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Physical, nutritional and organoleptic properties of muffins prepared with canistel fruit flour (*Pouteria campechiana*)

*Abdul Majeed, U.L., Madushani, A.H.K.L. and Asmath, A.M.M.

[1]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, University Park, Oluvil, Sri Lanka*

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Abstract

Canistel is an underutilized fruit available in Sri Lanka. It has potential nutritional value and various health benefits due to the presence of functional compounds in it. Therefore, muffins from canistel flour were prepared in various proportions together with wheat flour as a remedy for reducing gluten and minimising the wastage of nutritionally rich canistel fruit. In this study, the properties of muffins prepared with different ratios of wheat flour and canistel flour, such as 100/0, 80/20, 70/30, 60/40, and 50/50%, were evaluated. AOAC and AACC standard methods were used to determine the physical and nutritional properties of developed muffins. The Statistical Package for the Social Sciences (SPSS) was used to perform a statistical analysis of the data. The nutritional factors such as the moisture, ash, protein, fat, fibre, carbohydrates, and energy were discovered to differ between 14.91 - 15.49%, 1.39 - 1.62%, 6.01 - 7.29%, 13.37 - 15.80%, 6.07 - 10.67%, 49.13 - 58.25% and 435.87 - 459.63 J/Kg, respectively. All physical and nutritional properties exhibited substantial variations ($p<0.05$) among treatments. According to the result obtained, the physical and nutritive features of treatment C (Tc), that is 70:30 wheat: canistel flour blend, were selected as the most effective muffin. Therefore, this undervalued canistel fruit could be utilized to prepare baked goods blended with wheat flour, perhaps contributing to gluten-free, healthy baked goods.

1. Introduction

Nowadays, the majority of people consume bakery products for their main meal due to their busy lifestyles (Matos *et al*., 2014). Muffins are calorie-dense, sweet baked bakery goods that are popular with customers owing to their flavor, readily available nature, and smooth surface (Pauter *et al*., 2018). Wheat flour is an indispensable ingredient in muffins because it contains gluten. Generally, gluten is well tolerated by the majority of citizens, and some individuals may experience difficulties such as celiac disease, gluten sensitivity, wheat allergies, and a few other ailments (Volta *et al*., 2013; Kumuduni *et al.,* 2022). As a remedy to the ever-ascending consumer demand for healthy nutrition, the food industries heavily focus on formulating gluten-free foods. However, bakers encounter severe technological challenges when producing gluten-free baked items (Matos and Rosell, 2011). However, muffins made by substituting a portion of nutritionally rich flour instead of wheat flour can add nutritional value and reduce gluten content by reducing the wheat flour portion. Recently, muffins have been made using composite flour or fortified with nutrient-rich flours such as almond flour, pumpkin seed flour, palmyra sprout flour, and chickpea flour to improve their nutritive value, and reduce the gluten content (Białek *et al*., 2016; Alvarez *et al*., 2017; Stoin *et al*., 2018; Khatri *et al*., 2020).

Canistel (*Pouteria campechiana*) is a nutrient-dense tropical fruit that falls under the Sapotaceae family (De Lanerolle *et al*., 2008). It is an indigenous, inexpensive fruit commodity that is readily and freshly available at a low cost in Sri Lanka. Further, they are seasonal and underutilized, and most fruits go to waste due to their high nature of perishability and the reluctance of people to consume canistel in raw form. Several studies state that canistel is rich in minerals, carbohydrates, amino acids, carotene, carotenoids, and vitamins A and C. Furthermore, when compared to fellow underused fruits, canistel fruit has much greater anti-oxidant activity, phenolic, and flavonoid content (Adiyaman *et al*., 2016). Canistel fruit has beneficial properties, including being beneficial to the heart, lowering the probability of diabetes, being an immunity booster, lowering the chance of cataracts, mitigate flu-like symptoms and flu,

*Corresponding author.
Email: *ulmajeed@seu.ac.lk*

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preventing cancer, being beneficial to digestive processes, preventing anemia, making healthy joints and bones, and reducing the likelihood of cardiovascular issues, dermal diseases, liver problems, and gastritis (Aseervatham *et al*., 2013; Heben, 2021). Because of its medicinal and nutritional value, some people include canistel in their diet regularly (De Lanerolle *et al*., 2008). Furthermore, it was used to make ice cream, cookie-flavored desserts, salads, juices, spreads, ketchup, canistel pancakes, cookies, jams, puddings, and marmalades (Morton and Dowling, 1987; Lim, 2013). So, applying substitutional flours such as canistel flour with high nutritional value in different portions together with wheat flour in bakery products could reach a certain level on the path which leads to a healthy life with a gluten-free diet. Therefore, in this present study, a muffin made from canistel flour was prepared in various proportions together with wheat flour as a remedy for reducing gluten and minimizing the wastage of nutritionally rich canistel fruit.

2. Materials and methods

2.1 Canistel flour production

Canistel flour was prepared according to the method described by Pertiwi *et al*. (2020). The mature canistel fruits were thoroughly cleaned with tap water, and any extraneous matter was removed. The fruits were then skinned, de-seeded, chopped, and marinated for 30 min in a 7.5% NaCl solution to remove the latex from the fruit pieces prior to being dried and pulverized. They were then placed in an aluminum tray and dehydrated at 40°C for 6 h continuously in an air-dryer. The dried chips were then crushed into fine powder using an electric grinder (Model-TL740B, India) and then sieved (212 mm sieve size) to get uniform-sized flour granules. Finally, the processed flour was put into a clean, airtight container and stored at normal ambient temperature in a cold and dry place until further use.

2.2 Preparation of muffins

Table 1 describes the set of treatments associated with the preparation of muffins. According to the treatment plan, powdered sugar and butter were blended for 3 to 5 min, or until the mixture was fluffy. Eggs were then added to the mixer (Butterfly grand plus, HL-17029) one at a time and thoroughly mixed. The air bubbles were created by proteins to maintain the characteristic texture. Afterwards, the butter-egg-sugar mixture was mixed at low speed by a hand beater with canistel flour, wheat flour, and other ingredients. Following that, muffin liners were placed in a tray and the butter was applied in the liner cups before baking at 180°C for 20 min. The muffins were then allowed to cool to a normal ambient temperature and packed in polystyrene bags.

2.3 Determination of Physical Parameters

The diameter and height of muffins (cm) were measured using a Vernier Caliper (Ingco, HVC01150-ING), and the weight of muffins and batter (g) was measured using an analytical digital balance (TFD-300-3). The seed displacement method (AACC 10-91.01) was applied to determine the volume (AACC, 2000; Lee *et al.,* 2020). The specific volume (mL/g) was calculated by fractioning the volume (mL) by the weight of the muffin (g). The baking loss (AACC 10-91.01) and baking yield (AACC 10-91.01) were determined by the following formula using the weight of batter (AACC, 2000; Lee *et al.,* 2020).

$$\text{Baking yield (\%)} = (\text{muffin weight}/\text{batter weight}) \times 100$$

$$\text{Baking loss rate (\%)} = (\text{batter weight} - \text{muffin weight})/\text{batter weight}) \times 100$$

2.4 Determination of the nutritional composition

The nutritional contents of the muffins were examined using the AOAC INTERNATIONAL (1990) standard procedure. Moisture content was determined using the oven drying technique (AOAC 925.10). The semi-micro Kjeldahl method was used to determine protein content (AOAC 984.13). Fat content was determined using the solvent extraction method (AOAC

Table 1. Treatment plan and muffin recipe.

Ingredients	Treatments				
	T_A	T_B	T_C	T_D	T_E
Wheat flour	100 g	80 g	70 g	60 g	50 g
Canistel flour	0 g	20 g	30 g	40 g	50 g
Sugar	95 g	95 g	95 g	95 g	95 g
Margarine	95 g	95 g	95 g	95 g	95 g
Eggs	2	2	2	2	2
Baking powder	½ tsp	½ tsp	½ tsp	½ tsp	½ tsp
Condensed milk	1 ¼ tsp	1 ¼ tsp	1 ¼ tsp	1 ¼ tsp	1 ¼ tsp

T_A: 100% wheat flour (control), T_B: wheat flour substituted with 20% of canistel flour, T_C: wheat flour substituted with 30% of canistel flour, T_D: wheat flour substituted with 40% of canistel flour, T_E: wheat flour substituted with 50% of canistel flour.

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920.39). Ash and fibre contents were determined using the dry ash method (AOAC 923.03) and the gravimetric method (AOAC 985.29), respectively. Carbohydrate content was calculated using the formula as Carbohydrate (%) = 100% - (moisture + ash + protein + fat). The bomb calorimeter (IKA C6000, India) was used to find out the energy value.

2.5 Statistical analysis

The collected data were analyzed using the analysis of variance (ANOVA) of the SPSS statistical package (version 25.0, IBM) for physical, nutritive, and organoleptic parameters at a 5% significance level. The mean comparison was performed using Turkey's post-hoc test for all parameters.

3. Results and discussion

3.1 Physical parameters

Table 2 displays the findings of the physical parametric study of canistel-wheat composite flour muffins. The processed muffins had a mean weight ranging from 44.9 g to 46.82 g, with a significant difference (p = 0.00, f = 621.36). The highest weight was obtained in treatment T_E (50% canistel flour), while the lowest was obtained in the control sample T_A (100% wheat flour). Usually, canistel flour absorbs more water than wheat flour does, and it is recorded for higher moisture content. Sethuraman *et al.* (2020) reported that fresh canistel fruit had 52.96% of the moisture, whereas Pertiwi *et al.* (2020) reported that the dried canistel had 10.55% of moisture at 30°C. Hence, the absorbance of moisture could be the cause of the weight gain observed in T_E compared to the control sample T_A. The diameter varied between 5.28 to 5.44 cm, and a significant difference (p = 0.00, f = 24.64) was observed in diameter. However, incorporation of canistel flour up to 30% does not statistically affect the diameter.

Volume and shape are essential aspects of baked foods (Peressini and Sensidoni, 2009). Volume, specific volume, and height ranged between 96.56 and 99.58 mL, 2.06 and 2.22 mL/g and 4.5 and 5.12 cm, respectively. The control sample TA (100% wheat flour) had the highest volume, whereas T_E (50% canistel flour) had the lowest. Due to the addition of canistel flour, the volume, specific volume, and the height of muffins dropped dramatically (p = 0.00). As the amount of canistel flour added increased, the volume followed a similar pattern to the specific volume. These findings might be attributable to gluten dilution caused by the replacement of canistel flour for wheat flour (Chung *et al*., 2006). Furthermore, Heo *et al*. (2019) reported a decrease in muffin volume when kimchi byproduct was used as a substitute flour for wheat flour, but Walker *et al*. (2014) reported a decrease in muffin volume when wine grape pomace was used. Furthermore, Martínez-Cervera *et al*. (2011) discovered that increasing cocoa fibre resulted in a reduced muffin height. The inclusion of fibre causes a decrease in the final volume and height of the baked product (Peressini and Sensidoni, 2009). Furthermore, the specific volume of this study (2.01-2.89 mL/g) was compatible with that of Lee *et al*. (2020)

The rate of baking loss and baking yield varied from 9.58% to 12.59% and 87.43% to 90.40% respectively, as seen in Table 2. Baking loss observed being decreased significantly (P = 0.00, f = 3665.54) with increasing substitutions of canistel flour, while baking yield increased significantly (P = 0.00, f = 2559.22) with increasing substitutions of canistel flour. The lowest baking loss was recorded in T_E (50% canistel flour). A similar trend was seen in the study of Lee *et al*. (2020),

Table 2. Results of physical parameters.

Treatments	Physical parameters						
	Weight (g)	Diameter (cm)	Height (cm)	Volume (mL)	Specific volume (mL/g)	Baking loss rate (%)	Baking yield (%)
T_A	44.9±0.1^{a}	5.44±0.04^{a}	5.12±0.03^{a}	99.58±0.03^{a}	2.22±0.01^{a}	12.59±0.02^{a}	87.43±0.06^{a}
T_B	45.43±0.04^{b}	5.30±0.01^{a}	5.08±0.02^{a}	99.41±0.02^{b}	2.19±0.03^{ab}	11.40±0.02^{b}	88.58±0.03^{b}
T_C	45.70±0.02^{c}	5.28±0.02^{a}	4.83±0.02^{b}	98.09±0.01^{c}	2.15±0.03^{ab}	10.91±0.05^{c}	89.07±0.03^{c}
T_D	46.03±0.02^{d}	5.39±0.03^{b}	4.65±0.03^{c}	97.82±0.04^{d}	2.12±0.03^{bc}	10.40±0.04^{d}	89.58±0.05^{d}
T_E	46.82±0.01^{e}	5.40±0.02^{b}	4.50±0.03^{d}	96.56±0.04^{e}	2.06±0.02^{c}	9.58±0.01^{e}	90.4±0.02^{e}
P value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F value	621.357	24.638	364.562	6754.451	13.905	3665.54	2559.22
N value	3	3	3	3	3	3	3
df value	4	4	4	4	4	4	4

Values are presented as mean±SD (n = 3). Values with different superscripts in the same column are statistically significantly different (p<0.05). T_A: 100% wheat flour (control), T_B: wheat flour substituted with 20% of canistel flour, T_C: wheat flour substituted with 30% of canistel flour, T_D: wheat flour substituted with 40% of canistel flour, T_E: wheat flour substituted with 50% of canistel flour.

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the authors proposed that the water binding capacity influences the moisture content of muffin crumb, which could affect baking yield and baking loss. Furthermore, the percentage baking loss (11.20 to 14.54%) of this present study was in agreement with that of Lee (2015) in muffins made using *Rubus coreanus* flour.

3.2 Nutritional parameters

Table 3 shows the nutritional data obtained for various treatments, including moisture, ash, fibre, protein, fat, total carbohydrate, and energy content. As demonstrated in Table 3, the moisture levels of the muffins developed ranged from 14.91% to 15.49%. The control sample T_A (100% wheat flour) had the lowest moisture content (14.91%), whereas the sample T_E (50% canistel flour) had the highest (15.49%). However, the increased substitution of canistel flour with wheat flour resulted in a substantial rise ($p = 0.00$, $f = 257.82$) in moisture, which might be attributed to the greater absorbency of canistel flour, its water holding ability, and higher water content (Pertiwi, 2020). As a result, the integration of canistel flour is the cause of the wetness when compared to the control treatment. Muffins made using grain bran and corn starch had similar results (Hippleheuser *et al.,* 1995). Further, bakery items, including muffins, should have a low moisture content to guarantee safe and long-term storage, as well as to limit microbial development and growth, which might affect their quality (Adebowale *et al*., 2012).

The ash content of a dietary substance indicates the existence of total mineral content (Sanni *et al*., 2008). It encourages the breakdown of other substrates such as carbs, fat, and protein (Okaka and Ene, 2005). Higher ash concentration also suggests that composite muffin samples have a diverse mineral makeup that is healthier for customers. As indicated in Table 3, the mean ash content of the muffin ranged from 1.39% to 1.62%, with a significant difference ($p = 0.00$, $f = 66.9$) among the treatments used. Lee and Chung (2013) achieved comparable findings (0.99 to 1.19%) for muffins made from wheat flour and apricot powder mixes. The control had the lowest ash content T_A (100% wheat flour) due to being free from the addition of canistel flour. It could be observed that the addition of canistel flour and the derivation of ash content are proportional in the muffins studied. Multiple studies have found that raising the quantity of highly nutritious flour blends, such as high fruit dietary fibre and almond flour, increases the amount of ash content in muffins (Grigelmo *et al.,* 1999; Stoin *et al.,* 2018).

Fiber-rich foods are important because they induce bowel movement and inhibit a multitude of gastrointestinal problems in humans (Meegepala *et al*., 2022). The fibre content of muffins made with canistel flour mixes ranged between 6.07 and 10.67%. Muffins treated with T_E had the highest value (10.67%), whereas muffins treated with T_A had the lowest (6.07%). The fibre content of the treatments differed significantly ($p = 0.00$, $f = 6284.38$). Canistel has a greater fibre content than wheat, which helps to explain the results reported for muffin samples in this investigation. Heo *et al.* (2019) reported that the increasing trend in the fibre (6.71–12.73%) contents of muffins made of wheat-kimchi by-product flour composites.

As indicated in Table 3, the average fat content ranged from 13.37 to 15.80%. The greatest fat content was seen in T_E (50% canistel flour) due to the integration of a substantial quantity of canistel flour, and it demonstrated a significant difference ($p = 0.00$, $f = 643.57$) when compared to other treatments. Canistel has a high-fat level, as per Sethuraman *et al*. (2020). With

Table 3. Nutritional parameters of muffins with different treatments.

Treatment	Nutritional parameters						
	Moisture (%)	Ash (%)	Fiber (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy (kcal/100 g)
T_A	14.91±0.02^a	1.39±0.03^a	6.07±0.04^a	13.37±0.02^a	6.01±0.02^a	58.25±0.02^a	459.63±0.02^a
T_B	15.14±0.01^b	1.41±0.02^a	6.97±0.06^b	14.13±0.03^b	6.15±0.04^b	56.20±0.02^b	454.19±0.01^b
T_C	15.27±0.02^c	1.47±0.02^b	7.89±0.011^c	14.67±0.02^c	6.63±0.02^b	54.07±0.02^c	450.16±0.04^b
T_D	15.38±0.04^d	1.57±0.02^c	9.03±0.07^d	14.97±0.11^d	6.86±0.01^c	52.19±0.06^d	442.25±0.02^c
T_E	15.49±0.02^e	1.62±0.01^c	10.67±0.04^e	15.80±0.08^e	7.29±0.01^c	49.13±0.05^e	435.87±0.04^d
P value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F value	257.824	66.899	6284.379	643.566	1826.722	30224.93	287074
N value	3	3	3	3	3	3	3
df value	4	4	4	4	4	4	4

Values are presented as mean±SD (n = 3). Values with different superscripts in the same column are statistically significantly different ($p<0.05$). T_A: 100% wheat flour (control), T_B: wheat flour substituted with 20% of canistel flour, T_C: wheat flour substituted with 30% of canistel flour, T_D: wheat flour substituted with 40% of canistel flour, T_E: wheat flour substituted with 50% of canistel flour.

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the inclusion of canistel flour, the fat content in muffins could rise. Romero-Lopez *et al*. (2011) discovered a comparable fat level (15.3 to 15.5%) on muffins containing orange bagasse.

Protein composition varied from 6.01 to 7.29%. Protein content differed significantly (p = 0.00, f = 1826.72) with varying amounts of canistel and wheat flour. Elevated drying temperatures would harm the protein content, resulting in relatively minor changes in the protein level of muffins (Pertiwi *et al*, 2020). Grigelmo *et al*. (1999) found a comparable protein level (6.76% to 8.40%) in muffins manufactured from wheat flour mixes with high fruit dietary fibre. The findings are similar to Lee and Chung (2013), who measured the protein content of muffins made with wheat flour and apricot powder.

As indicated in Table 3, the carbohydrate and energy content ranged from 49.13 to 58.25% and 435.87 to 459.63 kcal/100 g, respectively. Carbohydrate and energy levels were shown to rise with diminishing canistel flour, resulting in the maximum carbohydrate and energy value with T_A (100% wheat flour) as well as the lowest value with T_E (50% canistel flour) for both nutritional characteristics. A substantial difference (p = 0.00) in carbohydrate and energy value was found in muffins made with different quantities of canistel and wheat flour. Muffins' calorie value was influenced by their carbohydrate, protein as well and fat content. This study's findings are congruent with those of Heo *et al.* (2019) for carbohydrate content (51.75% to 57.0%) and energy value (347.82 kcal//100 g to 374.76 kcal//100 g) of muffins produced with the blends of wheat flour and kimchi byproduct. Furthermore, similar findings for carbohydrate (38.89% to 50.49%) and energy (378.9 to 428.1 kcal//100 g) were reported by Grigelmo *et al.* (1999) for muffins produced from the blends of wheat flour and fruit with high dietary fibre. According to Pertiwi *et al*. (2020), varying drying temperature impacts the yield of moisture, carbohydrate, fibre, starch and energy contents based on the physical and chemical features of canistel flour.

4. Conclusion

According to the findings of this study, mixing wheat and canistel flour in varied quantities might result in an acceptable and healthy muffin. This study also supports the development of muffins with varying ratios of canistel flour and wheat flour with acceptable physicochemical, and nutritional criteria. The most preferred muffin is with a 30% canistel flour substitution. Canistel fruit is an undervalued fruit in Sri Lanka with several health benefits that might be used to manufacture muffins for human consumption, paving the way for future food security.

Conflict of interest

The authors declare no conflict of interest.

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