

Effect of Rice Types on Various Properties of Germinated Rice Ice Cream

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ABSTRACT

Three different types of germinated rice, including brown rice, red rice and purple rice, were utilized in this research to make ice creams. The ice cream making was started by soaking the rice grains for 5 h at room temperature, blending the grains with the soaking water and filtering it to produce rice milk. The rice milk was then heated, added with other ice cream ingredients (sugar, a stabilizer and coconut milk) and held at 70°C for 2 min. The cooled ice cream mixture was blended in a blender for 3 min before processing the mixture in an ice cream machine. The final ice cream product was stored at -18°C for different analyses. Using germinated brown rice, the final ice cream product significantly had the highest overrun and pH values with the lowest b^* and moisture content values compared to the other two ice creams. Different types of germinated rice did not significantly affect the melting rate, hardness, total soluble solid, protein and microbial contents of the final ice creams. When a sensory panel evaluated the three types of ice cream, the panelist team could significantly differentiate the color and smoothness of the ice cream samples. A supplementation of 5% (w/w) cooked rice particles in the germinated brown rice ice cream significantly increased the ice cream hardness with a significant reduction in the melting rate, pH, total soluble solid and moisture content values compared to the corresponded ice cream without rice particles.

Key words: Germinated rice, Ice cream, Physical, Chemical, Microbial and sensorial properties

INTRODUCTION

Rice is recognized as the staple food in Asia countries that contributes to 80-90% of the daily calorie intake for some people (Luh, 2001). Although there are 2 species of cultivated rice, *Oryza sativa* L. and *O. glaberrima*, the principal species that are grown is *O. sativa* L. For the other species, *O. glaberrima*, it is only cultivated in some areas of West Africa. The main cultivation area for rice is Asia, which contributes to 91% of the world production (Luh, 2001; Rosell and Marco, 2008).

The worldwide consumption of rice in 2005 was reported to be 406 million metric tons (Mitchell, 2009). Consumption of rice in the developing countries contributes to 27% of total energy intake (Rosell and Marco, 2008). The energy is generated from the grain that contains 84.5-85.1% digestible starch, 8.4-8.9% crude protein, 2.5-2.9% crude fiber, 0.3-0.4% crude fat and 0.3-0.5% mineral (Storck et al., 2005). The cereal grain does not have any cholesterol. A study by Roy et al. (2008) showed that the energy consumption of rice is affected by types of rice, degree of milling and processing conditions.

Rice is mainly consumed as cooked rice that is normally accompanied with other dishes of beef, pork, poultry, vegetables or seafood. Other processed rice products that have been sold in the market include noodles, puffed rice, breakfast cereals, rice cakes, fermented sweet rice and extruded snacks food from rice. Rice can also be used as a raw material in the production beer, wine and vinegar (Luh, 2001). Rosell and Marco (2008) stated that in 2000, there were over 400 new products containing rice were placed in the commercial market.

Germination is a part of the process for plant development (Shu et al., 2008). The process is

aimed to activate hydrolytic enzymes in the raw seeds. The activity of these enzymes can improve the nutritional value of the germinated seeds (Veluppillai et al., 2009). Investigation into 2 cultivars of Thai rice (waxy and non waxy rices) by Saman et al. (2008) showed that the amount of total reducing sugars, free amino nitrogen, amylolytic activity and sugar composition in the germinated rice were affected by different rice types and germination time. Another work on germinated rough rice found that the concentration of crude protein, total free amino acids, α -tocopherol, γ -oryzanol, thiamine, niacin and pyridoxine in the germinated rough rice were significantly higher than those of the ungerminated rice (Moongngarm and Saetung, 2010).

Ice cream is the most common product known within the category of frozen desserts. Although the legal definition of ice cream is restricted by regulations, the product is known as a sweetened product containing milk fat and milk solids non fat and is frozen while being whipped (Goff and Hartel, 2004). Milk is acknowledged as one of the five major food groups due to the presence of calcium in the commodity (Miller et al., 2000). However, lactose intolerance and the presence of cholesterol in milk hamper the consumption of milk by some consumer groups (Prado et al., 2008).

This study aimed to produce ice cream from different types of germinated rice. The final rice ice cream products were then subjected to physical, chemical, microbiological and sensorial analyses to understand different characteristics of the new diversification rice product.

MATERIALS AND METHODS

Ice cream ingredients

Different types of germinated rice, including red, brown and purple rices (I-Rice, Chiang Mai, Thailand), were bought from a local supermarket in Chiang Mai, Thailand. Other ice cream ingredients were sugar (Wang Kanai, Bangkok, Thailand), coconut milk (Chao Koh, Thailand) and gelatin (Gelaita, Chiang Mai, Thailand) as a stabilizer.

Ice cream production

The production of ice cream was started by soaking germinated rice in potable water at a ratio of 1:10 for rice and water, respectively, for 5 h at room temperature. At the end of the soaking time, the rice and its soaking water was blended together using a blender (Moulinex, China) and filtered with a cleaned white cloth to produce rice milk. The rice milk was then heated and added with sugar at a ratio of 1:0.38 for milk and sugar, respectively. A portion of warm rice milk was also used to dilute gelatin that was added at a level of 1.5% (w/w) based on the amount of rice milk. After the gelatin was diluted properly, the solution was combined with the rest of the rice milk. Coconut milk at a ratio of 1:1 to the rice milk was heated until the viscosity of the milk was slightly increased. Into the heated coconut milk, the rice milk containing sugar and gelatin was incorporated and the whole mixture was heated at 70°C for 2 min. Following the pasteurization, the mixture was cooled down to room temperature, blended in the blender at a high speed for 3 min, incorporated with air in an ice cream machine (Gelattissimo, Italy) and frozen to a temperature of -18°C until further analyses. Each of the germinated rice ice cream was produced in triplicate.

For the supplementation of 5% (w/w) cooked rice particles, an amount of 87.5 g of soaked rice (after the filtration of rice milk) for the production of 1,750 g ice cream was incorporated into boiled rice milk. The rice was boiled in the milk until it was cooked then the rest of the procedure would follow the production of ice cream.

Physical analysis

Viscosity of ice cream mixture was determined by a viscometer (Brookfield Programmable DV-II + Viscometer, Brookfield, USA) with a stirrer head no. 4. The final ice cream product was analyzed for its color values, the amount of incorporated air (% overrun), melting rate and hardness. The color measurement established L*, a* and b* values of the ice cream sample using a chroma

meter (Minolta CR-300, Japan). For the measurement of overrun, ice cream mixture was filled into a small cup and weighed. Using the same cup, the final ice cream product was also loaded and weighed again. The percentage of overrun was determined using a formula:

$$\text{overrun (\%)} = \frac{\text{weight of ice cream mixture} - \text{weight of ice cream (g)}}{\text{weight of ice cream (g)}} \times 100$$

The measurement of melting rate was done by packing a specific amount of ice cream in a plastic container and freezing it at -18°C for 24 h. On the measurement day, the ice cream sample was removed from a freezer and placed on the top of a metal sieve no. 4 (Endecolts, London, UK). The melted ice cream was weighed after 1 h at 30°C and the melting rate of the sample was established based on a formula:

$$\text{melting rate (g/min)} = \frac{\text{weight of melted ice cream within 60 min (g)}}{60 \text{ (min)}}$$

The hardness of the ice cream sample was analyzed by a texture analyzer (XTPL TAXT Plus Texture analyzer, UK). The hardness measurement was accomplished using a P2 probe and a maximum loaded cell of 50 kg. Velocity of the probe before, during and after testing was 1.0, 2.0 and 10.0 mm/s, respectively. The maximum probe determination was carried out when the probe was at the depth of 5 mm from the sample surface. The physical measurement was done in duplicate for each of ice cream samples.

Chemical analysis

The chemical properties of the ice cream mixture that were evaluated included pH, total soluble solid, protein content (AOAC, 2000) and moisture content (AOAC, 2000). The pH measurement was performed using a pH-meter (Consort C380, Belgium) and the total soluble solid was done by a hand refractometer (ATAGO, Tokyo, Japan).

The moisture content of ice cream was assessed using 2.0 g of the sample, which was heated at $100 \pm 3^{\circ}\text{C}$ in a hot air oven (Memmert, England) for a minimum of 3 h or until the heated sample reached a constant weight. The amount of water in the sample was then calculated using a formula:

$$\text{moisture content (\%)} = \frac{\text{the weight to ice cream that lost during drying (g)}}{\text{the initial weight of the ice cream (g)}} \times 100$$

Protein in the ice cream sample was determined by a Kjeldahl method using 2.0 g of samples. For the percentage of protein content in the ice cream, a factor value of 6.25 was applied.

Microbiological analysis

Determination of total microbial count in the ice cream samples was done by a pour plate method using 1 ml of melted ice cream. The sample was diluted appropriately by 9 ml 0.1% peptone water and added with Plate Count Agar (Merck, Germany) before being incubated at 37°C for 48 to 72 h (Harrigan, 1998).

Sensory analysis

To understand the consumer perception regarding the germinated rice ice cream, 20 untrained panelists, who were mainly Bachelor students of the Division of Food Science and Technology, Faculty of Agro-Industry, Chiang Mai University, were involved in the sensory evaluation. The sensory assessment was carried out on a 10 cm line scale method. There were six sensory attributes that were evaluated, included color (from white to purple), melting in the mouth (from very slow to very quick), smoothness in the mouth (from very rough to very smooth), creaminess (from too low to too high), rice flavor (from not have to have) and overall acceptance (from not like very much to like very much). Each of the panelists gave evaluation two times on different assessment days.

Statistical analysis

Collected data was analyzed statistically using Analysis of Variance by applying a Completely Randomized Design. The statistical analysis was carried out using a SPSS program version 17.0 for windows (SPSS Inc., Chicago, USA). Duncan's New Multiple Range Test was applied to determine differences between different treatment means.

RESULTS AND DISCUSSION

Germinated rice ice cream from different types of rice

Generally, ice cream contained 10-16% fat, 9-12% milk solids non fat, 10-14% sucrose, 3-5% corn syrup, 0-0.25% stabilizers, 0-0.25% emulsifiers and 55-64% water (Goff and Hartel, 2004). Since rice contained a low fat content (Rosell and Marco, 2008), the presence of fat in the germinated rice ice cream was increased by coconut milk, which was a vegetable fat that was widely utilized in Asia. The presence of fat in the frozen dessert supports the richness of flavor, produces a characteristic of smooth texture, helps to give body and aids in producing desirable melting properties (Goff and Hartel, 2004). The rice ice cream was also supplemented with sugar at 15.10% (w/w) and gelatin at 0.60% (w/w). Addition of sweeteners in ice cream improves the texture and palatability of the product and enhances flavors (Goff and Hartel, 2004). For gelatin, the presence of the component helps to produce a smoothness body and texture of ice cream, to retard or reduce ice and lactose crystal growth during storage and to provide uniformity to the product and resistance to melting (Goff, 1997; Goff and Hartel, 2004).

The physical, chemical and microbiological quality of germinated rice ice creams can be observed in Figures 1 and 2 and Table 1. In general, different types of germinated rice significantly affected the viscosity, pH and moisture content of the ice cream mixture and the overrun and color values of the final ice cream. This finding could be contributed from different chemical composition of rice types as was shown by Moongngarm and Saetung (2010). These authors reported that the total sugars, reducing sugar, total free amino acids, thiamine, niacin, pyridoxine, phytic acid, total phenolic compounds, α -tocopherol and γ -oryzanol of germinated brown rice and germinated rough rice were significantly different.

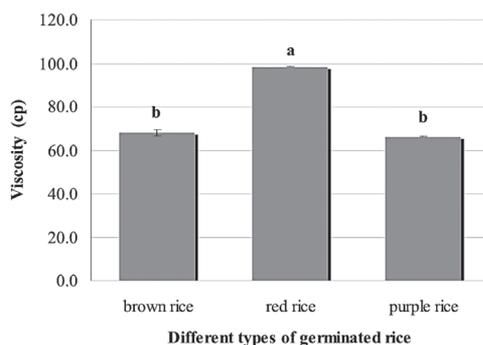


Figure 1. Viscosity (cp) of germinated rice ice cream mixtures affected by different rice types.

Viscosity of different rice ice cream mixtures was between 66.36 and 98.5 cp (Figure 1). These viscosity values were lower than the ice cream made from milk components that reached a viscosity of 112.33 ± 6.53 mPa·s (Alvarez et al., 2005). Although the ice cream formula in this paper had only 12% milk fat, the presence of 11% milk solid non fat and 0.3% stabilizer/emulsifier might contribute to the higher viscosity of the mixture. A supplementation of milk protein concentrate would also increase a viscosity of ice cream mix due to the voluminosity of casein micelles (Alvarez et al., 2005).

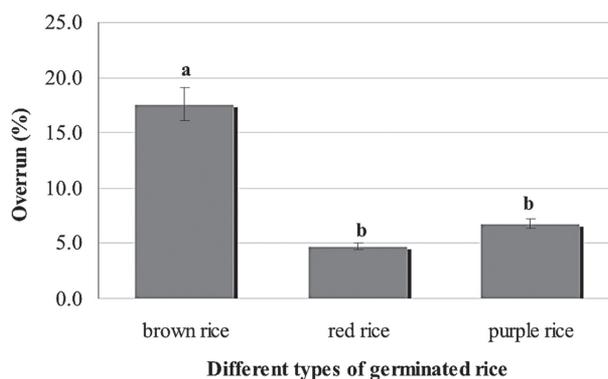


Figure 2. Overrun (%) of germinated rice ice creams affected by different rice types.

Table 1. Physical, chemical and microbiological properties of germinated rice ice creams.

Types of germinated rice/Ice cream properties	Brown rice	Red rice	Purple rice
Melting rate (g/min) ^{ns*}	0.21 ± 0.10 ^{**}	0.23 ± 0.05	0.22 ± 0.01
Color values	80.84 ± 0.92 ^{ab***}	81.68 ± 0.49 ^a	79.87 ± 1.72 ^b
L* value	0.07 ± 0.17 ^c	0.73 ± 0.34 ^b	2.28 ± 0.19 ^a
a* value	1.80 ± 0.29 ^b	2.44 ± 0.17 ^a	2.33 ± 0.10 ^a
b* value			
Hardness (g force) ^{ns}	3.08 ± 1.56	3.84 ± 1.60	1.51 ± 0.60
pH value	6.54 ± 0.01 ^a	6.41 ± 0.01 ^b	6.30 ± 0.00 ^c
Total soluble solid (^o Brix) ^{ns}	29.00 ± 0.00	29.00 ± 0.00	29.00 ± 0.00
Moisture content (%)	64.80 ± 0.59 ^b	66.22 ± 0.13 ^a	66.83 ± 0.10 ^a
Protein content (%) ^{ns}	1.40 ± 0.06	1.48 ± 0.16	1.16 ± 0.24
Total microorganisms (cfu/ml) ^{ns}	195.8 ± 133.9	1535.3 ± 1787.6	345.7 ± 288.2

^{ns} = not significantly different

^{**}Results were means + standard deviations of triplicate samples

^{***}Different letters within the same row indicated significantly different at $P < 0.05$

Overrun was the measurement of added air in frozen dessert products (Goff and Hartel, 2004). The presence of air in the product provided a light texture of frozen dessert and also influenced melting down and hardness of the final product (Sofjan and Hartel, 2004). The highest overrun that was achieved by the brown rice ice cream was 17.56±1.51% (Figure 2). This value was lower compared to the overrun of dairy ice cream that could reach an overrun value up to 120% (Sofjan and Hartel, 2004). The low overrun value of rice ice cream could be due to the low protein content of the ice cream mixture (Table 1) and the absence of milk solid non fat, particularly casein and whey protein, that normally be added at concentrations of 10 to 14% (Goff and Hartel, 2004). The presence of milk protein that had a foaming property significantly affected the development of ice cream structure, including emulsification, whipping and water holding capacity (Goff and Hartel, 2004). In addition, the rice ice cream was not supplemented with emulsifiers that could improve the whipping quality of the mix (Goff, 1997).

Although the overrun of three rice ice creams was significantly different, the melting rate and hardness of different rice ice creams were not significantly different (Table 1). Sofjan and Hartel (2004) reported that ice cream with lower overruns (80%) were harder than those made with 120% overrun, but melted more rapidly. Since these researchers worked with a wide range of overrun values, the overrun factor might give a significant contribution to the hardness and melting rate of the ice cream. Other factors, such as air cell and ice crystal size distributions, could also influence

the hardness of a frozen dessert (Sofjan and Hartel, 2004). In the case of melting rate, several parameters, including fat destabilization, air cell and ice crystal sizes and heat transfer rate, affected this physical feature (Sofjan and Hartel, 2004). A work by Alvarez et al. (2005) also showed that ice creams with overrun values between 65.04 and 74.01% had a very close value of melting rates, which were 0.26 to 0.29%/min.

Color was not a typical physical measurement that would be carried out for dairy ice cream, since the color of dairy ice cream would be depended on the type of flavoring material that was supplemented (Goff and Hartel, 2004). However the germinated rice used in this study possessed their natural colors that affected the final ice cream product. From Table 1, it could be observed that all of the rice ice creams exhibited a white color (L^* values were between 79.87 and 81.68) with a slight red (positive a^* value) and yellow color directions (positive b^* value). Differences in the natural color of rice ice creams were also significantly detected by sensory panelists. The sensory panel distinguished that the purple rice ice cream significantly had the highest purple color, while the brown rice ice cream had the whitest color among the three different rice ice creams. The natural color of the rice ice cream could be an attractive selling point of the product, since no artificial color was added into the product.

Different types of germinated rice significantly affected the pH and moisture content of the rice ice cream mixtures (Table 1). Although the pH of dairy ice cream mix could be used as an indicator of microbial quality (Patel et al., 2006), a lower pH value of rice ice cream mixtures in this study might be more affected by the chemical composition of the germinated rice. The pH of dairy ice cream mixture has been reported to have a value between 6.57 and 6.77, affected by the addition of milk solid non fat (Patel et al., 2006).

The moisture content of the rice ice cream mixtures was in the range of 64.80 to 66.83% (Table 1). This amount of water was similar to the fat reduced vanilla ice cream products, which had a total solid between 32.8 and 38.6% (Aime et al., 2001), and fat free ice creams with total solid contents between 30.5 and 39.2% (Roland et al., 1999), but it was slightly lower than the normal ice cream mix formulation that had a total solid content around 37% (Sofjan and Hartel, 2004; Patel et al., 2006).

The presence of around 7.9% protein in rough rice (Rosell and Marco, 2008) was reduced significantly to 1.16 to 1.48% in the rice ice cream mixture (Table 1). The main rice protein was glutelin, followed by globulin, prolamin and albumin (Pinciroli et al., 2009). These workers that worked about the functional properties of 2 rice cultivars found that the rice protein would exhibit its higher solubility at pH values of 3 and 9. Since the presence of higher amount of soluble rice protein would support its foaming property, the pH of rice ice cream mixture at 6.30 to 6.54 might partially contribute to the low overrun of rice ice cream. In the normal dairy ice cream, the milk protein would be present at a concentration of 3.4 to 3.8% (Aime et al., 2001; Patel et al., 2006).

All the three germinated rice ice creams had a microbial number of or lower than 3.19 log cycle in 1 ml of ice cream sample (Table 1). This microbial quality of ice cream could be considered acceptable, especially when it was compared to the number of total bacteria in commercial ice creams sold in Turkey, that were between 1.7×10^4 and 1.7×10^5 cfu/g ice cream or even higher in some products (Kanbakan et al., 2004). The Thai Ministry of Public Health also announced that the microbial quality of ice cream should not be more than 600,000 in 1 g of the product sample (Ministry of Public Health, 2006). For the rice ice cream, there might be some concern regarding the presence of psychrotolerant *Bacillus cereus* group strains in the future. Although the occurrence of this particular microbial group was low in the commercial ice cream (Zhou et al., 2010), some *Bacillus* outbreaks from rice products have been reported (Adams and Moss, 2000).

The sensory evaluation of three germinated rice ice creams is presented in Figure 3. The two main sensory attributes that could be distinguished by the sensory panel for the three different ice creams were color and smoothness properties. The purple rice ice cream was considered to be melting quicker, lower smoothness and lower creaminess, but it had a more purple color and more rice flavor compared to the other ice cream samples. The sensory attributes for the brown and red rice were evaluated to be similar, except for the color and smoothness values. In general, the

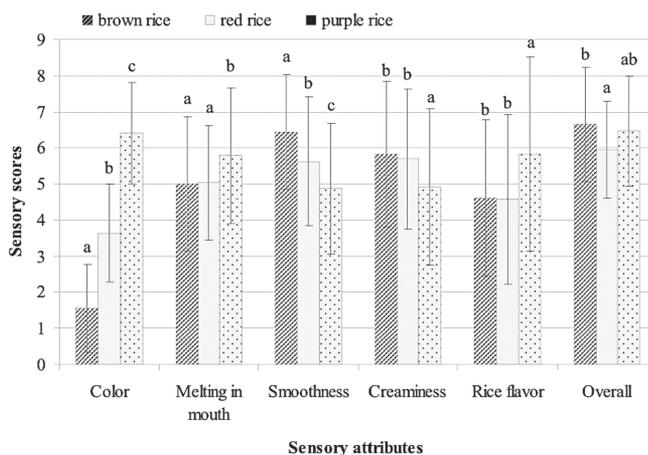


Figure 3. Sensory characteristics of germinated rice ice creams affected by different rice types.

sensory panel moderately accepted the rice ice creams with an overall acceptance value of 5.96 to 6.64. Compared to the previous result for dairy ice creams supplemented with protein (without stabilizers and emulsifiers), the creaminess of the rice ice cream in this study was slightly higher than the reported paper that had a creaminess value of 4.25 to 4.83 from a 9 hedonic scale (Patel et al., 2006). Ohmes et al. (1998) that worked about ice creams containing milk fat or fat replacers reported that the smoothness of the control ice cream was 8.87 from a 15 cm line score. This result was only a slight higher compared to the finding in this study, where the smoothness of the rice ice creams was between 4.91 and 5.83 from a 10 cm line scale. The smoothness of the rice ice cream was contributed from the presence of 40.10% coconut milk, since the occurrence of milk fat in an ice cream highly affected the texture and body of the product (Ohmes et al., 1998).

Germinated brown rice ice cream with 5% cooked rice

Since the germinated brown rice ice cream had the highest overrun value, the highest pH value, the lowest microbial number and was assessed to be slower melting in the mouth and have higher smoothness compared to the other rice ice creams by the sensory panel, this rice ice cream was further studied. In the second part of the study, 5% cooked rice was supplemented in the rice ice cream ingredients and processed as the normal rice ice cream. The data of the physical, chemical and microbial properties of the brown rice ice cream added with rice particles is displayed in Table 2.

Table 2. Physical, chemical and microbiological properties of germinated brown rice ice cream in the presence of 5% (w/w) rice particles.

Ice cream profiles	Brown rice ice cream with cooked rice
Viscosity (cp)	1509.17 ± 51.67*
Overrun (%)	11.56 ± 4.50
Melting rate (g/min)	0.024 ± 0.01
Color values	
L* value	84.94 ± 2.34
a* value	-0.31 ± 0.26
b* value	6.46 ± 0.49
Hardness (g force)	239.01 ± 122.78
pH value	6.38 ± 0.04
Total soluble solid (°Brix)	25.00 ± 0.82
Moisture content (%)	61.19±0.52
Protein content (%)	1.37±0.11
Total microorganisms (cfu/ml)	3,453.00 ± 5,610.74

*Results were means ± standard deviations of triplicate samples.

The supplementation of cooked rice was aimed to improve the rice flavor of the ice cream. However, the cooked rice was also significantly affected several aspects of the physical and chemical characteristics of the ice cream. Compared to the brown rice ice cream without cooked rice, the addition of cooked rice in the ice cream significantly increased the viscosity of the ice cream mixture and the hardness, L* value and b* value of the ice cream. On the other hand, the rice ice cream with the cooked rice significantly had lower pH, total soluble solid, moisture content and melting rate compared to those of the rice ice cream without rice particles. Changes in the rice ice cream with cooked rice could be due to the high amount of amylose and amylopectin in the rice starch, which contributes to around 80% of the rice composition (Rosell and Marco, 2008). An increase in the total solid of the rice ice cream with cooked rice was similar to the report Cody et al. (2007) that supplemented rice flour in the vanilla ice cream. The addition of cooked rice in the rice ice cream could be further investigated for the low fat rice ice cream products, since starch and modified food starches are reduced in calories (Cody et al., 2007).

CONCLUSION

The germinated rice ice cream could be presented as another diversification product of rice. Between the three germinated rice utilized in this study, germinated brown rice ice cream was superior in the terms of overrun, total solids and microbial quality compared to those of the other two ice creams. Although the brown rice ice cream had whiter color and lower rice flavor, the ice cream was evaluated to be slower melting in the mouth, smoother and creamier by the sensory panel. The physical and sensorial properties of the rice ice cream could be improved by a correct supplementation of cooked rice particles.

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