Broken Rice for Production of Functional Ice Cream

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Abstract: Broken rice is a by-product from rice milling industry. The aim of this study was to prepare buffalo skim milk – broken rice milk blends for ice cream production. Ice cream mixtures were standardized to contain 8% fat, 8% SNF, 15% sugar and 0.5% laca 9060. Broken rice milk was used to replace 25, 50, 75 and 100% of fresh skimmed milk. All mixes and the resultant ice cream samples were evaluated for their physio-chemical and chemical properties as well as the sensory quality attributes. The production costs of different treatments were also studied. The results indicated that the physio-chemical and chemical properties of all mixes were significantly affected. The overrun decreased while, the melting resistance of ice-cream samples significantly increased with increasing the proportion of broken rice milk in the blend. The sensory evaluation results showed that the most acceptable treatments were those made by replacing 25 and 50% of skim milk with broken rice milk. From the data obtained it could be recommended that ice cream can be produced with high quality by substitution buffalo skim milk with broken rice milk up to 50% with 17% reduction in the cost. Production of ice cream free approximately from lactose can be manufactured with up to 34% reduction in the cost by full substitution of buffalo skim milk with broken rice milk.

Keywords: Broken rice, buffalo skim milk, ice cream, cream

INTRODUCTION

Ice cream is a frozen combination of milk components, sweeteners, stabilizers, emulsifiers and flavours. It is defined as partially frozen foam containing 40 to 50% air by volume (Larson and Friberg, 1990).

Ice cream is a nutritious, healthful and relatively inexpensive food that supplies per 100 g approximately 196.7 calories, 4.1 g protein, 0.122 g calcium, 0.105 g phosphorus, 442.8 IU vitamin A, 0.04 mg thiamine and 0.23 mg riboflavin (Arbuckle, 1986). The quality of ice cream depends upon the ingredients used; suitable stabilizers are the most important. Nowadays, consumers are interested in low cost healthy dairy products (functional dairy products). Preparation of functional ice cream has been studied by several investigators. A novel low fat ice cream based on the use of cactus pear pulp was investigated by EL-Samahy et al. (2015). They mentioned that cactus fruit pulp improved the rheological characteristics, the antioxidant activity and the total acceptability of the low fat ice cream. The use of avocado fruit pulp (AFP) as functional ingredients rich in natural antioxidants and high content of unsaturated fatty acids in the manufacture of ice cream was investigated by Khalil and Blassy (2015). They found that the use of AFP up to 15% can be recommended in developing a new low fat ice cream of high antioxidant scavenging activity and acceptable sensory properties.

Novel functional low fat ice cream flavoured with roasted date seed (RDS) was studied by Khalil et al. (2016). They reported that RDS could potentially be an inexpensive source for cocoa/coffee flavour substitute and possibly used as a functional food ingredients.

Broken rice is a by-product of rice milling industry. It is a very good source of carbohydrates but low in fat. Broken rice could be used as an important ingredient for manufacture of many low cost, low lactose and low fat dairy products. Carbohydrates of rice are predominantly starch with small portions of pentosan, hemicelluloses and sugars. Rice protein has one of the highest nutritive values among cereal proteins because of its high lysine content (Bandyopadhyay and Roy, 1992). Rice protein has a comparatively high content of essential amino acids with high total digestibility of protein (Pillaiyar, 1988).

Therefore, this study was undertaken to investigate the effect of using broken rice milk in ice cream production pertaining of the properties of the resultant ice cream as well as the cost of its production.

MATERIALS AND METHODS

Materials

Fresh buffalo skim milk (0.5% fat and 9% S.N.F) and fresh cream (65% fat and 6% S.N.F) were obtained from the Dairy Technology Unit, Dairy Science Department, Faculty of Agriculture, Cairo University, Egypt. Sugar and vanilla were obtained from the local market in Cairo. Lacta 9060 (combination of selected emulsifiers and stabilizers blends) was obtained from Misr Food Additives (MIFAD). Broken rice was obtained from Crops Research Institute, Agriculture Research Center, Ministry of Agriculture, Giza, Egypt.

Preparation of ice cream mixtures

Formulation: Ice cream mixtures were prepared from the formentioned ingredients with quantities calculated as shown in Table 1. Ice cream mixtures were standardized to contain 8% fat, 8% S.N.F, 15% sugar and 0.5% lacta 9060. Broken rice milk was used to replace 25, 50, 75 and 100% of fresh skimmed milk.

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Preparation of broken rice milk

**Broken rice**

**Cleaning**

**Soaking (2 h)**

**Draining**

**Cooking (1:3) /30 min**

**Blending with water**

*Broken rice milk (0.6% fat and 8.72 S.N.F)*

**Methods of analysis**

Total solids, fat, total protein, lactose and ash were determined according to AOAC (2007). The carbohydrates content was determined by subtracting the sum of fat, protein, lactose and ash from total solids. Titratible acidity of mixes was determined in duplicate according to Richardson (1986) by titration with NaOH 0.1 N. Values of pH were measured using a digital laboratory pH meter (HI 931400, Hanna instruments) with glass electrode. Overrun of ice cream samples was calculated according to Marshall *et al.* (2003) as the difference in volume between resultant ice cream and original mix. Melting rate of the resultant ice cream samples was determined as mentioned by Segall and Goff (2002). Ice cream samples were allowed to melt at room temperature (23±1°C) and the melted portion was weighed every 10 min. The percent mass loss /min in the linear region (slope) was used to compare the meltdown rate of different samples.

Viscosity was determined using a coaxial rotational viscometer (Rheotest II, Medingen, Germany) at shear rates ranging from 3.0 to 1312 s⁻¹. The measuring device (S1) was used with a sample volume of 30 ml per run. All samples were adjusted to 20±1°C before loading in the viscometer device. Apparent viscosity was calculated at shear rate of 48.6 s⁻¹.

**Sensory evaluation**

All the ice cream samples were sensory rated for flavour (45), body & texture (30), melting properties (10) and colour (15) by 12 panelists of experienced staff members at Dairy Science Department, Cairo University and Agriculture Research Center, Ministry of Agriculture, Giza, Egypt.

**Statistical analysis**

The data (mean of three replicates) were analyzed by the General Linear Models procedure of SAS (1996). Least significant difference test was performed to determine differences in means at P≤ 0.05.

| Ingredients (%) of different ice cream recipes (Kg/100 Kg mix) |
|------------------|-----|-----|-----|-----|-----|
| **Ingredients %** | **T₁** | **T₂** | **T₃** | **T₄** | **T₅** |
| Sugar            | 15   | 15   | 15   | 15   | 15   |
| Lacta 90-60      | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Fresh skim milk  | 72.80| 54.60| 36.40| 18.20|     |
| Cream            | 11.70| 11.70| 11.70| 11.70| 11.70|
| Broken rice milk | -    | 18.20| 36.40| 54.60| 72.80|
| **Total**        | 100  | 100  | 100  | 100  | 100  |

**T₁**: 100% skim milk + zero broken rice milk, **T₂**: 75% skim milk + 25% broken rice milk **T₃**: 50% skim milk + 50% broken rice milk, **T₄**: 25% skim milk + 75% broken rice milk **T₅**: zero% skim milk + 100% broken rice milk

T₅: 20±1° C.
RESULTS AND DISCUSSION

Properties of ice cream mixes

Physico-chemical properties and chemical composition of different ice cream mixes are shown in Tables (2) and (3). Titratable acidity values tended to slightly decrease and the pH values increased with increasing the proportion of broken rice milk in the blend (Table 2). These differences may be due to the changes of protein and ash content of the mixes (Table 3). Natural titratable acidity in milk and milk products is dependent on casein, albumin, phosphates, citrates and carbon dioxide as mentioned by Atherton and Newlander (1977).

Viscosity is considered as an important aspect for proper whipping and retention of air cells. The viscosity of experimental mixes progressively increased with increasing the proportion of broken rice milk in the blend. Viscosity ranged from 86±1.5 to 176±1.0 cp (Table 2). In this respect Cottrell et al. (1980) mentioned that polysaccharides such as starch are reported to increase the mix viscosity. Similar results were obtained by Awad (2007). He mentioned that the apparent viscosity of ice cream mixes significantly increased with substitution of skim milk powder by rice flour.

Chemical composition of ice cream mixes prepared from different blends of buffalo skim milk – broken rice milk is shown in Table (3). There were noticeable differences in the total solids and fat contents of ice cream mixes. These differences may be due to differences in the quantity and chemical composition of broken rice milk and skim milk.

Total protein, lactose and ash contents of ice cream mixes were significantly decreased with increasing the proportion of broken rice milk in the blend. On the other hand, the total carbohydrates content was increased as the proportion of broken rice milk increased.

Awad (2007) reported that all mixes with rice flour had lower protein and ash contents and the values were decreased with increasing the add ratio of rice flour instead of skim milk powder in the formula. Carbohydrates content, on the other hand was increased as the substitution increased.

Table (2): Physico-chemical properties of different ice cream mixes

<table>
<thead>
<tr>
<th>Treatments*</th>
<th>pH</th>
<th>Acidity%</th>
<th>Apparent Viscosity (cp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>6.56±0.40d</td>
<td>0.23±0.015a</td>
<td>86.0±1.5e</td>
</tr>
<tr>
<td>T2</td>
<td>6.63±0.26c</td>
<td>0.23±0.02a</td>
<td>96.0±1.0d</td>
</tr>
<tr>
<td>T3</td>
<td>6.69±0.006b</td>
<td>0.20±0.02a</td>
<td>110.0±1.0c</td>
</tr>
<tr>
<td>T4</td>
<td>6.83±0.017a</td>
<td>0.21±0.01a</td>
<td>138.0±0.8b</td>
</tr>
<tr>
<td>T5</td>
<td>6.86±0.052a</td>
<td>0.20±0.025a</td>
<td>176.0±1.0a</td>
</tr>
</tbody>
</table>

L.S.D 0.064 0.031 1.97

*See Table (1) for details
Means in the same column having different superscript letters are significantly different p ≤ 0.05

Table (3): Chemical composition (%) of different ice cream mixes

<table>
<thead>
<tr>
<th>Treatments*</th>
<th>T.S</th>
<th>Protein</th>
<th>Fat</th>
<th>Ash</th>
<th>Lactose</th>
<th>Carbohydrates</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>30.67±0.06c</td>
<td>3.26±0.11a</td>
<td>8.11±0.05d</td>
<td>0.616±0.001a</td>
<td>4.064±0.0075b</td>
<td>14.61±0.792d</td>
</tr>
<tr>
<td>T2</td>
<td>30.50±0.05d</td>
<td>2.32±0.00b</td>
<td>8.31±0.03b</td>
<td>0.48±0.001b</td>
<td>3.220±0.070b</td>
<td>16.179±1.005cd</td>
</tr>
<tr>
<td>T3</td>
<td>30.98±0.02a</td>
<td>1.96±0.09c</td>
<td>8.40±0.01a</td>
<td>0.423±0.008c</td>
<td>2.316±0.283c</td>
<td>17.880±1.010bc</td>
</tr>
<tr>
<td>T4</td>
<td>30.61±0.02c</td>
<td>1.15±0.11d</td>
<td>8.20±0.03c</td>
<td>0.382±0.011d</td>
<td>1.243±0.266d</td>
<td>19.621±1.005b</td>
</tr>
<tr>
<td>T5</td>
<td>30.83±0.03b</td>
<td>0.078±0.00e</td>
<td>8.19±0.02c</td>
<td>0.317±0.005e</td>
<td>0.042±0.008e</td>
<td>22.203±1.001a</td>
</tr>
</tbody>
</table>

L.S.D 0.067 0.141 0.033 0.012 0.3008 1.758

*See Table (1) for detail
Means in the same column having different superscript letters are significantly different p≤ 0.05
The overrun and melting resistance results of the resultant ice cream are shown in Figs (1 and 2). The overrun in ice cream is directly related with the yield and profit. The overrun differed significantly among the treatments as shown in Fig (1). Control ice cream had the maximum (i.e. 88%) overrun whereas T₃ had the least overrun (i.e. 55%). Patel et al. (2006) stated that the more the protein, the more the protienious bubbles trapping air inside and resulting in high overrun.

Melting rate as influenced by the proportion of buffalo skim milk– broken rice milk has been given in Fig (2). It can be notice from the results that the melting resistance of ice cream samples significantly increased with the addition of broken rice milk. The higher viscosity of experimental mixes (Table 2) might be partly responsible for low melting rate of the treatments.

Fig. (1): The overrun of the resultant ice cream
T₁: 100% skim milk + zero broken rice milk; T₂: 75% skim milk + 25% broken rice milk; T₃: 50% skim milk + 50% broken rice milk; T₄: 25% skim milk + 75% broken rice milk; T₅: zero% skim milk + 100% broken rice milk

Fig. (2): Melting rate of the resultant ice cream
T₁: 100% skim milk + zero broken rice milk; T₂: 75% skim milk + 25% broken rice milk; T₃: 50% skim milk + 50% broken rice milk; T₄: 25% skim milk + 75% broken rice milk; T₅: zero% skim milk + 100% broken rice milk
Sensory evaluation

The resultant ice cream samples prepared from different blends of skim milk and broken rice milk were subjected to sensory evaluation for overall acceptability attributes by panelists.

Results in Table (4) indicated that as the proportion of broken rice milk increased the overall acceptability scores of the resultant ice cream decreased. Statistically, there was no significant difference between the different treatments except T5 in flavour which had the lowest score compared with other treatments. However, the most acceptable treatments were T2 and T3 (those made by replacing 25 and 50% of skim milk with broken rice milk) as reported by the panelists.

Production costs

Production costs of different ice cream recipes were calculated and presented in Table (5). Data obtained showed that the cost reduction (%) remarkably increased as the proportion of broken rice milk increased in the blend. As shown the approximately free lactose ice cream treatment can be manufactured with up to 34.0% reduction in the cost by full substitution of buffalo skim milk with broken rice milk.

Table (4): Sensory evaluation of the resultant ice cream

<table>
<thead>
<tr>
<th>Treatments*</th>
<th>Flavour (45)</th>
<th>Body Texture (30)</th>
<th>Melting properties (10)</th>
<th>Colour (15)</th>
<th>Total score (100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>43.35±1.84a</td>
<td>28.0±1.87a</td>
<td>8.81±1.35a</td>
<td>14.62±0.87a</td>
<td>94.77±4.11a</td>
</tr>
<tr>
<td>T2</td>
<td>41.69±2.17a</td>
<td>27.88±2.12a</td>
<td>8.88±1.12a</td>
<td>14.46±0.75a</td>
<td>92.92±4.47a</td>
</tr>
<tr>
<td>T3</td>
<td>42.31±2.53a</td>
<td>27.81±2.39a</td>
<td>9.31±0.95a</td>
<td>14.12±0.77a</td>
<td>93.53±5.33a</td>
</tr>
<tr>
<td>T4</td>
<td>40.69±2.89a</td>
<td>27.15±2.23a</td>
<td>8.73±1.05a</td>
<td>14.35±0.94a</td>
<td>90.92±4.55a</td>
</tr>
<tr>
<td>T5</td>
<td>37.59±5.55b</td>
<td>26.58±3.35a</td>
<td>8.77±1.17a</td>
<td>13.96±1.39a</td>
<td>86.91±8.08a</td>
</tr>
</tbody>
</table>

L.S.D 2.66 1.92 0.89 0.76 9.41

*See Table (1) for details
Means in the same column having different superscript letters are significantly different p≤0.05

CONCLUSION

As the objective of the present study was to use the maximum level of broken rice milk to manufacture acceptable product, the combination of 50:50 buffalo skim milk – broken rice milk can be recommended. In other words, as there is a great deal of attention has been focused on functional food production such as low or free lactose products, utilization of higher percentage of broken rice milk as an ingredient in ice cream formulation (T4 and T5) may lead to production of inexpensive healthy food with up to 25.5% and 34% reduction in the cost respectively.

Table (5): Production costs of different treatments (L.E./100Kg mix)

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Lacta 90-60</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Fresh skim milk</td>
<td>364.0</td>
<td>273.0</td>
<td>182.0</td>
<td>91.0</td>
<td>-</td>
</tr>
<tr>
<td>Cream</td>
<td>526.5</td>
<td>526.5</td>
<td>526.5</td>
<td>526.5</td>
<td>526.5</td>
</tr>
<tr>
<td>Broken rice milk</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total costs</td>
<td>1040.5</td>
<td>979.5</td>
<td>888.5</td>
<td>797.5</td>
<td>706.5</td>
</tr>
<tr>
<td>Cost reduction %</td>
<td>-</td>
<td>8.5</td>
<td>17.0</td>
<td>25.5</td>
<td>34.0</td>
</tr>
</tbody>
</table>

*See Table (1) for details
ACKNOWLEDGMENT

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REFERENCES


استخدام كسر الأرز في صناعة ايس كريم وظيفي
فوزية حسن جبر عبد الرحيم، أمينة محمد دويدار
قسم علوم الألبان، كلية الزراعة، جامعة القاهرة

كسر الأرز هو المنتج الثانوي الناتج من عملية تبييض محصول الأرز. تهدف هذه الدراسة إلى إعداد خليط من اللبن الجاموسي الخالي من الدهن ولين كسر الأرز بغرض استخدامه في صناعة ايس كريم ذو خصائص مميزة (منخفض % للكاكتوس). وذلك بإعداد مخلوط الأيس كريم محشي ده و8% جوامد لا دهنية 15% سكر و5% لاكطا 10.60% على أن يتم استخدام كسر الأرز لحء محل اللبن الجاموسي الفرزر الطازج بنسبة استبدال 0.25، 0.50 و1.00%. تم تقييم الخواص الطبيعية والكيميائية لمخلوط المختلطة وقد الاختلافات الخصية للممنتج النهائي مع دراسة تاكليف التصنيع أيضاً. أظهرت النتائج تأثير كلاً من الخواص الطبيعية والكيميائية باختلاف نسبة الخليط المستخدمة لوحظ أيضاً انخفاض الزيت والمكونات لدرجة الاصهار للمنتاج النهائي بزيادة نسبة الحلات. أظهرت نتائج التقييم الحيوي فائقة المنتج النهائي الناتج من استبدال اللبن الفرزر بنسبة 25% و50% لين كسر الأرز مع خفض التكلفة بنسبة 8.6% وتزايد الين الفرزر بنسبة 7.5% لين كسر الأرز بخفض التكلفة بنسبة 20.5% وان استبدال اللبن الجاموسي الفرزر لين كسر الأرز كلية يمكن استخدامه لإنتاج منتاج خالي اللاكتوز تقريباً ومتكلفة أقل بمقدار 34%.