

A COMPARATIVE STUDY OF DAIRY AND NON-DAIRY COCOA BUTTER-BASED MUSANG KING DURIAN ICE CREAM

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ABSTRACT – *Musang King durian has been gaining popularity in ice cream. Ice cream typically contains milk fat, milk and milk-derived ingredients which contribute to creaminess, flavour and texture to the ice cream. Increasing health concerns related to saturated fat intake, along with the growing prevalence of lactose intolerance and milk allergies have driven consumers demand for alternative fats and milk sources. Cocoa butter and almond milk have emerged as promising substitutes in non-dairy ice cream. Unlike milk fat, cocoa butter does not raise serum cholesterol levels, and almond milk offers lactose and milk free option, making them attractive alternatives for health conscious and dairy sensitive consumers. This study aimed to characterize cocoa butter-based Musang King durian ice cream prepared using two formulations: a dairy version (with fresh skim milk) and non-dairy version (with almond milk). Physical properties including overrun, total solids, melting properties, colour, and organoleptic qualities were evaluated. The non-dairy formulation exhibited significantly ($p < 0.05$) higher overrun ($43.54 \pm 2.87\%$) compared to the dairy variant ($31.12 \pm 1.24\%$), resulting in a lighter and airier texture. In contrast, the dairy formulation showed a significantly ($p < 0.05$) higher total solids content ($39.76 \pm 0.13\%$) than the non-dairy counterpart ($36.15 \pm 0.04\%$), contributing to a denser texture. In terms of melting properties, the non-dairy ice cream displayed a delayed first drop time (41.71 ± 1.55 min) and a lower melting rate (0.02 ± 0.00 g/min) compared to the dairy version (27.28 ± 0.82 min, 0.03 ± 0.00 g/min). Colour analysis revealed that the dairy variant had higher L^* values (lightness) while the non-dairy variant exhibited significantly ($p < 0.05$) higher a^* (redness) and lower b^* (yellowness) values. Sensory evaluation results indicated positive acceptance for both formulations; however, the dairy-based ice cream was preferred in terms of colour and Musang King durian flavour.*

Keywords: Durian ice cream, dairy, non-dairy, cocoa butter, almond milk

INTRODUCTION

The Musang King durian (*Durio zibethinus*), also known as Mao Shan Wang or D197, is highly prized in Malaysia and internationally for its rich, bittersweet flavour, creamy texture, and distinctive aroma (Top Fruits Team, 2024). Renowned as the “King of Durians,” it is also a nutrient-dense fruit, containing vitamins B1, B2, B6 and C, essential minerals like potassium, magnesium, and zinc as well as dietary fiber, and antioxidants such as carotenoids, flavonoids, and anthocyanins (Baylis, 2023; The Plantations International Group, 2024).

Musang King durian has been gaining popularity in frozen desserts, particularly ice cream, which serves as an ideal medium for incorporating functional ingredients due to its ability to preserve bioactive compounds (Soukoulis *et al.*, 2014). Traditional ice cream formulations typically include milk fat or saturated vegetable fats such as palm and coconut oil (Li, *et al.*, 1997, Wan Rosnani *et al.*, 2007, Efik Kurultay *et al.*, 2010), along with milk and milk-derived ingredients that contribute to creaminess, flavour and texture (Goff and Hartel, 2013). However,

rising health concerns over saturated fats, linked to increase low density lipoprotein (LDL) cholesterol and cardiovascular risks (American Heart Association, 2021) have prompted the search for healthier alternatives. Cocoa butter is a promising substitute, delivering a rich mouthfeel without raising serum cholesterol despite its saturated fat content (Denke, 1994).

Increasing rates of lactose intolerance, milk-related allergies, and the growing adoption of vegan lifestyles have significantly driven the growth of the non-dairy ice cream market, which expanded from USD 505 million in 2019 to a projected USD 1,390.77 million by 2027, at a CAGR of 13.5% (Medeiros, 2019; Fior Markets, 2021). Among plant-based milk alternatives, almond milk has emerged as a popular choice due to its favorable nutritional profile which high in monounsaturated fats, vitamins A, B2, B9, B12, D, and E), and minerals such as calcium, magnesium, and potassium—and its suitability for those with lactose or milk protein intolerance (Dhakal *et al.*, 2014; Chalupa-Krebzdak *et al.*, 2018; McClements *et al.*, 2019; Jalali-Khanabadi *et al.*, 2010). Its functionality in non-dairy frozen desserts has also been validated by

previous studies supporting its use in vegan ice cream development (Kot *et al.*, 2021).

Given the limited research on almond milk-based ice cream and the absence of studies on cocoa butter-based Musang King durian ice cream, this study aims to comparatively assess the physical properties and sensory attributes of dairy and non-dairy Musang King durian ice creams, with cocoa butter as the primary fat source.

MATERIALS AND METHODS

Materials

Sugar, skim milk powder, fresh skim milk, and almond milk were purchased from the local supermarket. Deodorised cocoa butter was procured from the local cocoa processor. Stabilizer and emulsifier were obtained from ingredient supplier. Frozen Musang King durian pulp was sourced from Daily Fresh Malaysia.

Methods

Production of Cocoa Butter-Based Durian Ice Cream

Cocoa butter-based durian ice cream was produced following the method outlined by Chin and Nor Haslita (2021) (Figure 1). Dry ingredients namely sugar, skim milk powder (SMP), stabilizer (S) and emulsifier (E) were blended into fresh skim milk (FSM) until a homogeneous mixture. Musang King durian pulp (MKDP) was then incorporated into the mixture.

The mixture was pasteurized at 68°C for 20 minutes using a batch pasteurizer (Taylor, Model CH02, USA). After pasteurization, molten deodorised cocoa butter (DCB) was added, and the mixture was homogenised at 5000 revolutions per minute (rpm) for 20 minutes using a high-shear homogenizer (Silverson, Model L5M).

The homogenised mixture was aged at 5°C for 20 hours in a chiller. Following the aging process, the ice cream mix was frozen for 12 minutes using a scraped-surface freezer (Taylor by Frigomat, Model C122, Italy). The frozen ice cream was then portioned into one-liter plastic containers and subjected to blast freezing at –18°C for 15 minutes (Gram, United Kingdom). Finally, the ice cream was hardened at –20°C for 24 hours in a chest freezer.

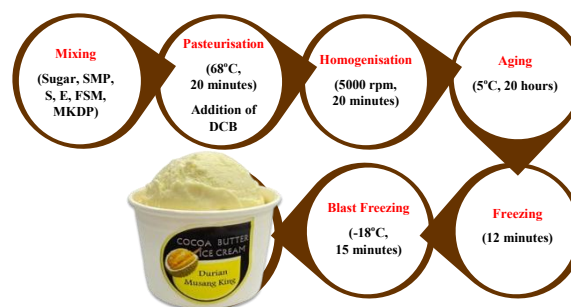


Figure 1: Production of Cocoa Butter-Based Musang King Durian Ice Cream (MKDIC)

Production of Cocoa Butter-Based Durian Ice Cream Made with Almond Milk (Non-Dairy)

The non-dairy cocoa butter-based Musang King durian ice cream was developed by replacing the dairy components namely fresh skim milk and skim milk powder, which constituted 62% of the original dairy formulation, with almond milk. All other ingredients, including Musang King durian pulp, sugar, deodorised cocoa butter, stabilizer, and emulsifier were retained in their original proportions to maintain formulation consistency. The production process of the non-dairy durian ice cream is illustrated in Figure 2.

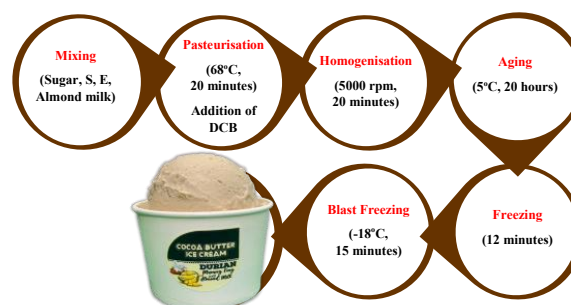


Figure 2: Production of Cocoa Butter-Based Durian Ice Cream Made with Almond Milk (Non-Dairy)

Analyses of Cocoa Butter-Based Durian Ice Cream

a) Overrun

Overrun refers to the amount of air incorporated into ice cream and can be measured by the reduction in weight of a given volume of the mix due to air addition (Goff and Hartel, 2013). The percentage of overrun was calculated as follows:

$$\% \text{ Overrun} = \frac{\text{Wt. of mix} - \text{Wt. of same volume of ice cream}}{\text{Wt. of same vol. of ice cream}} \times 100 \quad (1)$$

Where,
Wt. = Weight
Vol. = Volume

b) Total Solids

The total solids was measured according to the method described by Wehr and Frank (2004). Three grams of the melted ice cream were weighed into a dried and

pre-weighed pan. The sample was then dried in an oven at $100 \pm 2^\circ\text{C}$ for 3.5 hours. After drying, the pan and its contents were cooled in a desiccator and weighed. The percentage of total solids was calculated as follows:

$$\text{Total Solids (\%)} = \frac{\text{Wt.of the dried pan and sample} - \text{Wt.of the dried pan}}{\text{Wt.of the sample before drying}} \times 100 \quad (2)$$

Where,
Wt. = Weight

c) Melting Properties

The melting rate of ice cream was determined using the method described by Bolliger *et al.* (2000). A 70 g portion of ice cream was removed from a 100 mL cup and placed on a wire screen (9 holes/cm²) positioned over a funnel. The test was conducted in a controlled environment at a temperature of $24 \pm 1^\circ\text{C}$. The first dripping time as well as the drip-through weight were recorded every 10 minutes for a total duration of 60 minutes. Melting rate was defined as the mass of the drip loss divided by the initial mass of the ice cream sample (Koxholt *et al.*, 2001).

d) Colour

The colour of the ice cream samples was measured using a calibrated colorimeter (Konica Minolta, Model CR-5, Japan), operating with illuminant D65 (simulating daylight) and a 10° standard observer angle. Ice cream samples were placed into a petri dish (60 mm diameter × 15 mm height) and filled to the top. Colour measurements were expressed using the CIELAB colour space parameters: L* (lightness, where 100 = white and 0 = black), a* (red-green axis, with positive values indicating redness and negative values indicating greenness), and b* (yellow-blue axis, with positive values indicating yellowness and negative values indicating blueness).

e) Sensory Evaluation

The organoleptic quality for both ice creams was assessed by 30 panelists in terms of colour, Musang King durian flavour, sweetness, texture, meltability, and overall acceptability using 9-points hedonic scale (score 9: like extremely; score 8: like very much; score 7: like moderately; score 6: like slightly; score 5: neither like nor dislike; score 4: dislike slightly; score 3: dislike moderately; score 2: dislike very much; score 1: dislike extremely).

Statistical Analysis

Data were collected in triplicate and statistically analysed by analysis of variance (ANOVA) and mean separation was by least significant difference at $p < 0.05$ using Minitab®17 (Minitab Inc., United States of America).

RESULTS AND DISCUSSIONS

Table 1 presents the physical properties of cocoa butter-based Musang King durian ice cream using dairy and almond milk bases.

Table 1: Physical Properties of Musang King Durian Ice Cream Using Dairy and Almond Milk Bases

Physical Properties	Type of Ice Cream	
	Cocoa Butter-Based Musang King Durian Ice Cream (Dairy)	Cocoa Butter-Based Musang King Durian Ice Cream Made with Almond Milk (Non-Dairy)
Overrun (%)	31.12±1.24 ^b	43.54±2.87 ^a
Total Solids (%)	39.76±0.13 ^a	36.15±0.04 ^b
Melting Properties		
Time of 1 st Drop (Minute: Second)	27:28±0.82 ^b	41:71±1.55 ^a
Melting Rate (g/minutes)	0.03±0.00 ^a	0.02±0.00 ^b
Colour		
L*	87.99±0.02 ^a	79.02±0.04 ^b
a*	-0.02±0.01 ^b	1.12±0.01 ^a
b*	27.09±0.09 ^a	16.22±0.04 ^b

Different superscripts (a, b) in the same row indicate significant differences at $p < 0.05$.

L*: Difference in lightness and darkness (+: lighter, -: darker)

a*: Difference in red and green (+: redder, -: greener)

b*: Difference in yellow and blue (+: yellower, -: bluer)

Overrun

Almond milk-based Musang King durian ice cream has a significantly ($p < 0.05$) higher overrun (43.54 ± 2.87) compared to dairy-based Musang King durian ice cream (31.12 ± 1.24). The protein structure in almond milk is different from that in dairy milk which can stabilize air bubbles more effectively, contributing to a higher overrun (Mahmudah *et al.*, 2022).

Total Solids

The significantly ($p < 0.05$) higher total solids content in dairy-based Musang King durian ice cream (39.76 ± 0.13) compared to the almond milk-based variant (36.15 ± 0.04) is attributed to the base ingredients. Fresh skim milk contains approximately 9-10% total solids, mainly from proteins, lactose, and minerals (Walstra *et al.*, 2006). In contrast, almond milk contains only 3-4% total solids (Sethi *et al.*, 2016).

Melting Properties

The non-dairy durian ice cream demonstrated a significantly ($p < 0.05$) lower melting rate (0.02 ± 0.00) compared to its dairy counterpart (0.03 ± 0.00). This

reduced melting behavior may be attributed to the higher overrun observed in the non-dairy formulation, which results in a greater dispersion of air cells throughout the ice cream matrix. These air cells act as micro-scale thermal insulators, impeding heat transfer into the product and thereby slowing the melting of ice crystals (Goff & Hartel, 2013; Sofjan & Hartel, 2004). Consequently, the non-dairy durian ice cream exhibited a delayed onset of the first drip and a reduced overall melting rate, indicating superior thermal stability relative to the dairy-based formulation.

Colour

The dairy ice cream had a significantly ($p < 0.05$) higher L^* value (87.99 ± 0.02), indicating a lighter colour, while the non-dairy variant exhibited a more yellowish-red hue due to the almond milk content. Significant differences ($p < 0.05$) were observed in a^* and b^* values, with the non-dairy version showing greater redness ($a^*: 1.12 \pm 0.01$) and lower yellowness ($b^*: 16.22 \pm 0.04$). Similar trends have been observed in plant-based ice creams, where nut-based milks impart a distinct hue due to natural pigments and processing conditions (Kot *et al.*, 2021).

Sensory Evaluation

A comparative sensory evaluation was conducted to assess key quality attributes of dairy-based and almond milk-based Musang King durian ice creams using a 9-point hedonic scale. Figure 3 depicted that MKDIC was significantly preferred in most attributes, particularly in colour with the mean score of 8.0 compared to AMMKDIC (6.3). In terms of Musang King durian flavour, MKDIC again showed higher acceptability (mean score: 8.2) relative to AMMKDIC (mean score: 7.7), suggesting a stronger flavour perception, likely due to better retention of volatile flavour compounds in the presence of milk proteins and higher total solids.

Texture and meltability scores for both ice creams were comparable, with both samples rated 7.9 and 8.1 respectively. In the sweetness attribute, MKDIC was rated higher (mean score: 8.3) than AMMKDIC (mean score: 8.0). Overall acceptability followed a similar trend, with MKDIC scoring higher (mean score: 8.3) than AMMKDIC (mean score: 7.6), indicating a general preference for the dairy-based formulation.

These results suggest that while the almond milk-based non-dairy formulation was well accepted, particularly for its meltability and texture, the dairy-based ice cream was more favourably perceived in terms of colour, flavour, sweetness, and overall acceptability.

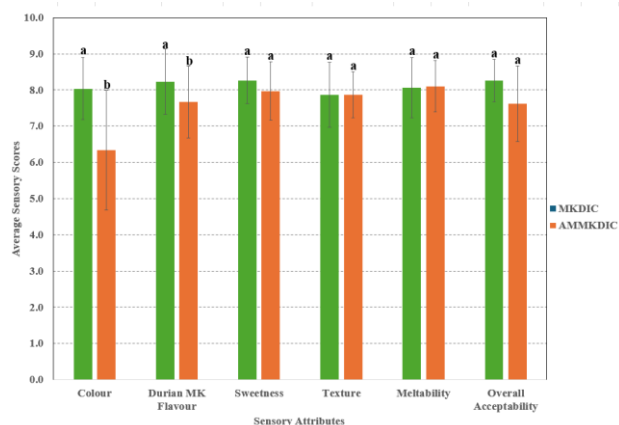


Figure 3: Organoleptic Properties of Cocoa Butter-Based Musang King Durian Ice Cream (Dairy) And Cocoa Butter-Based Musang King Durian Ice Cream Made with Almond Milk (Non-Dairy)

CONCLUSIONS

This study demonstrated the feasibility of using cocoa butter as a viable alternative to traditional dairy fats in the development of Musang King durian ice cream. The non-dairy formulation using almond milk showed promising results with superior overrun, improved melting properties, and positive sensory acceptance, despite its lower total solids content. These attributes make it a suitable option for health-conscious and lactose-intolerant consumers. However, the dairy-based formulation prepared with fresh skim milk exhibited higher total solids, richer texture, better colour, and a more pronounced Musang King flavour, leading to greater overall preference.

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