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FULL PAPER

Physical and chemical characteristics of carboxymethyl cellulose from *Kepok* banana (*Musa paradisiaca formatypica*) and corncobs (*Zea mays*) modified alkalization-carboxymethylation process in ice cream products

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Abstract

This study compared two physicochemical characteristics of carboxymethyl cellulose to determine the effect of adding variations in carboxy methyl cellulose (CMC) concentration and ageing time to ice cream products. There were three treatments in one category, namely the addition of CMC concentrations of 0.375, 0.75, and 1.5 g, and ageing times of 25, 50, and 75 mins. The effectiveness of carboxymethyl cellulose was evaluated by analysing the physical characteristics to determine the best ice cream sample. Meanwhile, further testing on ice cream products includes the sensitivity of the human senses to the safety of the product. The results showed the best results at a concentration of 1.5 g of carboxymethyl cellulose and an ageing time of 75 mins because it resulted in an assessment above 4.00 with the notation "A" based on two factor analysis of variance without replication and Duncan multiple range test (DMRT).

1. Introduction

The development of food products is currently required to meet the quantity and quality desired by consumers. Various additives are added to the production process to improve quality (Saratale *et al*., 2018). One of the most commonly used additives is carboxymethyl cellulose, also known as CMC. carboxymethyl cellulose is a derivative of cellulose carboxymethylation, a linear ether polymer with a carboxymethyl (CH_2-COOH) group bound to several OH groups of glucopyranose monomers. This anion compound is biodegradable, colourless, odourless, non-toxic, water-soluble, and has a pH range of 6.5-8.0 (Jantanasakulwong *et al.,* 2018). Cellulose nanofibers with high flexibility and absorption ability can form film layers and matrices.

In contrast, cellulose nanocrystals with a very rigid rod-like structure and negative surface charge can reinforce the chitosan matrix (Deng *et al.,* 2017). In the food sector, carboxymethyl cellulose is a stabilizer, thickener, adhesive, and emulsifier. An example of its application is in the production of ice cream (Dong *et al*., 2021). Carboxymethyl cellulose is in demand because it has many uses and is inexpensive (Jia *et al.,* 2016).

Corncobs are 30% waste from corn and agriculture, usually used for animal feed or firewood. Corncobs consist of 30% crude fibre, which has 35–55% pure cellulose. Like Kepok banana peels, 40% of banana waste was previously used as raw material in the food-making process (Yu *et al.,* 2021). Both of these wastes can be used as carboxymethyl cellulose because of their large quantities. This waste can increase economic value when processed, it can also reduce potential environmental pollution (Yu *et al.,* 2021). The use of agricultural products in industrial applications can be considered a way to reduce environmental pollution and consolidate the use of these products (Tavares *et al.,* 2020).

Ice creams are made from dairy products such as cream and the like. It is a solid food made by freezing cream or a mixture of milk, animal or vegetable fats, with sugar or without other food ingredients, and permitted food ingredients (Konstantas *et al.,* 2019). Ice cream can be grouped into three categories, namely standard, premium and super-premium. The difference between the three types is based on the fat content and non-fat solid components or skim milk (Bullock *et al.,* 2020). The stabilizer serves to keep the air in the ice cream from freezing and reduces crystallization. The stabilizer is a gelling agent or thickening agent widely used in the food industry to improve ice cream quality. It maintains emulsion stability, prevents ice crystals, provides product uniformity, reduces melting speed,

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improves product properties, and improves ice cream texture (Sim *et al.,* 2021).

This study aimed to make and analyse cellulose stabilizer produced from corn cobs and *kepok* banana peels using alkalization and carboxymethylation processes. In other hand, the effect of cellulose stabilizer produced in the manufacture of ice cream was determined.

2. Materials and methods

2.1 Carboxymethyl cellulose production

The process of making carboxymethyl cellulose powder began with making liquid Na-CMC first by destroying lignin compounds and taking alpha-cellulose on corncobs and *kepok* banana peels used the alkalization -carboxymethylation method. Na-CMC must be produced at an appropriate pH, before converting it into carboxymethyl cellulose in powder form. The manufacture of carboxymethyl cellulose was carried out by a renewable process with the addition of purification and neutralization processes, as shown in Figure 1. The test method was carried out specifically on the physical characterization of carboxymethyl cellulose (CMC).

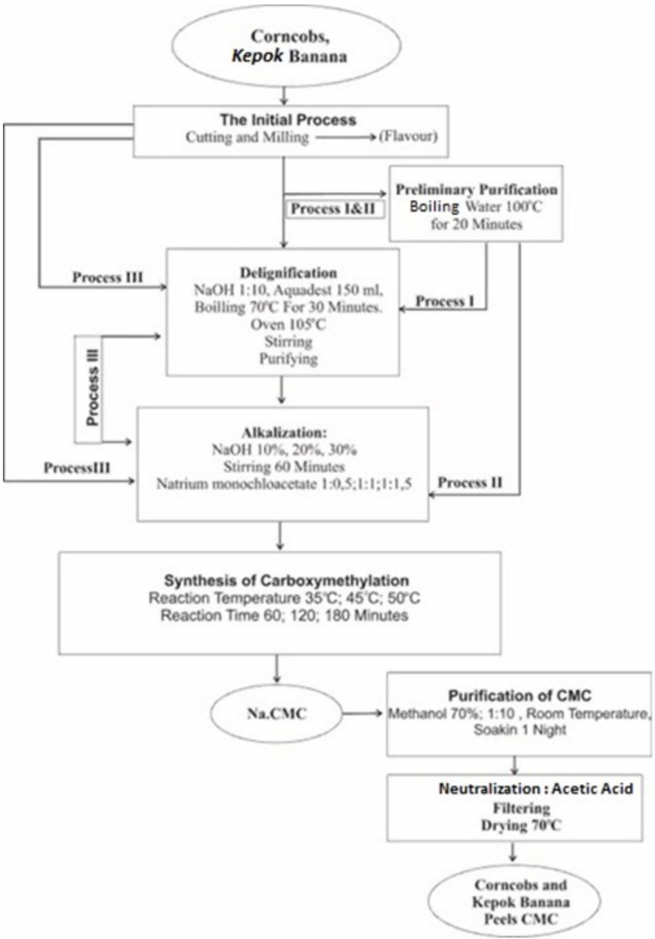


Figure 1. Preliminary and final purification carboxymethyl cellulose

2.2 Variations of ice cream production

Ice cream was made with raw materials of full cream milk, skim milk, egg yolk, sugar, watered, corn-starch, butter, and CMC which were stirred together for 40 mins followed by pasteurization at 30 for 40 mins and stirred again for 40 mins. The process of adding variations in the ageing process were 25, 50, 75 mins, and the addition of CMC concentrations of 0. 375, 0. 75, 1. 5 g (Figure 2). This variation aims to determine how suitable the mixture of raw materials was for consumption. The test was carried out by organoleptic tests on 10 respondents, tested on rats and hedonic tests with DMRT (Duncan Multiple Range Test) data processing.

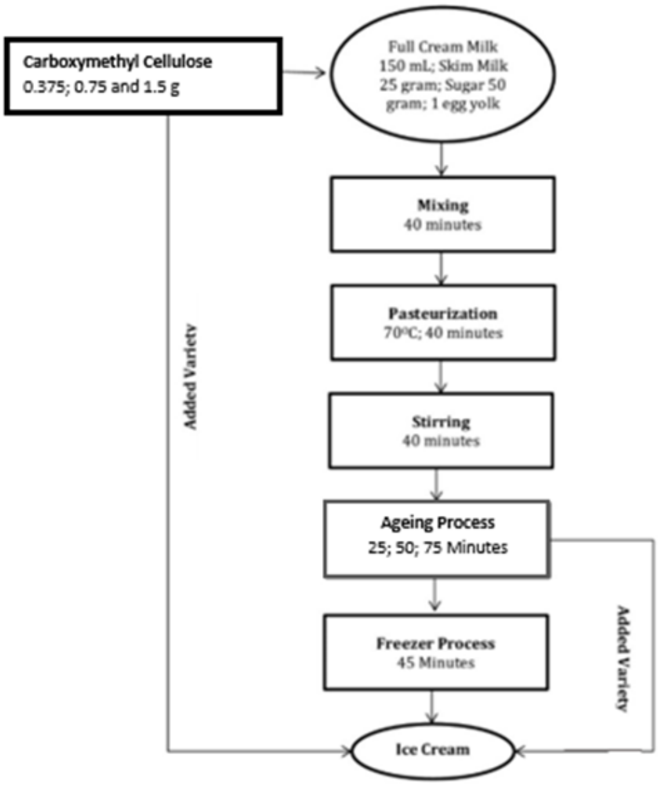


Figure 2. Carboxymethyl cellulose concentration and time aging process added variety

3. Results

3.1 Characterization of carboxymethyl cellulose corncob *and Kepok banana peels*

Figure 3 shows the physical characteristics at the pH value. Changes in pH due to the addition of alkaline solution in delignification (Dimawarnita *et al.,* 2019). While the alkalization-carboxymethylation process also has a different pH character, this is based on the use of alkaline reagents (NaOH) and Monocloroacetic Salicylic Acid ($C_7H_5NaO_3$) reagents are acidic. The last process of characterization is purification, the washing process was carried out to adjust the pH to neutral conditions. The results obtained were suitable for both samples, namely pH 7, this suitability was obtained from distilled water which can dissolve monomers that can affect the pH (Adinugraha *et al.,* 2005).

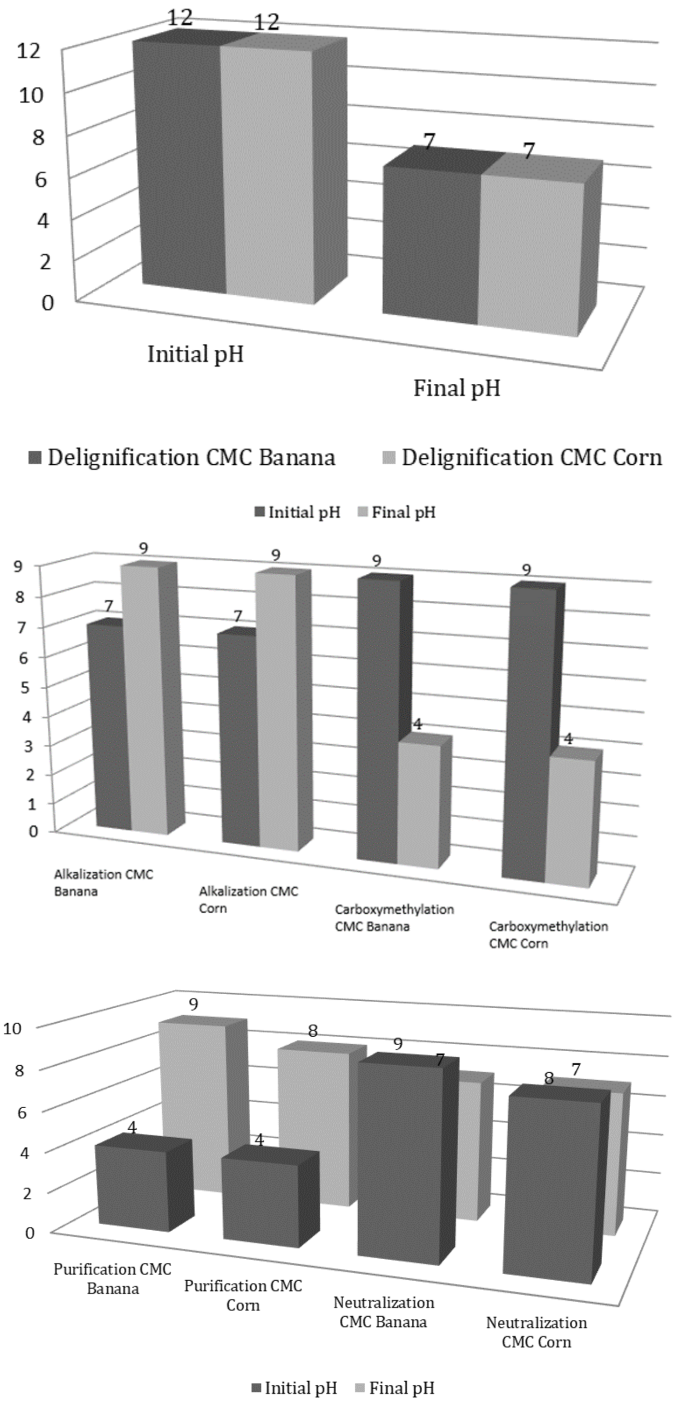


Figure 3. pH value result

The difference in the degree of substitution with respect to the concentration of carboxymethyl cellulose can be seen in Figure 4. The results of the analysis of DS levels showed that there were differences in the levels of acetate in CMC at the time of the titration test (Nur *et al.,* 2016). The resulting graph decreased due to the concentration of CMC, which is directly proportional to the DS (Lin *et al.,* 2019). Table 1 shows the differences in water content obtained in the oven process with 9% CMC banana and 11% CMC corn. The thicker the material, the higher the mass transfer and the heat makes it harder to dry. This difficulty occurs because the more water bound to the material, the harder it is to evaporate (Amanto *et al*., 2015).

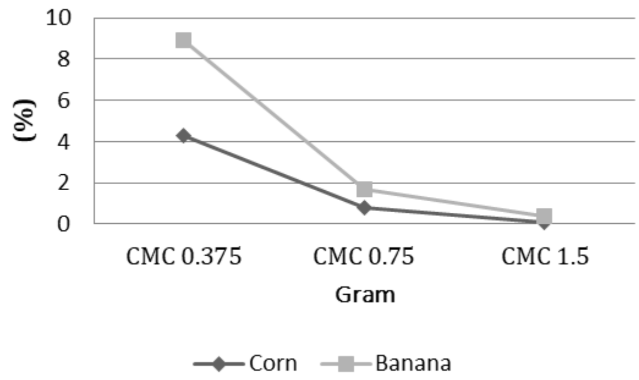


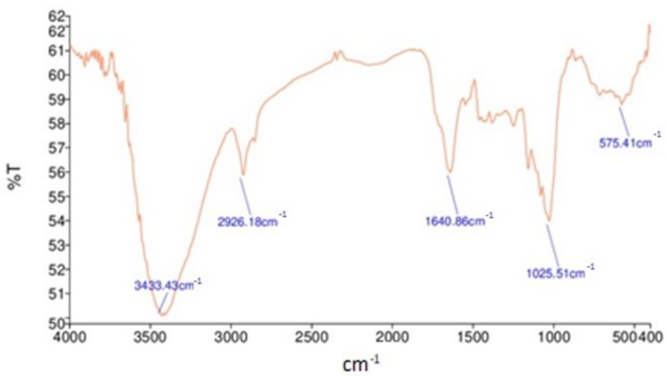
Figure 4. Comparison of DS levels.

Table 1. Moisture content.

Sample	Water Content (%)
Carboxymethyl Cellulose Banana	9
Carboxymethyl Cellulose Corn	11

Table 2 shows the results obtained have different yield levels for banana CMC 29.5% with an extract weight of 2.95 g, while for CMC corn, it has a yield of 26.9% and an extract weight of 2.69 g. The difference in the results of this test was due to the hemicellulose and lignin components in the stalks of corn and banana peels having been hydrolyzed to dissolve glucose in the washing process using water (Silsia *et al.,* 2018). The results of the Fourier Transform Infra-Red Figure 5 on corncobs have the highest absorption occupied by the

(a)



(b)

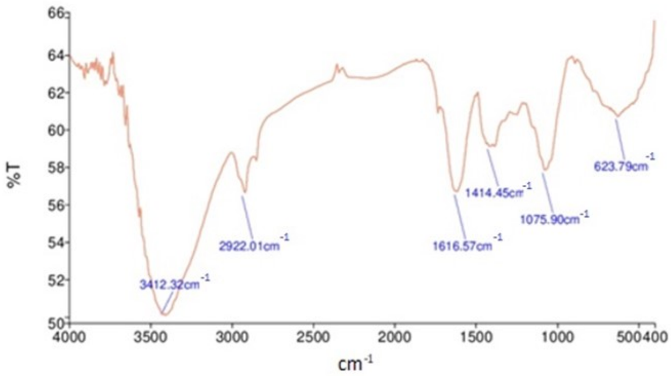


Figure 5. Fourier Transform Infrared result: (a) Corncobs; and (b) *Kepok* Banana Skin.

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OH group of 3433 cm^{-1} then the CH group of 2926 cm^{-1} followed by C=C with 1640 cm^{-1} and COC, CO 1025 cm^{-1}. In the corncob samples, the C-H, C-O-C, and C=C groups were not read. The functional group of the carboxymethyl cellulose sample of kepok banana peels consisted of OH 3412 cm^{-1}, 2922 cm^{-1} CH, 1616 cm^{-1} was occupied by C = C, 1414 cm^{-1} was occupied by CH, and after, COC, CO 1075 cm^{-1}. The results obtained vary due to the differences in the characters in the sample.

Table 2. Comparison of yield levels.

Sample	Yield Levels (%)
Carboxymethyl Cellulose Banana	29.5
Carboxymethyl Cellulose Corn	26.9

3.2 Ice cream analysis

Figure 6 shows the overrun values obtained in the sample. The difference in the overrun value from the results obtained is on a scale of 6–9 (%) in the CMC sample of kepok banana peels and 4–6 (%) in the corncob sample. The addition of CMC increases the overrun or clumping of ice cream, due to the binding of air by CMC and the convertion of glucose into CO_2 gas and ethanol. This carbon dioxide gas will be trapped in the ice cream mixture which increases the overrun. The higher the overrun value, the better the ice cream (Ahmad and Nurwantoro, 2012).

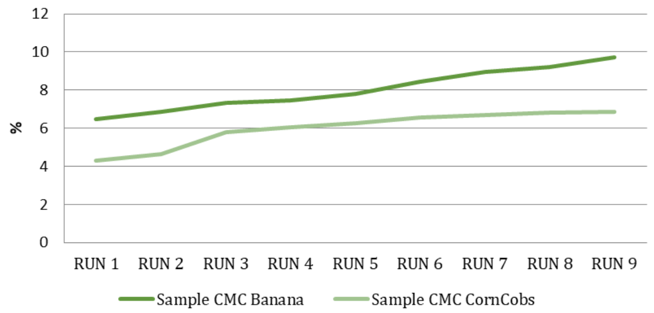

Figure 6. Overrun value.

Figure 7 shows the longest time for the ice cream to melt, the Banana CMC sample was 16.7 mins, while the corncob CMC ice cream sample showed 15.3 mins. Melting time is a parameter of the quality of ice cream in maintaining its texture after being removed from the freezer. The results of the graph show a rising graph which proves that the longer the ice cream melts, the better the quality of the ice cream (Ahmad and Nurwantoro, 2012). Figure 8 shows the difference in solids with fluctuating graph. The difference in the concentration of Carboxymethyl Cellulose is what causes the difference. Total solid plays a role in shaping the texture of ice cream and consists of all solid ingredients in ice cream. If the total solids are too low then the texture of the resulting ice cream will be rough, but if the total solids are too high then the cream will be soft and sticky (Ahmad and Nurwantoro, 2012).

Table 3 is a taste test, whereby the results obtained with the DMRT method treatment, samples 8 and 9 got the highest score, marked with the notation "A". This is because the use of different concentrations of CMC changes the taste of ice cream (Fitriyaningtyas and Widyaningsih, 2015). Table 4 is an aroma test, in the 9th treatment, the DMRT test resulted in the highest score among others and was marked with the notation "A". This is caused by differences in sensory acceptance of the tested samples (Ahmad and Nurwantoro, 2012). Table 5 shows the texture test and the DMRT results show that the 9th treatment also received the best score and was noted as “A”. The best results in texture occurred when the addition of variations in concentration and ageing time was of the right composition of raw materials (Oksilia *et al.*, 2019). Figure 9 displays the acceptance test on rats which is likened to a person's ability to respond to food according to the level of likes or dislikes. The best results were shown in the corn CMC

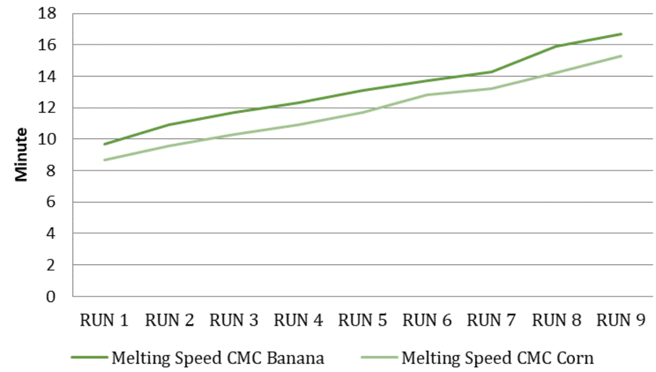

Figure 7. Melting speed value.

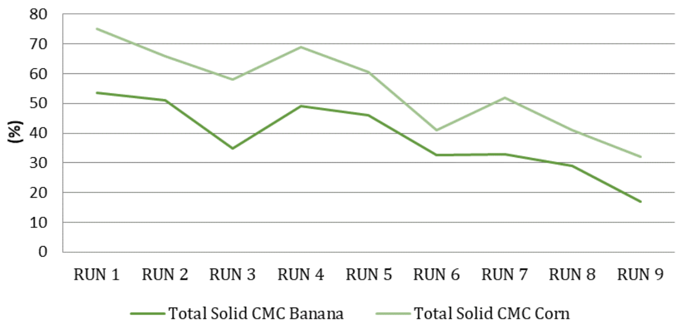

Figure 8. Total solid value.

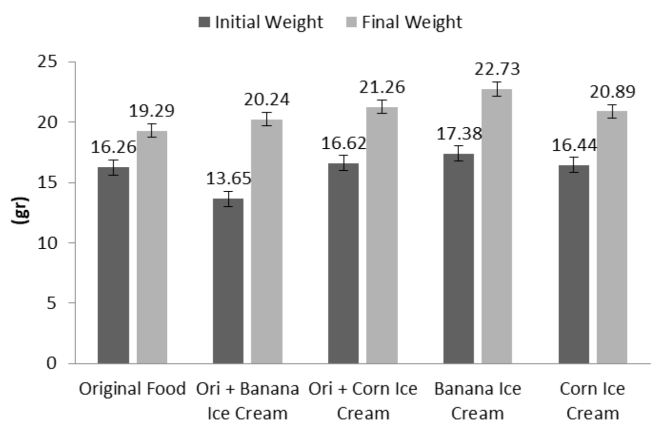

Figure 9. Acceptance value.

ice cream sample of 23.66%, banana peel CMC ice cream only 21.30% in increasing the bodyweight of rats (Lin *et al.,* 2019).

Table 3. Organoleptic taste result

a) Corncobs

Treatment	Average Taste Score	Notation
Run 1	1.40	d
Run 2	2.10	c
Run 3	2.70	bc
Run 4	2.9	b
Run 5	2.90	b
Run 6	3.00	b
Run 7	3.10	b
Run 8	4.30	a
Run 9	4.40	a

b) Kepok banana skin

Treatment	Average Taste Score	Notation
Run 1	1.40	d
Run 2	2.20	c
Run 3	2.70	bc
Run 4	2.90	bc
Run 5	3.00	bc
Run 6	3.10	b
Run 7	3.10	b
Run 8	4.30	a
Run 9	4.40	a

Table 4. Organoleptic smell result

a) Corncobs

Treatment	Average Taste Score	Notation
Run 1	1.60	d
Run 2	2.10	cd
Run 3	2.10	cd
Run 4	2.10	bc
Run 5	2.60	bc
Run 6	2.90	bc
Run 7	2.90	bc
Run 8	3.10	b
Run 9	4.10	a

b) Kepok banana skin

Treatment	Average Taste Score	Notation
Run 1	1.60	d
Run 2	1.90	d
Run 3	1.90	d
Run 4	2.10	c
Run 5	2.20	bc
Run 6	2.90	bc
Run 7	2.90	bc
Run 8	3.10	b
Run 9	4.00	a

Table 5. Organoleptic texture result

a) Corncobs

Treatment	Average Taste Score	Notation
Run 1	1.30	d
Run 2	2.20	cd
Run 3	2.60	cd
Run 4	2.80	cd
Run 5	2.90	cd
Run 6	3.10	bc
Run 7	3.30	b
Run 8	4.00	b
Run 9	4.40	a

b) Kepok banana skin

Treatment	Average Taste Score	Notation
Run 1	1.30	d
Run 2	2.20	cd
Run 3	2.80	cd
Run 4	2.90	bc
Run 5	2.90	bc
Run 6	3.10	bc
Run 7	3.30	bc
Run 8	4.10	a
Run 9	4.50	a

4. Conclusion

The addition of variations in the manufacture of ice cream was successful, as shown in the results, evidenced by the CMC characteristic test, organoleptic test and Multiple Range Test (DMRT) which showed a positive effect on ice cream products. The best results were observed with a score of 4.00 and the notation "A". It also shows that the alkalization-carboxymethylation method applied to food is safe for use in appropriate compositions and edible raw materials.

Conflict of interest

The authors declare no conflict of interest.

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