*Research article*

# Characterization of Riceberry Rice Ice Cream Enriched with Jerusalem Artichoke (*Helianthus tuberosus*) Extract

**Sawanit Aichayawanich[1] and Jittimon Wongsa[1,2]***

[1] *Department of Agricultural Engineering for Industry, Faculty of Industrial Technology and Management, King Mongkut's University of Technology North Bangkok (Prachinburi Campus), Prachinburi, Thailand*
[2] *Food and Agro-Industry Research Center, Science and Technology Research Institute, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand*

Received: 24 May 2021, Revised: 1 November 2021, Accepted: 25 November 2021

DOI: 10.55003/cast.2022.04.22.013

## Abstract

Jerusalem artichoke is a good source of inulin, oligofructose, and fructose, which are beneficial to human health. The objectives of this study were to characterize riceberry rice ice cream enriched with Jerusalem artichoke (with emphasis on its physicochemical properties), to assess the functional properties, and to perform sensory evaluation of the enriched ice cream. The ice cream was made from riceberry rice milk, dairy whipping cream, sucrose, and egg yolk. Jerusalem artichoke was used to substitute for the dairy whipping cream and sucrose at 10, 20, and 30% of the total weight. The results indicated that ice cream enriched with Jerusalem artichoke showed optimal physicochemical and functional properties, reduced fat and calorie intake and increased fiber. The overall acceptability scores were highest at 20% level of incorporation. Furthermore, the overrun, viscosity, melting rate, total soluble solids and calorie value were 25.42 ± 1.20%, 50.46 ± 0.40 cP, 0.10 ± 0.01 g/min, 32.60 ± 0.10°Brix and 178.96 Kcal/100g, respectively.

**Keywords**

fiber;

Jerusalem artichoke;

ice cream;

inulin;

riceberry rice

## 1. Introduction

Obesity and cardiovascular disease, among others, are major health concerns of modern life. Health-conscious consumers are increasingly interested in low-calorie food products [1]. Ice cream typically contains 10-16% of fat [2] and approximately 15% of sugar. To address consumer concerns, the dairy industry has developed various low-calorie, low-fat and fat-free ice cream products in recent years. However, the quality aspects of these products sometimes do not meet consumer expectations. Compared with traditional ice creams, products formulated with low-calorie and low-fat content offer a less favorable flavor and degenerative texture. In determining the overall acceptance of a

*Corresponding author: Tel.: (+66) 37 217 300 Fax: (+66) 37 217 317
E-mail: jittimon.w@fitm.kmutnb.ac.th

low-fat food, texture is a property that is more important than the product flavor. Reducing fat content causes structural and textural deformities including roughness and iciness, crumbliness, shrinkage, and also flavor abnormalities [3].

Inulin has been frequently used in dairy products as a prebiotic, fat replacer, sugar replacer, stabilizer, flavor enhancer and functional foods. Due to its beneficial role in gastric health, it is considered to improve consumer nutritional intake. Inulin is a polysaccharide in the fructan family, consisting of 2 to 60 units long chains of fructose bonded by β-(2-1) glycosidic linkages [4]. The human intestine cannot digest inulin into short-chain sugars due to its β-(2-1) bond configuration between fructose monomers. Inulin's properties are similar to those of soluble dietary fiber and non-digestible carbohydrate, with low calorie and low glycemic indexes [5]. Inulin, an oligomer found as a natural component of fruits and vegetables such as chicory and Jerusalem artichoke, has sweetening power 30-65% of that of sucrose [6]. In addition, many clinical studies use inulin for the prevention and treatment of diabetes mellitus, dyslipidemia, overweight and obesity.

Jerusalem artichoke (*Helianthus tuberosus*) presents a new alternative for the food industry, as its tubers offer an excellent source of vitamins and minerals. More importantly, they store carbohydrates as inulin instead of starch [7]. Jerusalem artichoke has been recently used as an ingredient in various food products such as cakes, crackers, bread, low-fat ice cream and yogurt.

Thai black riceberry rice provides practical nutritional benefits to consumers. It is used as a supplement for patients with anemia and diabetes. Grits, germ and bran are inexpensive, but are highly nutritious by-products from the rice mill. Riceberry germ and bran, in particular, contain large amounts of bioactive compounds such as phenol and anthocyanin compounds [8].

Therefore, the research was intended to characterize riceberry rice ice cream enriched with Jerusalem artichoke extract by examining its physicochemical properties, functional properties, and sensory characteristics. Jerusalem artichoke has been used in this study as a replacement agent for dairy whipping cream and sugar, and as a source of inulin, to produce low-calorie ice cream.

## 2. Materials and Methods

### 2.1 Materials

Jerusalem artichoke tubers (CN 52867 variety) were purchased from Kasiwattana farm, Nontaburi province, Thailand. Thai riceberry (*Oryza sativa* L.) was supplied as broken grains by Suansongsaen farm, Sa Kaeo province, Thailand. The broken rice sample was dried at 60°C to achieve approximately 13% moisture content. Dairy whipping cream (Anchor, Auckland, New Zealand), sucrose (Mitr Phol, Bangkok, Thailand) and eggs were purchased from a local supermarket in Prachinburi province, Thailand.

### 2.2 Extraction of riceberry rice

Riceberry rice milk was extracted by; 1) mixing broken riceberry rice grain with boiling water at a ratio of 1:5 (w/w), 2) soaking the grain for 30 min, and 3) extracting with a multipurpose extractor (Kitchenmall, Model T-01, Pathum Thani, Thailand). The pasteurization process of thr riceberry rice milk was done by heating in a stainless steel boiler at 85°C for 5 min, and then reducing the temperature to 30°C [9].

## 2.3 Extraction of Jerusalem artichoke

Jerusalem artichoke tubers were graded and cleaned by rinsing with distilled water to remove dirt and physical contaminants. Then, the tubers were sliced with a conventional food slicing machine (Simon, Model UT-MFC, Bangkok, Thailand) into thin pieces with a thickness of 2 mm. The sliced tubers were placed in a container with boiling water at a ratio of 1:1.5 (w/w). The boiling was continued at 80°C for 20 min before being cooled down to 30°C. The mixture was blended until a smooth homogeneous mixture was obtained. The samples were then extracted to remove coarse residues using a multifunction food processor (Kenwood, Model Multione, Bangkok, Thailand).

## 2.4 Preparation of riceberry rice ice cream

In this research, four riceberry rice ice creams containing Jerusalem artichoke at different quantities were formulated in order to observe and evaluate their physicochemical, functional and sensory properties. The formulations of riceberry rice ice cream are presented in Table 1. The first formulation, the control sample, contained 37.10% of dairy whipping cream, 16% of sucrose and was free of Jerusalem artichoke extract. The second to the fourth formulation contained dairy whipping cream and sucrose contents which were reduced to 10, 20 and 30%, respectively. Jerusalem artichoke extract was added as a replacement agent for the dairy whipping cream and sucrose, at the above-mentioned quantities. All of the formulations also contained 46.30% riceberry rice milk and 0.60% egg yolk. Each ice cream mixture was homogenized with a high-speed homogenizer (IKA, T 25 ULTRA-TURRAX, Staufen, Germany) at 5000 rpm for 10 min. Subsequently, the mixtures were pasteurized using a laboratory pasteurizing unit (Laboratory Pasteurize, P.S.A.21 Limited Partnership, Pathum Thani, Thailand) at 85°C for 15 s [10]. Then, each mixture was placed in an ice cream machine (N2ice clubsweety, Model Scoopy ice, Bangkok, Thailand) at -5°C. The obtained ice cream was kept at -20°C for one day to allow the hardening process to take place.

**Table 1**. Formulations of riceberry rice ice cream enriched with Jerusalem artichoke

| **Ingredients** | **Content (Amount/100g)** | | | |
|---|---|---|---|---|
| | **Control** | **JA10** | **JA20** | **JA30** |
| Riceberry rice milk | 46.30 | 46.30 | 46.30 | 46.30 |
| Dairy whipping cream | 37.10 | 33.40 | 29.68 | 25.97 |
| Sucrose | 16.00 | 14.40 | 12.80 | 11.20 |
| Egg yolk | 0.60 | 0.60 | 0.60 | 0.60 |
| Jerusalem artichoke extract | 0.00 | 5.30 | 10.62 | 15.93 |

## 2.5 Chemical analysis

Proximate analysis was carried out on Jerusalem artichoke and all formulations of riceberry rice ice cream samples to assess their moisture, carbohydrate, protein, fat, ash, fiber and inulin contents. The samples were analysed for crude fiber using Fibertec methods [11]. Inulin was determined according to the spectrophotometric method [12]. Other parameters in the proximate analysis were determined according to the Association of Official Analytical Chemists methods [13]. Total carbohydrates were calculated by difference as follows:

$$\text{Carbohydrate (\%)} = 100 - (\%\ \text{moisture} + \%\ \text{protein} + \%\ \text{fat} + \%\ \text{ash} + \%\ \text{fiber}) \quad (1)$$

All analyses were carried out in triplicate.

## 2.6 Physicochemical characterization of riceberry rice ice creams

### 2.6.1 pH

Before measuring pH, a portable pH meter (Milwaukee, Model pH55, North Carolina, USA) was calibrated with standard buffer solutions of pH 4.0 and 7.0. The riceberry rice ice cream samples were homogenized for pH analysis at 25°C.

### 2.6.2 Total soluble solids

Ice cream samples were analyzed to determine their total soluble solids (TSS) using a portable refractometer (Atago, model PAL-3, Tokyo, Japan). The values were expressed as °Brix values. The measurements were done at 25°C.

### 2.6.3 Overrun

The presence of air in the mixture while solidifying the ice cream increases the volume of the ice cream. This is known as overrun which is usually expressed as an increased percentage of the ice cream volume per the volume of the mixture. The percentage of overrun can be calculated from mass of the mixture ($m_{mix}$) and mass of ice cream ($m_{ice\ cream}$).

A 10 ml of the $m_{mix}$ was weighed after the ageing process, and the $m_{ice\ cream}$ of the same volume was weighed immediately after the freezing and aeration process. The percentage of the overrun was calculated in triplicate using the following equation [14].

$$\text{Overrun (\%)} = (m_{mix} - m_{ice\ cream})/m_{mix} \quad (2)$$

### 2.6.4 Viscosity

The viscosity was measured at 20°C using a Brookfield viscometer (Brookfield, Model DV3T, Massachusetts, USA). Viscometer reading was recorded in centipoises (cP). The viscometer was operated at 20 rpm [9].

### 2.6.5 Melting

The melting times of the ice cream mixtures were determined by storing a 50 g of ice cream sample at -20°C for 24 h. Afterwards, the sample was allowed to melt on a wire-mesh screen at 30±1°C until 100% of the sample had melted. The melted ice cream's weight was recorded every 2 min and percentages of the melted ice cream against the time were used to construct a graph. The slope value of the linear curve represents the melting rate of ice cream in g/min [15].

### 2.6.6 Color

Color analysis was carried out using a Colorimeter (HunterLab, MiniScan Model EZ4500, Virginia, USA). The analysis was based on the color parameters CIE L*a*b* scale for which L* represents the lightness of the ice cream (scale 1-100), a* represents the (+a) red and (-a) green color balance, and b* represents the (+b) yellow and (-b) blue color balance.

#### 2.6.7 Calorie value

The total calorie value of ice cream depends on the amount of energy per gram of carbohydrates, fats and proteins normally expected to be derived from ice cream. The equation to calculate this value is as follows [16].

$$\text{Calorie value} = (\%\ \text{Carbohydrate} \times 4) + (\%\ \text{Fat} \times 9) + (\%\ \text{Protein} \times 4) \quad (3)$$

### 2.7 Sensory evaluation

The control ice cream and experimental samples were evaluated by 50 semi-trained panelists at the King Mongkut's University of Technology North Bangkok, Prachinburi Campus. A 9-point hedonic scale; 9 = extremely like, 5 = neither like nor dislike and 1 = extremely dislike, was employed to evaluate appearance, flavour, taste, mouthfeel and overall liking of ice cream samples. Before the analysis, samples were hardened at -20°C for 24 h, and stored in a cooler box during sensory analysis.

### 2.8 Statistical analysis

SPSS statistical software program for Windows version 16 (SPSS Inc., Chicago, IL, USA) was used to analyze statistical information. To evaluate significant differences between test results, variance (ANOVA) and Duncan's multiple range test (DMRT) were used.

## 3. Results and Discussion

### 3.1 Chemical composition of Jerusalem artichoke tubers

The chemical composition of the Jerusalem artichoke is shown in Table 2. The results indicated that the chemical compositions of Jerusalem artichoke tubers extracted were: 19.10 ± 0.10, 1.12 ± 0.05, 0.96 ± 0.04, 0.11 ± 0.01 and 6.81 ± 0.16 g/100g, for total soluble solid, ash, protein, fat and carbohydrate, respectively. Jerusalem artichoke has low fat and protein contents and high levels of ash, carbohydrate and fiber. It also contains high amount of dietary fibers namely inulin and fructo-oligosaccharides [7]. The use of inulin from Jerusalem artichoke as a functional ingredient in processed foods has increased due to its unique characteristics. Also, the tubers are the source of fiber, which is the most appreciable property. The results in Table 2 showed that the fiber content was 5.25 ± 0.12 g/100g of fresh weight whereas the inulin content was 4.22 ± 0.11 g/100g of fresh weight. After processing the Jerusalem artichoke tubers by blending and extraction, 20.37 ± 0.09 g/100g of inulin was obtained. This was consistent with previous studies on the same variety of Jerusalem artichoke tubers [12]. The differences in the tubers' compositions might relate to variety and maturity of the tubers. From these results, it can be concluded that Jerusalem artichoke tubers are a rich source of inulin and fibers.

### 3.2 Chemical composition of riceberry ice cream enriched with Jerusalem artichoke

The chemical composition of riceberry rice ice cream enriched with Jerusalem artichoke at different levels is shown in Table 3. The results indicated that the enriched ice cream contained more ash, carbohydrate and fiber, whereas the total soluble solids, protein and fat were lower than control

**Table 2.** Chemical composition of Jerusalem artichoke tuber

| Compositions | (g/100g) |
|---|---|
| TSS (°Brix) | 19.10 ± 0.10 |
| Ash | 1.12 ± 0.05 |
| Protein | 0.96 ± 0.04 |
| Fat | 0.11 ± 0.01 |
| Carbohydrates | 6.81 ± 0.16 |
| Fiber | 5.25 ± 0.12 |
| Inulin | 4.22 ± 0.11 |

**Table 3.** Chemical compositions of riceberry rice ice cream enriched with Jerusalem artichoke

| Compositions | Treatments | | | |
|---|---|---|---|---|
| | Control | JA10 | JA20 | JA30 |
| TSS (°Brix) | 38.90 ± 0.10$^{c}$ | 35.80 ± 0.10$^{b}$ | 32.60 ± 0.10$^{a}$ | 30.00 ± 0.20$^{a}$ |
| Ash (%) | 0.62 ± 0.01$^{a}$ | 0.79 ± 0.02$^{a}$ | 1.01 ± 0.01$^{b}$ | 1.16 ± 0.01$^{b}$ |
| Protein (%) | 3.52 ± 0.10$^{b}$ | 3.26 ± 0.08$^{a}$ | 3.18 ± 0.05$^{a}$ | 3.12 ± 0.08$^{a}$ |
| Fat (%) | 14.70 ± 0.30$^{b}$ | 12.62 ± 0.30$^{b}$ | 9.79 ± 0.16$^{a}$ | 8.62 ± 0.20$^{a}$ |
| Carbohydrates (%) | 18.61 ± 0.30$^{a}$ | 18.96 ± 0.20$^{a}$ | 19.51 ± 0.12$^{b}$ | 20.05 ± 0.24$^{b}$ |
| Fibers (%) | 0.20 ± 0.10$^{a}$ | 0.76 ± 0.16$^{b}$ | 1.15 ± 0.20$^{c}$ | 1.32 ± 0.17$^{c}$ |
| Inulin (%) | - | 0.46 ± 0.04$^{a}$ | 1.08 ± 0.04$^{b}$ | 1.58 ± 0.06$^{c}$ |

Values are displayed as means ± standard deviation (n = 3)
Significant differences at $P < 0.05$ are indicated by different superscripts in the same row.

samples. Reducing the amount of dairy whipping cream in the formulation resulted in a lower fat content. Moreover, the lower fat content of the Jerusalem artichoke was a factor responsible for the decrease in fat content in ice cream. Partially substituting sucrose with Jerusalem artichoke extract results in a lower sweetness of riceberry rice ice cream as the inulin is less sweet than sucrose [6]. Inulin in the riceberry rice ice cream containing Jerusalem artichoke ranged from 0.46 ± 0.04- 1.58 ± 0.06%, depending on the added level of Jerusalem artichoke.

### 3.3 Physicochemical properties of riceberry rice ice cream enriched with Jerusalem artichoke

The data in Table 4 shows a slight decrease in pH values of riceberry rice ice cream containing Jerusalem artichoke when compared with that of the control sample. The progressive increases in acidity of the ice cream mixture that occurred when the quantity of the Jerusalem artichoke content in the mixture was increased were possibly due to the Jerusalem artichoke tuber extract having a pH of 5.96±0.11. The changes in the magnitude of pH, when Jerusalem artichoke level is raised, reveal that Jerusalem artichoke has an acidifying effect on processed food [17].

Viscosity is one of key characteristics of ice cream and is one factor that affects the structural and textural properties of ice cream products. The results indicated that the substitution of

**Table 4.** Physical properties of riceberry rice ice cream enriched with Jerusalem artichoke

| Parameters | Treatments | | | |
|---|---|---|---|---|
| | **Control** | **JA10** | **JA20** | **JA30** |
| pH | 6.09 ± 0.00$^{b}$ | 6.08 ± 0.01$^{ab}$ | 6.08 ± 0.01$^{ab}$ | 6.06 ± 0.02$^{a}$ |
| Viscosity (cP) | 57.20 ± 0.64$^{c}$ | 47.54 ± 0.26$^{a}$ | 50.46 ± 0.40$^{ab}$ | 52.18 ± 0.22$^{b}$ |
| Overrun (%) | 35.60 ± 0.50$^{c}$ | 27.08 ± 1.15$^{b}$ | 25.42 ± 1.20$^{b}$ | 21.15 ± 0.82$^{a}$ |
| Melting rate (g/min) | 0.17 ± 0.02$^{b}$ | 0.12 ± 0.01$^{a}$ | 0.10 ± 0.01$^{a}$ | 0.11 ± 0.02$^{a}$ |
| Calorie value (Kcal/100g) | 220.82 | 202.46 | 178.96 | 170.26 |

Values are displayed as means ± standard deviation (n = 3)
Significant differences at P < 0.05 are indicated by different superscripts within the same row.

dairy whipping cream with Jerusalem artichoke extract decreased the viscosity of the ice cream. The rheology of ice cream is inversely associated with the fat content of the ice cream mixture. A rising fat content decreases the number of ice crystals. Increasing ice crystals can cause the ice cream's texture to become harder while the stickiness is reduced. This leads to unacceptable viscosity for consumers [10]. On the other hand, when a high level of Jerusalem artichoke was added, the viscosity of the ice cream increased. The results showed an increase in viscosity, which was the same results obtained from adding commercial inulin powder and Jerusalem artichoke powder to dairy products [17]. Thus, among the other benefits of its addition, Jerusalem artichoke extract enrichment also improved the viscosity of riceberry rice ice cream.

Riceberry rice ice cream enriched with Jerusalem artichoke extract had overrun values that ranged from 27.08±1.15 to 21.15±0.82% compared with 35.60±0.50 control samples. Ice cream made from rice milk had a lower overrun value than that of dairy-based ice cream, which was possibly due to the milk's high-fat content. In addition, high sugar content and total solids also led to the higher overrun values. Moreover, the high shear efficiency of an industrial scale ice cream production results in a high quantity of air bubbles. This could cause the industrially made ice cream to have a higher overrun than that of the laboratory machine-made ice cream [18]. Overrun and melting are related to the amount of air incorporated into the texture of the ice cream during the manufacturing process. This property can determine the final product's structure because it gives a light texture as well as affecting specific physical properties such as density, melting, and viscosity [17].

The melting rate was 0.07±0.02 g/min for control ice cream samples compared with 0.12±0.01- 0.10±0.01 g/min for Jerusalem artichoke enriched ice cream. The effect of Jerusalem artichoke added at a 20-30% level gave the lower melting rates, compared with then effect obtained when adding 10%. These results show the high resistance of ice cream enriched with Jerusalem artichoke against melting. Additionally, the slow melting of inulin-contained ice cream could be due to inulin's ability to prevent the water molecules from moving independently [19].

The calorie value of riceberry rice ice cream enriched with Jerusalem artichoke was lower than that of the control sample due to decreased dairy whipping cream and sucrose, both of which are significant contributors to calorie value. Also, the non-digestible property of inulin inherently resulted in a calorie value that is significantly lower than other typical carbohydrates.

Jerusalem artichoke extracted was dark brown in color with color values of 35.14 ± 0.63, 6.44 ± 0.09 and 6.65 ± 0.57 for $L*$, $a*$ and $b*$ values, respectively. The color of ice cream samples showed $L*$ values that were close to each other, but those of JA30 sample were significantly lower than the others (Table 5). The $L*$ values decreased with the addition of Jerusalem artichoke extract.

**Table 5.** Color of riceberry rice ice cream enriched with Jerusalem artichoke

| Treatments | Color value | | |
|---|---|---|---|
| | ***L**** | ***a**** | ***b**** |
| Control | 68.20 ± 0.08$^{bc}$ | 1.12 ± 0.13$^{a}$ | 0.20 ± 0.10$^{a}$ |
| JA10 | 66.85 ± 0.22$^{b}$ | 1.15 ± 0.11$^{a}$ | 1.65 ± 0.15$^{b}$ |
| JA20 | 65.50 ± 0.18$^{b}$ | 2.30 ± 0.20$^{b}$ | 2.40 ± 0.16$^{b}$ |
| JA30 | 61.95 ± 0.20$^{a}$ | 3.95 ± 0.15$^{c}$ | 2.95 ± 0.21$^{b}$ |

Values are displayed as means ± standard deviation (n = 3)
Significant differences at P < 0.05 are indicated by different superscripts within the same column.

All of the ice cream samples taken into consideration were found to have positive redness (*a**) rates, while JA20 and JA30 samples appeared to be higher than the others. The yellowness (*b**) color value was not significant.

## 3.4 Sensory evaluation

The results of the sensory evaluation are shown in Table 6. Sensory properties of the ice cream samples were affected by the addition of Jerusalem artichoke. The results demonstrated that the riceberry rice ice cream enriched with 30% Jerusalem artichoke attained a significantly lower average score than the control ice cream. This was due to its color and flavor, and due to the specific taste of Jerusalem artichoke.

The average scores obtained from the evaluation of the mouthfeel of riceberry rice ice creams were consistent with the results of the melting rate experiments. The ice creams enriched with Jerusalem artichoke melted in the mouth faster than the control ones. They also received significantly lower average scores than the control samples. From the panelist's views, only the sample containing 20% of Jerusalem artichoke had a mouthfeel which was almost similar to that of the control sample.

**Table 6.** Sensory analysis results of riceberry rice ice cream enriched with Jerusalem artichoke

| Sensory attributes | Treatments | | | |
|---|---|---|---|---|
| | **Control** | **JA10** | **JA20** | **JA30** |
| Appearance | 7.89 ± 0.18$^{b}$ | 7.68 ± 0.20$^{b}$ | 7.68 ± 0.23$^{b}$ | 6.80 ± 0.32$^{a}$ |
| Flavor | 8.16 ± 0.21$^{b}$ | 7.77 ± 0.26$^{b}$ | 7.76 ± 0.18$^{b}$ | 6.74 ± 0.46$^{a}$ |
| Taste | 8.02 ± 0.10$^{c}$ | 7.68 ± 0.15$^{b}$ | 7.72 ± 0.24$^{b}$ | 7.29 ± 0.12$^{a}$ |
| Mouthfeel | 8.07 ± 0.12$^{b}$ | 7.42 ± 0.38$^{a}$ | 7.80 ± 0.21$^{ab}$ | 7.50 ± 0.32$^{a}$ |
| Overall liking | 8.10 ± 0.32$^{c}$ | 7.35 ± 0.26$^{b}$ | 7.88 ± 0.26$^{c}$ | 7.06 ± 0.22$^{a}$ |

Values are displayed as means ± standard deviation (n = 50)
Significant differences at P < 0.05 are indicated by different superscripts within the same row.

## 4. Conclusions

The study showed that adding Jerusalem artichoke improved the physicochemical properties and functional characteristics of riceberry rice ice cream. The riceberry rice ice cream treatments with Jerusalem artichoke as a replacement agent of dairy whipping cream and sucrose at 20% gained similar sensory scores when compared to samples with the full fat and sucrose contents. These results show that Jerusalem artichoke, which contains inulin content and other functional components that produce low-calorie ice cream, can be used as a replacement agent for dairy whipped cream and sucrose.

## 5. Acknowledgements

This research was funded by King Mongkut's University of Technology North Bangkok, contract no. KMUTNB-63-DRIVE-23.

## References

[1] Akalin, A.S., Karagözlü, C. and Ünal, G., 2008. Rheological properties of reduced-fat and low-fat ice cream containing whey protein isolate and inulin. *European Food Research and Technology*, 227(3), 889-895.
[2] Marshall, R.T., Goff, H.D. and Hartel, R.W., 2003. *Ice Cream*. 6th ed. New York: Kluwer/Plenum Publishers.
[3] Devereux, H.M., Jones, G.P., McCormack, L. and Hunter, W.C., 2003. Consumer acceptability of low-fat foods containing inulin and oligofructose. *Journal of Food Science*, 68, 1850-1854.
[4] El-Kholy, W.M. and Mahrous, H., 2015. Biological studies on bio-yoghurt fortified with prebiotic obtained from Jerusalem artichoke. *Food and Nutrition Sciences*, 6(16), 1552-1564.
[5] Roberfroid, M.B., 2005. Introducing inulin-type fructans. *British Journal of Nutrition*, 93(1), 13-25.
[6] Chavan, R.S., Khedkar, C.D. and Bhatt, S., 2016. Fat replacer. In: B. Caballero, P. Finglas and F. Toledra, eds. *Encyclopedia of Food and Health*. London: Academic Press, pp. 589-595.
[7] Ozgoren, E., Isik, F. and Yapar, A., 2019. Effect of Jerusalem artichoke (*Helianthus tuberosus* L.) supplementation on chemical and nutritional properties of crackers. *Journal of Food Measurement and Characterization*, 13(4), 2812-2821.
[8] Jangmesin, K., Rimkeeree, H. and Tadakittisarn, S., 2017. Enzymatic optimization of riceberry bran protein hydrolysate extraction and characterization. *Current Applied Science and Technology*, 17(2), 209-223.
[9] Kemsawasd, V. and Chaikham, P., 2020. Effects of frozen storage on viability of probiotics and antioxidant capacities of synbiotic riceberry and sesame-riceberry milk ice creams. *Current Research in Nutrition and Food Science*, 8(1), 107-121.
[10] Akbari, M., Eskandari, M. H., Niakosari, M. and Bedeltavana, A., 2016. The effect of inulin on the physicochemical properties and sensory attributes of low-fat ice cream. *International Dairy Journal*, 57, 52-55.
[11] FOSS Analytical, 2010. AN 3437: Determination of crude fiber according to EN ISO 6865:2000 and 92/89/EEC. In: *FOSS Application Notes for Fibertec™ 2010 and Fibertec™ 1020 M6*. Hilleroed: Foss Analytical.

[12] Saengkanuk, A., Nuchadamrong, S., Jogloy, S., Patanothia, A. and Srijaranai, S., 2011. A simplified spectrophotpmetric method for determination of inulin in Jerusalem artichoke (*Helianthus tuberosus* L.) tubers. *European Food Research and Technology*, 233, 6009-6016.

[13] A.O.A.C., 2000. *Official Methods of Analysis*. $17^{th}$ ed. Arlington: The Association of Official Analytical Chemists.

[14] Rinaldi, M., Dall'Asta, C., Paciulli, M., Guizzetti, S., Barbanti, D. and Chiavaro, E., 2014. Innovation in the Italian ice cream production: Effect of different phospholipid emulsifiers. *Dairy Science and Technology*, 94, 33-49.

[15] Criscio, T.D., Fratianni, A., Mignogna, R., Cinquanta, L., Coppola, R., Sorrentino, E. and Panfili, G., 2010. Production of functional probiotic, prebiotic, and synbiotic ice creams. *Journal of Dairy Science*, 93(10), 4555-4564.

[16] Khan, S., Rustagi, S., Choudhary, S., Pandey, A., Khan, M. K., Kumari, A. and Singh, A., 2018. Sucralose and maltodextrin-an alternative to low fat sugar free ice-cream. *Bioscience Biotechnology Research Communications*, 11(1), 136-143.

[17] Darwish, A.S.M., Elkot, F.W. and Mohamed, O.R., 2012. Functional properties and nutritional quality of ice cream enriched with Jerusalem artichoke flour. *Journal of Agroalimentary Processes and Technologies,* 22(2), 87-94.

[18] Syed, Q.A., Anwar, S., Shukat, R. and Zahoor, T., 2018. Effects of different ingredients on texture of ice cream. *Journal of Nutritional Health and Food Engineering*, 8(6), 422-435.

[19] Akin, M.B., Akin, M.S. and Kirmaci, Z., 2007. Effects of inulin and sugar levels on the viability of yogurt and probiotic bacteria and the physical and sensory characteristics in probiotic ice-cream. *Food Chemistry*, 104, 93-99.