overall acceptability of both P2 and P3 formulations scored the highest preference level (lowest median). According to Table 5, there was no significant ($p > 0.05$) difference between P2 and P3 formulations for all attributes except for aroma. In evaluating aroma, findings indicate that formulations P1, P2, and P4 exhibited no notable ($p > 0.05$) variance. Considering all sensory attributes, P2 which was prepared with 100 ml of creamed coconut with 400 ml of water (CC: water = 1:4) formulation was selected as the most preferred formulations.

The radar chart in Figure 2 depicts the assessment of the four formulations through a preference ranking test. A lower median in the ranking test signifies a higher preference level. Lines nearing zero on the radar chart represent the highest preference level, while lines moving away from zero indicate a gradual decrease in preference level. All sensory qualities of the P1 formulation had median scores around 4, while the P4 formulation's median scores were around 3 for these attributes. All attributes of P3 and flavor, creaminess, and overall acceptability attributes of P2 formulation have exhibited near the value of 2. Moreover, appearance, aroma, and color of P2 formulation have shown the lowest median range. On the contrary, when examining the medians associated with sensory attributes of appearance, aroma, colour, creaminess, flavor, and overall acceptability in the P2 formulation, there is a noticeable shift towards zero on the radar chart. Hence, based on the graphical illustration, P2 sample which was prepared with 100 ml of creamed coconut with 400 ml of water (CC:water = 1:4) was selected as the most preferred formulation.

Benefits and advantages

Coconut cream and coconut milk both contain fat, protein, sugars, minerals, and vitamins as nutrients. The proportion of each nutrient might be different. Coconut milk is actually a fat in water emulsion but coconut cream products are viscous non-emulsion liquids. It is a well-known fact that the emulsion stability of coconut milk is a relatively low. Under ambient conditions, its emulsion may break down into two distinct phases: a heavy aqueous phase and a lighter creamy phase. This is not the case for the two coconut creamed products as they do not undergo phase separation immediately. The fat contents of coconut cream products are overwhelmingly high when compared to fresh coconut milk. Unlike the two coconut cream products, fat contents of coconut milk might vary depending on the volume of the water added to grated coconut during milk extraction. Owing to the high nutrients and moisture content, coconut milk is perishable and may undergo fast deterioration at room temperature condition. As the moisture content of the two creamed-paste is less than 0.85%, it may display a longer shelf-life stability at ambient temperature. Since they are prepared from the dehydrated coconut kernel or testa by grinding using an electrically-operated grinder, the temperature of the two-creamed products might rise above 80°C during the grinding process, which may help to pasteurize the substance inactivating microbes and enzyme activities. For culinary uses, the creamed-paste can be reconstituted readily with an appropriate amount of warm water to make into either thick milk or thin milk. In this way, we can reduce coconut wastage during the conventional method of coconut milk preparation.

Conclusion

The proximate compositions of creamed coconut and creamed coconut testa showed that there were significant variations in different component parameters exception for ash and moisture contents. The presence of low moisture content can be beneficial to the food quality and shelf-life stability of both products. The fat content, crude protein content, and carbohydrate content in creamed coconut was higher than those of creamed coconut testa excluding crude fiber content. The ash content showed no significant difference between the two products, indicating that both products had the same amount of minerals. The sensory evaluation of the potato curry formulations which was incorporated with CCT, demonstrated that 50 ml of CCT and 450 ml of water (F1, CCT: water = 1:9) was the most preference formulation. In the case of creamed coconut formulations, 100 ml of CC with 400 ml of water (P2, CC:water = 1:4) was selected as the most preferred formulation based on sensory attributes. When evaluating the comparison of both products, CCT require a smaller quantity than CC for preparation of the best potato curry. Based on the results of this study, there is a potential use for coconut cream and coconut of creamed testa as a viable alternative for fresh coconut milk in culinary applications. Moreover, the outcome of this study suggests that the potential of commercializing these products due to the hectic lifestyles prevalent in these days, offering opportunities to save time and money while enhancing household well-being in Sri Lanka.

Acknowledgements

This study was partly funded by the National Institute of Fundamental Studies, Hanthana Road, Kandy, Sri Lanka.

References

AOAC International. (2000). *Official methods of analysis of AOAC International (Vol. 17, No. 1-2)*. AOAC International.

Appaiah, P., Sunil, L., Kumar, P. K. P., Kumar, G. S., & Krishna, A. G. G. (2021). Coconut testa-a valuable by-product of coconut oil industry. *Indian Coconut Journal, 64*(6), 11–18.

Appaiah, P., Sunil, L., Prasanth Kumar, P. K., & Gopala Krishna, A. G. (2014). Composition of coconut testa, coconut kernel and its oil. JAOCS, *Journal of the American Oil Chemists' Society, 91*(6), 917–924.

Arunachalam, V. (2012). *Genomics of cultivated palms*. Elsevier.

Beegum, P. P. S., Nair, J. P., Manikantan, M. R., Pandiselvam, R., Shill, S., Neenu, S., & Hebbar, K. B. (2022). Effect of coconut milk, tender coconut and coconut sugar on the physico-chemical and sensory attributes in ice cream. *Journal of Food Science and Technology, 59*(7), 2605–2616.

Belewu, A. M., Muhammed-Lawal, A., Abdulsalam, K., Belewu, K. Y., & Belewu, N. O. (2014). Date-coconut drink : physico-chemical and sensory qualities. *Daffodil International University Journal Of Science And Technology, 9*(2), 1–6.

Chakraborty, P. (1985). Functional properties of coconut protein isolate obtained by ultrafiltration. *Journal of Food Science and Technology, 22*, 248–254.

Deen, A., Visvanathan, R., Wickramarachchi, D., Marikkar, N., Nammi, S., Jayawardana, B. C., & Liyanage, R. (2020). Chemical composition and health benefits of coconut oil: an overview. *Journal of the Science of Food and Agriculture, 101*(6), 2182–2193.

deMan, J. M., Finley, J. W., Hurst, W. J., & Lee, C. Y. (2018). *Principles of Food Chemistry*. Springer International Publishing.

Dendy, D. A. V., & Timmins, W. H. (1974). Development of a process to extract protein and oil from fresh coconut: The work of the Tropical Products Institute. *Oleagineux*.

Dewi, D. C., Novrianti, H., Handayani, C., Wulandari, O., & Nurhayati, I. (2019). Design of ergonomic grated coconut squeezer. *IOP Conference Series: Materials Science and Engineering, 602*(1), 012043.

Fareed, R., Ulpathakumbura, S., Yalegama, C., Hewapathirana, D., & Marikkar, N. (2022). Evaluation of Staple Foods Supplemented with Defatted Coconut Testa Flour. *CORD, 38*, 43–50.

Gunarathne, K. M. R. U., Marikkar, J. M. N., Mendis, E., Yalegama, C., Jayasinghe, U. L. B., Liyanage, R., & Jayaweera, S. (2021). Bioactivity studies of different solvent extracts of partially defatted coconut testa obtained from selected coconut cultivars. *Journal of Agricultural Sciences – Sri Lanka, 17*(1), 171–184.

Marasinghe, S. S. K., Marikkar, J. M. N., Yalegama, C., Wimalasiri, S., Seneviratne, G., Weerasooriya, R., & Liyanage, R. (2019). Comparision of inter-varietal differences in chemical composition and nutritional proporties of coconut testa flour. *Journal of the National Science Foundation of Sri Lanka, 47*(3), 349–356.

Marikkar, J. M. N., & Madurapperuma, W. S. (2012). Coconut. In *Tropical and Subtropical Fruits* (pp. 159–177). Wiley.

Perera, S. A. C. N., Dissanayaka, H. D. M. A. C., Herath, H. M. N. B., Meegahakumbura, M. G. M. K., & Perera, L. (2014). Quantitative characterization of nut yield and fruit components in indigenous coconut germplasm in Sri lanka. *International Journal of Biodiversity, 2014*, 1–5.

Raihana, A. R. N., Marikkar, J. M. N., Amin, I., & Shuhaimi, M. (2015). A review on food values of selected tropical fruits seeds. In *International Journal of Food Properties* (Vol. 18, Issue 11, pp. 2380–2392).

Suyitno, T. (2003). Health Benefit of Coconut Milk. In I*ndonesian Food and Nutrition Progress* (Vol. 10, Issue 2, pp. 106–112).