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Development of instant cream soup from durian waste industry

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Abstract The properties of powder derived from the peel and core of durian from five varieties including Monthong, Chanee, Puangmanee, Kan Yao, and Kradum Thong were investigated. Antioxidant activity variety was significantly highest selected to replace potato starch in an instant cream soup product. The results showed that the core powder from the Chanee variety exhibited significantlyhighest antioxidant activity, having an IC_{50} value of 3.47±0.07 mg/ml. The durian core powder was then used to substitute for the potato starch portion in the instant soup product. It showed that the cream soup with 25.00%w/w durian core substitution was selected in term of high preference score and proportion of durian core powder. The sensory evaluation of the developed product for the overall acceptability revealed the score of 7.30±0.68 (moderately liked). The optimal formulation consisted of powdered milk, potato starch, corn oil, durian core powder, sugar, chicken soup powder, salt, pepper, and garlic powder at 59.06%, 19.69%, 8.86%, 6.56%, 2.76%, 1.97%, 0.92%, 0.09%, and 0.09%, respectively. Interestingly, the developed cream soup formulation showed higher antioxidant activity and fiber content, while, the viscosity was lower than those the commercial one. Overall, this finding could be used as an alternative ingredient in health oriented instant soup products.

Keywords: Core of durian, Instant soup, Antioxidant activity

Introduction

Nowadays, durian (*Durio zibethinus* Murr.) is widely recognized as the "king of fruits," and extensively cultivated in Southeast Asia, particularly in Thailand, Malaysia, and Indonesia. In Thailand, durian is grown in multiple regions, with more than half of the national production concentrated in the eastern region, especially Chanthaburi province. Although, numerous varieties are cultivated but only a few are widely favored by both farmers and consumers such as Monthong, Chanee, Puangmanee, Kan Yao and Kradum Thong.

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Normally, the durian fruit is large, covered with hard spines, and can reach up to 30 cm in length and 15 cm in diameter. Typically, the weighs are between 1 to 3 kilograms. Its shape are varies from oval to round, and the outer shell ranges from green to brown in color. The edible pulp has a sweet taste and yellow coloration, which may depending on the species. Durian has a distinctive and strong odor attributed to volatile compounds including esters, ketones, and sulfur-containing compounds (Hokputsa *et al*., 2004).

In term of favorite fruits, durian plays a significant role in Thailand's agricultural economy, serving both domestic and export markets. In 2024, Thailand exported durians valued at approximately 157,506 million baht, of which 134,852 million baht came from fresh durians and 22,654 million baht from chilled and frozen products (Office of Agricultural Economics, 2024). Domestically, durians are also highly consumed in various forms such as crispy fried durian, durian paste, and other processed products.

However, durian processing generates a large amount of waste, particularly peels and cores, leading to serious environmental issues. Only about 10–30% of the fruit is edible pulp, while the rest consists of peel (50–60%) and seed (10–20%) (Charoenphun *et al*., 2020). So, there are over 70% of the fruit becomes waste. The durian processing enterprises in Chanthaburi revealed that the waste is often used as compost, but it can become breeding grounds for pests and fruit flies. It could be create significant disposal and environmental challenges for local communities.

Recent research has explored various applications for durian by-products, such as the extraction of bioactive compounds with antioxidant, anti-inflammatory and antimicrobial activities. The development of polysaccharide gels from durian peel such as gums, pectin, and carboxymethylcellulose for use in edible coatings and biodegradable films in order to inhibit oral pathogen. Additionally, starches have been produced from immature pulp, seeds, cores and peels for the development of gluten-free pasta (Charoenphun and Kwanhian, 2018).

In case of durian peel, it contains approximately 4.84% ash, 13.09% hemicellulose, and 15.45% lignin (Jun *et al*., 2010). So, it recognize these potentials to add in the food product for improving nutritional value. In addition, the waste durian peel and core were as sources of antioxidants and dietary fiber. Therefore, there are various researches conducted to convert these by-products into flour. It can be used as an alternative ingredient in health-oriented instant soup products. For example, Bunyasawat and Bhoosem (2018) investigated the effect of durian peel powder substitution on the quality of brownies. The results showed that a 30% substitution was well accepted by consumers, with no significant difference in overall liking compared to the control brownie. The

obtained brownie contained 6.37 g of dietary fiber. Additionally, Bhoosem and Bunyasawat (2019) incorporated durian peel powder (51.43% crude fiber) to partially replace wheat flour in butter cakes. The sensory evaluation indicated that the most preferred formulation was with 5% substitution. The developed butter cake showed an energy content of 300.28 kcal and 1.70 g of dietary fiber per serving. Furthermore, Srirajan *et al.* (2021) developed rice spaghetti fortified with dietary fiber from durian peel powder (DPP). They reported that the obtained formulations containing 0.00, 2.50, 5.00, 7.50 and 10.00% DPP (w/w) increased total dietary fiber from 8.13% to 24.14% and enhanced antioxidant activity. The developed spaghetti supplemented with 5.00% and 7.50% DPP showed no significant difference in overall liking compared to the control (0.00% w/w) formulation.

Moreover, Putri *et al.* (2025) studied the effects of different ratios of pumpkin flour and yellow sweet potato flour on the physicochemical properties and sensory characteristics of instant cream soup. The 80:20 ratio of pumpkin to yellow sweet potato flour improved protein content (9.07%), dietary fiber (3.99%) and antioxidant activity (67.4%). Furthermore, a healthy dry soup made from yellow sweet potato flour supplemented with moringa leaf powder showed that the formulation with 50% sweet potato flour and 2% moringa leaf powder achieved the highest overall liking. The developed soup had higher protein (33.25%), fiber (7.23%) and calcium (13.10 mg/100 g) than those the soup without moringa leaf powder (Limroongreungrat and Yuenyongputtakal, 2013).

However, there is currently no research on the production of cream soup supplemented with durian fiber waste. Thus, the objective of this study was to evaluate the antioxidant activity and some properties of powders derived from the peel and core of five durian cultivars such as Monthong, Chanee, Puangmanee, Kan Yao, and Kradum Thong.

Materials and methods

Materials

Five durian (*Durio zibethinus* Murr.) varieties such as Monthong, Chanee, Puangmanee, Kan Yao and Kradum Thong core powder and peel powder with unripe and ripening period were obtained from a Community Enterprise Group Processing Durian, Chanthaburi province, Thailand.

The fruits were separated into inner peel and core. Then, its were cut into small pieces and then dried by hot air oven-dried at 60◦C for 30 h or until the moisture was lower than 12%w/w. Then, the dried fruits were ground by a grinder. The powder samples were passed through sieves of 150 mesh. Twelve powder types including unripe Monthong peel (UMP), unripe Monthong core

(UMC), ripe Monthong peel (RMP), ripe Monthong core (RMC), Chanee peel (CP), Chanee core (CC), Puangmanee peel (PP), Puangmanee core (PC), Kan Yao peel (KP), Kan Yao core (KC), Kradum Thong Peel (KrP) and Kradum Thong core (KrC) were stored in vacuum plastic bags before further properties investigation. For chemical properties determination, DPPH antioxidant activity assay and chemical composition were analysed as described below. For physical properties, the color parameter was evaluated by using the color meter (Nippon Denshoku, ZE2000) and expressed as L*, a* and b* parameters.

The properties of durian waste powders evaluation

The DPPH antioxidant assay was performed. First, the powder samples were extracted in 95% ethanol (10 grams of powder per 100 mL of ethanol) for 1 h. The extracts were filtered by WhatmanTM Grade 4 Filter Paper (Merck KGaA, Darmstadt, Germany). The extraction procedure for each sample was determined three times. The extracts were dried by a vacuum evaporator and the dry samples were then weighed. The sample extracts were then dissolved in 95% ethanol for study.

The radical scavenging activity test using the DPPH (2,2-diphenyl-1-picryl-hydrazyl) method according to the research of Zhu *et al*. (2006) with modifications. Samples were prepared at various concentrations. Then, 1 mL of each concentration was mixed with 1 mL of 0.1 mM DPPH solution in 95% ethanol. The mixture was thoroughly mixed and left for 30 minutes. The absorbance was measured using a spectrophotometer at a wavelength of 517 nm. The experiment was investigated in triplicate, with ascorbic acid used as standard compounds for comparison. The obtained absorbance values were used to calculate the % DPPH radical scavenging activity according to the following equation:

$$\text{DPPH radical scavenging activity (\%)} = [(A_0 - A_1)/ A_0] \times 100$$

Where:

A_0 = Absorbance of the control sample

A_1 = Absorbance of the test sample

The % radical scavenging activity values at different concentrations of the samples were used to construct a graph to calculate the IC_{50} value. The IC_{50} value represents the concentration of the test substance that inhibits 50% of DPPH free radicals.

For the chemical composition analysis including moisture, protein, fat, ash, and carbohydrate content were analyzed as the methode of AOAC (2000). The the color parameter (L*, a* and b*) were evaluated by using the color meter (Nippon Denshoku, ZE2000).

Optimal concentrations of durian waste powder on instant cream soup production evaluation

Based on significantly highest antioxidant activity durian waste powder, those treatments were chosen and then used to supplement in an instant soup product by replacing potato starch portion.

Firstly, the four treatments of durian core powder were supplemented in potato starch portion such as 12.50%w/w, 25.00%w/w, 37.50%w/w and 50.00%w/w. The cream soup were prepared using a formula modified from Sunyoto *et al*. (2018). The control cream soup recipe was composed of 59.06% milk powder, 26.25% potato starch, 8.86% corn oil, 2.76% sugar, 1.97% soup powder, 0. 92% salt, 0.09% pepper, and 0.09% garlic powder. The soup samples prepared by adding 150 ml of water to 30 grams of dry instant soup. Next, the sensory evaluation of instant soup product was conducted using a 9-point hedonic scale (1=extremely dislike and 9= extremely like) with 40 untrained panelists from the staff and students of the Department of Food Innovation and Business (Faculty of Agro-industrial Technology, Rajamangala University of Technology Tawan-ok Chanthaburi Campus, Chanthaburi, Thailand) to evaluate the following attributes as appearance, aroma, taste, texture and overall acceptability. Secondly, some properties determination were observed such as DPPH antioxidant activity, fiber content, viscosity, moisture content, color parameter (L*, a* and b*) compare with the commercial instance soup. Lastly, the product's nutritional value was investigated by Central Laboratory Co. Ltd. Thailand including total energy, total fat, saturated fat, cholesterol, protein, carbohydrates, fiber, sodium, potassium, ash, and moisture (AOAC, 2023).

Statistical analysis

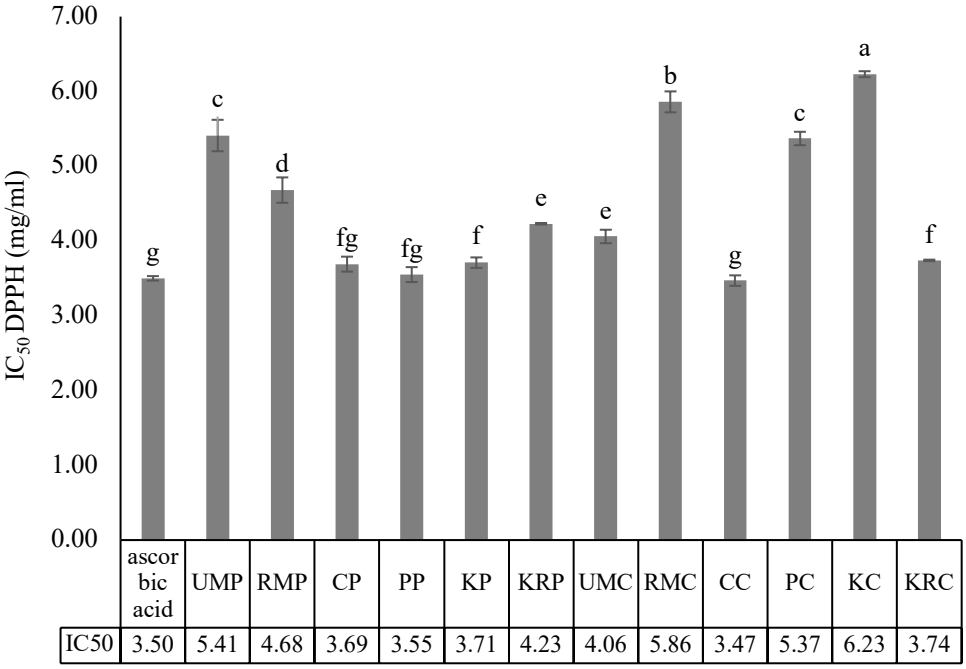
All experiments and analyses were conducted in three replications. The data were collected and analysed. Analysis of variance (ANOVA) was performed using computer software. Mean comparisons were determined using Duncan’s multiple range test.

Results

The properties of durian waste powders evaluation

Twelve durian powders waste including unripe Monthong peel (UMP), unripe Monthong core (UMC), ripe Monthong peel (RMP), ripe Monthong core (RMC), Chanee peel (CP), Chanee core (CC), Puangmanee peel (PP), Puangmanee core (PC), Kan Yao peel (KP), Kan Yao core (KC), Kradum Thong

Peel (KrP) and Kradum Thong core (KrC) were prepared and determined antioxidant activity. The evaluation was based on the concentration required to inhibit 50% of free radicals (IC_{50} DPPH), where a lower value indicates higher antioxidant activity. It was found that the crude extract from Chanee core powder (CC) exhibited the highest antioxidant activity with an IC_{50} value of 3.47±0.07 mg/mL, which was not significantly different from the standard ascorbic acid (3.50±0.03 mg/mL). Those values were followed by Kradum Thong (KRC), unripe Monthong (UMC), Puangmanee (PC), ripe Monthong (RMC), and Kan Yao (KC), with IC_{50} values of 3.74±0.01, 4.06±0.09, 5.37±0.09, 5.86±0.14, and 6.23±0.04 mg/mL, respectively. In contrast, the Kan Yao core (KC) showed significantly ($\rho \leq 0.05$) lowest antioxidant activity. For the peel extracts, significant differences were also observed among cultivars. Puangmanee peel (PP) exhibited the highest antioxidant activity, followed by Chanee (CP), Kan Yao (KP), Kradum Thong (KRP), ripe Monthong (RMP), and unripe Monthong (UMP), with IC_{50} values of 3.55±0.10, 3.69±0.10, 3.71±0.07, 4.23±0.01, 4.68±0.17, and 5.41±0.21 mg/mL, respectively (Figure 1).



	ascorbic acid	UMP	RMP	CP	PP	KP	KRP	UMC	RMC	CC	PC	KC	KRC
IC50	3.50	5.41	4.68	3.69	3.55	3.71	4.23	4.06	5.86	3.47	5.37	6.23	3.74

Figure 1. The antioxidant activities of durian powder waste extracts

Then, the chemical composition of 12 durian peel and core powders from different cultivars were determined. It was found that the peel powder contained higher amounts of dietary fiber than those of the core powder with the value

ranged from 10.39–38.49%w/w, while the core powder ranged from 5.28–28.84%w/w. For protein content, both peel and core powders contained in the range of 4.71–10.39%w/w.

Ash and fat content exhibited ranged from 4.09–6.15%w/w and 0.28–0.92%w/w, respectively. In terms of carbohydrate content, raw durian peel powder showed higher carbohydrate levels than those of ripe durian peel powder ranged from 42.58±0.07-69.25±0.48%w/w and 36.95±0.58-60.94±0.55%w/w, respectively. However, for durian core powders of cultivars other than Monthong, the carbohydrate content was exhibited to be higher than that those of the peel powder. For Chanee core powder, chemical composition analysis revealed that it contained 22.81% dietary fiber, 4.91%w/w protein (Table 2).

For color parameter of durian peel and core powders, it was showed that the lightness (L*) values ranged from 86.58 to 91.05. For the redness value (a*), significant($p<0.05$) differences were also observed ($p<0.05$), with values ranging from 4.69 to 7.89. In terms of yellowness (b*), significant($p<0.05$) differences were found, with values ranging from 7.99 to 14.46. These results indicate that the color appearance of durian peel and core powders had appeared by a light yellow hue (Table 3).

Table 2. Chemical composition of peel and core powders from various durian cultivars

Sample	Fiber	Protein	Ash	Fat	Carbohydrate	Moisture
UMP	10.39±0.14^{j}	6.84±0.09^{c}	4.69±0.05^{d}	0.39±0.03^{de}	60.94±0.55^{c}	16.75±0.49^{a}
RMP	21.34±0.15^{g}	5.26±0.12^{e}	6.02±0.12^{a}	0.50±0.08^{bc}	51.61±0.59^{g}	15.27±0.12^{bc}
CP	38.49±0.70^{a}	4.71±0.25^{f}	4.06±0.15^{e}	0.40±0.04^{cde}	37.79±1.04^{j}	14.55±0.40^{de}
PP	36.79±0.09^{b}	4.94±0.05^{ef}	5.13±0.03^{c}	0.30±0.01^{ef}	36.95±0.58^{j}	15.89±0.48^{b}
KP	28.07±0.70^{d}	8.39±0.14^{b}	5.50±0.17^{b}	0.52±0.04^{b}	42.16±0.43^{i}	15.36±0.08^{bc}
KRP	17.85±0.65^{h}	5.66±0.03^{d}	6.00±0.07^{a}	0.28±0.32^{f}	56.04±0.32^{e}	14.17±0.31^{e}
UMC	14.51±0.06^{i}	7.06±0.09^{c}	4.67±0.05^{d}	0.92±0.11^{a}	57.33±0.82^{d}	15.51±0.61^{bc}
RMC	28.84±0.30^{c}	5.79±0.21^{d}	6.15±0.08^{a}	0.91±0.05^{a}	42.58±0.07^{hi}	15.73±0.13^{bc}
CC	22.81±0.35^{f}	4.91±0.16^{ef}	4.09±0.20^{e}	0.43±0.03^{bcd}	53.69±0.20^{f}	14.07±0.18^{e}
PC	5.48±0.05^{k}	8.16±0.06^{b}	5.64±0.08^{b}	0.34±0.02^{def}	65.27±0.19^{b}	15.11±0.27^{cd}
KC	25.34±0.80^{e}	10.39±0.70^{a}	5.98±0.05^{a}	0.33±0.09^{def}	43.40±0.59^{h}	14.56±0.35^{de}
KRC	5.28±0.21^{k}	5.81±0.16^{d}	5.99±0.35^{a}	0.51±0.04^{b}	69.25±0.48^{a}	13.16±0.20^{f}

$^{a-k}$ Mean values with different letters in each column are significantly different ($p<0.05$).

Table 3. The color parameters of the peel and core powders from various durian cultivars

Samples	Color		
	L*	a*	b*
UMP	87.06±0.04[h]	7.89±0.01[a]	14.46±0.04[a]
RMP	90.15±0.03[b]	6.14±0.01[i]	12.04±0.03[h]
CP	89.55±0.04[d]	4.69±0.02[k]	7.99±0.01[l]
PP	89.55±0.03[d]	6.52±0.03[f]	11.02±0.02[j]
KP	89.33±0.01[e]	6.40±0.03[h]	12.77±0.03[f]
KRP	88.66±0.05[f]	6.84±0.02[d]	13.68±0.03[d]
UMC	86.58±0.02[i]	7.24±0.04[c]	14.32±0.03[b]
RMC	89.61±0.01[c]	6.07±0.01[j]	11.62±0.02[i]
CC	91.05±0.02[a]	6.10±0.02[ij]	9.65±0.01[k]
PC	88.42±0.02[g]	6.67±0.07[e]	13.42±0.03[e]
KC	87.70±0.01[h]	7.62±0.03[b]	14.01±0.03[c]
KRC	89.30±0.01[e]	6.46±0.01[g]	12.62±0.02[g]

[a-i] Mean values with different letters in each column are significantly different ($p<0.05$)

Optimal concentrations of durian waste powder on instant cream soup production evaluation

Based on significantly antioxidant activity, Chanee core powder (CC) was chosen to investigate the optimal concentrations of durian waste powder on enhanced in instant cream soup production. The four treatments of durian core replaced in potato starch portion such as 12.50%w/w, 25.00%w/w, 37.50%w/w and 50.00%w/w were mixed in the cream soup, boiled and sensory evaluation. It was found that at 12.50%, the consumers gave the highest preference scores across all attributes, namely appearance (7.43 ± 0.74), aroma (7.40 ± 0.92), taste (7.23 ± 0.69), texture (7.25 ± 0.63), and overall acceptability (7.43 ± 0.74). However, these scores were not significantly different from those of the 25.00%w/w formulation, which obtained preference scores of 7.18 ± 0.74 for appearance, 7.13 ± 0.79 for aroma, 7.13 ± 0.60 for taste, 7.00 ± 0.64 for texture, and 7.30 ± 0.68 for overall acceptability (Table 4). Therefore, the cream soup with 25.00%w/w formulation was selected in term of high proportion of durian core powder, thereby enhancing the antioxidant activity and dietary fiber content of the product (Figure 2). The optimal formulation consisted of powdered milk, potato starch, corn oil, durian core powder, sugar, chicken soup powder, salt, pepper, and garlic powder at 59.06%, 19.69%, 8.86%, 6.56%, 2.76%, 1.97%, 0.92%, 0.09%, and 0.09%, respectively.

Table 4. Sensory evaluation of cream soup products formulated with different levels of durian core powder as a substitute for potato starch

Durian core powder (%)	Appearance	Aroma	Taste	Texture	Overall acceptability
12.50	7.43±0.74[a]	7.40±0.92[a]	7.23±0.69[a]	7.25±0.63[a]	7.43±0.74[a]
25.00	7.18±0.74[ab]	7.13±0.79[ab]	7.13±0.60[a]	7.00±0.64[ab]	7.30±0.68[ab]
37.50	7.10±0.67[ab]	7.03±0.69[ab]	7.08±0.65[b]	6.78±0.62[bc]	7.08±0.65[b]
50.00	7.08±0.73[b]	6.97±0.70[b]	6.78±0.66[b]	6.65±0.58[c]	6.95±0.71[c]

[a-c] Mean values with different letters in each column are significantly different ($p<0.05$)

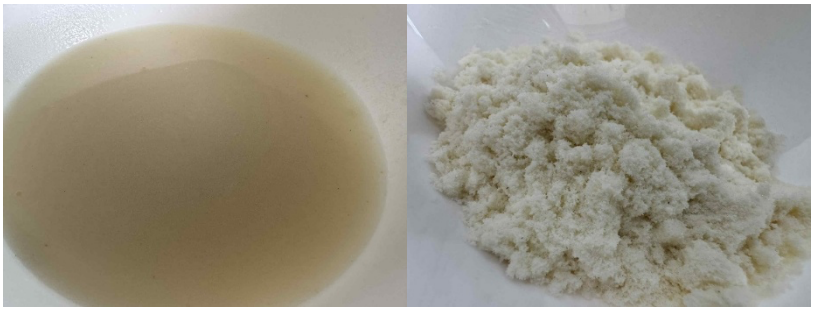


Figure 2. The developed cream soup product with added durian core powder

Then, the developed cream soup product with added durian core powder was investigated some properties including antioxidant activity, fiber content, viscosity, moister content and color parameters compare with the commercial instant soup. Interestingly, our results showed that significantly ($\rho \leq 0.05$) antioxidant activity and fiber content (82.64±0.14 mg/ml and 3.70±0.16%w/w) than those commercial instant soup (94.47±2.11 mg/ml and 1.54±0.12%w/w). However, our developed soup formulation exhibited significantly lower viscosity (1,756 ± 2.00 cP) than those commercial one (2,085±0.57 cP). For the moisture content and color parameter (L*, a* and b*) did not significantly difference. The developed product found the moisture content of 2.80 ± 0.05%, color parameters of L* 91.37 ± 0.03, a* 3.43 ± 0.02, and b* 9.96 ± 0.01 (Table 5). These results indicate that incorporation of durian core powder can enhance both the functional and physicochemical characteristics of instant soup.

Table 5. Quality of the instant soup with durian core powder compared with commercial instant soup

Properties	Commercial instant soup	Instant soup with durian core powder
DPPH (mg/ml)	94.47±2.11[a]	82.64±0.14[b]
Fiber (%w/w)	1.54±0.12[b]	3.70±0.16[a]
Viscosity (cP)	2,085±0.57[a]	1,756±2.00[b]
Moisture[ns] (%w/w)	2.66±0.00	2.80±0.05
L*[ns]	91.22±0.00	91.37±0.03
a*[ns]	2.48±0.00	3.43±0.02
b*[ns]	6.77±0.02	9.96±0.01

[a-b] Mean values with different letters in each column are significantly different ($p<0.05$)

Finally, the nutritional facts of the developed instant soup with durian core powder were observed and presented in Table 6. The developed instant cream soup with durian core powder for one serving (30 g) had a total calorie of 120 Kcal. It contained 26 g of carbohydrates, 1 g of sugar, 2 g of total fat, 210 mg of sodium, and 35 mg of potassium (Table 6).

Table 6. Nutritional facts for one serving size of 30 g instant soup with durian core powder

Nutritional facts	Per 1 serving size (30 g)	%RDI	Standard procedure
Calories (Kcal)	120	-	In-house method TE-CH-169 based on Method of Analysis for Nutrition Labelling, 1993, P.106 AOAC (2023)
Total fat (g)	2	3	In-house method TE-CH-208 based on AOAC (2023) 996.06
Cholesterol (mg)	0	0	In-house method TE-CH-143 based on AOAC (2023) 994.10
Protein (g)	0	-	AOAC (2023) 981.10
Carbohydrate (g)	26	9	In house method TE-CH-169 based on Method of Analysis for Nutrition Labelling., 1993, P.106
Sugar (g)	1	-	In-house method TE-CH-164 based on AOAC (2023) 977.20
Sodium (mg)	210	10	In-house method TE-CH-208 based on AOAC (2023) 984.27 by ICP-OES Technique
Potassium (mg)	35	1	In-house method TE-CH-208 based on AOAC (2023) 984.27 by ICP-OES Technique

Discussion

From properties of durian waste powders investigation section, the antioxidant activity revealed that the ripe durian peels of all five cultivars including Monthong, Chanee, Puangmanee, Kan Yao, and Kradum Thong exhibited higher antioxidant activity compared to the unripe Monthong peel. This could be in the ripening process, the levels of polyphenols and flavonoids in the peel increase. Because thosecompound are synthesized to protect the fruit against oxidation and oxidative stress within the cells (Staveckiene *et al*., 2023). Therefore, the levels of flavonoids and total phenolic content in ripe durian cultivars exhibited high and also high antioxidant activity. In term of previous studies demonstrated a positive relationship between flavonoid and phenolic content with antioxidant activity, suggesting that higher levels of these compounds generally enhance antioxidant capacity (Shui and Leong, 2005; Toledo *et al.*, 2008). So, the high antioxidant activity was exhibited in ripe durian peel and demonstrated in this research. Our result was agreeing with Leontowicz *et al*. (2011), who demonstrated that differences in ripening stages influence the amount of flavonoids and phenolics produced. The highest concentrations of these compounds are usually found in ripe or overripe fruits, while the lowest levels are detected in unripe ones. Moreover, Poovarodom *et al*. (2010) also reported that certain compounds, such as caffeic and apigenic acids, are only present in fully mature or overripe durian fruits.

However, ripe Chanee core (CC) powder exhibited significantly ($\rho<0.05$) highest antioxidant activity than those other samples in this study. This result is consistent with the findings of Charoenphun *et al*. (2022), who investigated the antioxidant activity of crude extracts from unripe Monthong and Chanee peels using the ABTS assay. Their study reported that the extract from Chanee peel had an SC_{50} value of 10.48 ± 0.26 µg/mL, indicating higher antioxidant activity than the Monthong peel extract, which had an SC_{50} value of 18.03 ± 1.06 µg/mL. In addition, this result also corresponded with the level of total phenolic content, Chanee peel extract (3,576.74 ± 259.99 mg GAE/g) indicated a higher content than those of Monthong peel extract (3,471.98 ± 141.06 mg GAE/g) (data not shown).

Additionally, this could be Chanee durian flesh had a more intense yellow color compared to other varieties, which results from the presence of carotenoids, pigments responsible for red to yellow coloration. Since, all durian varieties predominantly contained β-carotene, followed by lutein and α-carotene. This finding is consistent with a report from Malaysia (Isabelle *et al*., 2010), which found that durian (unspecified variety) had carotenoids as the main component (517 µg/100 g DM), accounting for 66% of the total carotenoids. In addition,

Charoenkiatkul *et al*. (2016) reported that Thailand's Chanee and Monthong varieties contained β-carotene at 421 and 117 μg/100 g DM, respectively. Moreover, Chani durian contained α-carotene at 279 ± 190 μg/100 g DM compared to Monthong durian (13 ± 5 μg/100 g DM). Overall, the total carotenoid content in Chanee was 2–3 times higher than that in Monthong. However, differences in carotenoids content could result from variety, ripening stage, or cultivate location (Mercadante and Rodriguez-Amaya, 1998).

From the analysis of the chemical composition of durian peel and core powders from different cultivars (Table 2), it was found that durian peel contained higher fiber content than the core, ranging from 10.39–38.49%w/w, while the crude fiber content of the core ranged from 5.28–28.84%w/w. This finding is consistent with the study of Nordin *et al*. (2017), which reported that whole durian peel had the highest crude fiber content at 14.66%w/w, highlighting its fiber-rich structure and nutritional potential for commercial applications. Durian peel is considered a lignocellulosic biomass with a complex structure, consisting of cellulose (57–64%w/w), hemicellulose (approximately 30.70%w/w), and lignin (approximately 15.60%w/w) (Lubis *et al*., 2018).

Durian core flour contains less dietary fiber but higher carbohydrate content than durian peel flour (Table 2). This could be due to the fact that the core has softer tissues and does not serve as a protective structure but rather functions as a storage site for nutrients and starch to support the development of durian flesh. According to the study by Charoenkiatkul *et al.* (2016), which investigated the chemical composition of four durian cultivars such as Mon thong, Chanee, Kradum Thong, and Kobtakam. All varieties were found to have high carbohydrate contents (62.9–70.7 g/100 g DM) and total sugar contents (47.9–56.4 g/100 g).

Based on significantly ($p<0.05$) highest antioxidant activity, Chanee core (CC) powder was chosen to study optimal concentrations of durian waste powder on instant cream soup production. From sensory evaluation, the cream soup supplemented durian core powder 25.00%w/w was selected in term of high preference score for appearance, aroma, taste, texture and overall acceptability and high dietary requirements. This developed cream soup formulation showed higher antioxidant activity and fiber content than commercial soup, while, the viscosity lower than those commercial one (Table 6). Because of the substitution of durian core powder, thereby enhancing the antioxidant activity and dietary fiber content of the product. But, the durian core fiber was retarded the viscosity.

Lastly, the developed cream instant soup was analyzed of nutritional value revealed that the product was relatively low in energy (120 kcal per serving, 30 g) but contained a relatively high dietary fiber content of 3.70%w/w. The recommended daily intake (%RDI) of dietary fiber, including both soluble

and insoluble types (25 g/day) (Nutrition Division, Department of Health, Ministry of Public Health, 2020).

In conclusion, the findings of the study indicated that the significantly highest antioxidant activity was found in CC (Chanee core powder). This treatment was chosen to develop of the cream soup product. Substitution of potato starch with 25.00%w/w durian core powder showed high preference scores for appearance, aroma, taste, texture, and overall acceptability. Interestingly, the developed cream soup showed significantly higher of antioxidant activity and fiber content than those commercial soup. Therefore, this study adds value to durian and reduces environmental waste by utilizing durian waste as an alternative ingredient in healthy instant soup, improving nutrition, digestion, and antioxidant intake. The findings may benefit other areas of the food industry, though further research is needed on production, shelf life, and quality. Overall, the study offers guidance for using durian by-products in developing functional food products for consumers and the industry.

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Conflicts of interest

The authors declare no conflict of interest.

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