Research article

Formulation of Supplemented Thai Custard Spread Using Jackfruit Rag and Sugar Replacement with Stevia

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Curr. Appl. Sci. Technol. 2024, Vol. 24 (No. 4), e0259802; https://doi.org/10.55003/cast.2024.259802

Received: 19 October 2023, Revised: 1 January 2024, Accepted: 27 April 2024, Published: 30 April 2024

Keywords

jackfruit rag;
waste utilization;
fiber;
stevia;
custard spread

Abstract

The aims of this study were to investigate whether jackfruit rags could be incorporated into a food product like custard spread, and to evaluate the sensory and physicochemical properties of the resulting products. The first trial comprised four treatments, each of which contained a different concentration of jackfruit rag (0, 20, 40, and 60% w/w). It was found that 40% jackfruit rag substitution gave higher acceptance ratings (appearance, colour, taste, odour, spreadability and overall likeness) than other concentrations. Subsequently, stevia substitution at 20% produced considerably greater sensory acceptability across all treatments. In addition, the nutritional and physicochemical characteristics of jackfruit rag-supplemented custard with 0% and 20% stevia were evaluated. Proximate analysis results showed there were no differences no difference between custard spreads fortified with 0% and 20% stevia. However, carbohydrate and energy were reduced about twice in the 20% stevia treatment. Moreover, texture profile analysis revealed that replacement with stevia increased spreadability and decreased stickiness. The results suggested that jackfruit rag could be used in custard spreads and could enhance the recovery of food waste for food production.

1. Introduction

Nowadays, consumers prefer custard as a dessert after the main course, as a snack between meals, or as part of breakfast along with tea or coffee. Custard is extensively consumed because it is simple to prepare and has a sweet flavor. This product can be found in convenience stores, bakeries, dessert shops, flea markets, and on the Internet. It is a popular commodity that offers commercial opportunities, and its formula can be adjusted to meet consumer demand.

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Custard is a creamy dessert with a sweet flavor and a pleasant aroma. Eggs, sugar, coconut milk, and condensed milk or fresh milk, are the main ingredients, and custard comes in numerous flavors including vanilla aroma, pandan (from squeezed pandan juice), Thai tea and green tea. Custard has the qualities of being thick, glossy, and sweet [1]. However, the sweet flavor of custard may be harmful to consumer health. Excessive free or added sugar consumption increases total calorie intake and presumably body weight and has been associated with the onset of obesity [2], and related chronic illnesses such as Type 2 diabetes [3]. The World Health Organization (WHO) strongly recommend that less than 10% of total energy consumption per day should come from free sugars, for both adults and children. A further decrease to less than 5% is a conditional suggestion [4]. One alternative to sucrose is stevia, which is a low-calorie sweetener and dietary supplement that is 200-300 times sweeter than sucrose [5]. This low-calorie natural sweetener is widely used in a variety of dietary products, including ice cream, beverages, baked goods, and sauces [6, 7]. Ingredients such as stevia can be used in the formulation of functional foods that provide a range of nutrients and minerals. To improve health and nutritional safety, the use of available resources, affordable, and nutrient-rich plant components in custard compositions must be identified and encouraged.

Currently, the fruit processing sector creates tons of fruit waste that is made up of peels, stones, seeds, and pomace, which account for 30-40% of fruit weight. Some fruit wastes have been shown to have a variety of biological effects, including antioxidant, antibacterial, antiviral, anti-inflammatory, anti-allergic, antithrombotic, and vasodilatory properties. Jackfruit (*Artocarpus heterophyllus* Lam.) is an indigenous fruit that is usually served fresh, and the pulp is commonly consumed. The remaining portions, known as co-products, such as rag, peel, pith, seeds, and seed coats, are simply discarded as waste [8]. Although jackfruit has many benefits, it has not been adopted into the general food chain, due in part to limitations in its processing and distribution, and due to a lack of information regarding its usage techniques and nutritional and nutraceutical values [9]. Rag is one of the by-products of jackfruit. The fibrous elements within the fruit make up around 30-50% of the overall fruit. Few people utilize the rag in their cooking or as an ingredient in fruit salads; instead, they discard the jackfruit rag. However, amid the current economic crisis, people have become reluctant to throw away residues such as jackfruit co-products. According to Cagasan *et al*. [8], jackfruit co-products are interesting raw materials for wine production. Ihediohanma *et al*. [10] demonstrated that jackfruit is a viable pectin source that can be effectively used in food gel systems such as fruit jams, jellies, and fillers.

There is the possibility of partially replacing fat and sugar in the production of Thai custard with substances that contain less calories. For example, pandanus custard with 1/3 coconut milk substitution with soy milk, 50% sugar replacement with sucralose, and 5% inulin was found to have acceptable sensory properties [11]. Mekrawee *et al*. [12] investigated the development of tofu custard by incorporating black sesame into the custard and found that tofu mixed with black sesame can be used in custard instead of 100% pandan juice, with panelists acceptance of 100%. Achimugu *et al*. [13] convincingly demonstrated that carrot-coloured custard powder based on millet and guinea corn, rather than the use of maize in custard making, proved to be a product of improved nutrition.

To the best of our knowledge, no research study has examined the qualitative attributes and consumer acceptance of custard when the components of the regular formulation were concurrently substituted with jackfruit co-product and sugar replacement. As a response, this study was carried out to investigate the viability of incorporating jackfruit rags and stevia into Thai dessert products such as custard spread.

2. Materials and Methods

2.1 Jackfruit rag preparation

The jackfruit rag was separated from discarded fully ripened fruit that had been obtained from a local market in Bangkok, Thailand. Consequently, the rag samples were sanitized with 50 ppm sodium hypochlorite and rinsed in running tap water. The rag samples were blended for 5 min at medium speed to produce a fine paste. The jackfruit rag pastes were kept in a freezer (-20ºC) until further utilization.

2.2 Jackfruit rag properties

A colourimeter (Model CR-400 Chroma Meter; Konica Minolta Sensing Inc., Osaka, Japan) was used to determine the colour of the jackfruit rag. Jackfruit rag samples were placed in an acrylic chamber and their colour was recorded using the CIE colour system, as L^* (lightness), a^* (redness), and b^* (yellowness). The chemical compositions (moisture, protein, lipid, ash and fiber) of the jackfruit rag samples were measured by AOAC [14]. Furthermore, carbohydrate content was estimated by the formula: carbohydrate = 100% - (% moisture + protein + lipid + ash).

2.3 Preparation of custard spread added with jackfruit rag

Jackfruit rag was employed to produce custard spread of various formulas. Sugar, coconut milk, duck egg, green tea concentrate (green tea powder/water at a ratio of 1:1 w/w), and jackfruit rag were used as ingredients to produce the custard spread. Sugar (130 g), coconut milk (200 g), and duck whole egg (300 g) were combined and strained through a filter cloth. The jackfruit rag pastes were subsequently incorporated into the mixture at various amounts (0, 20, 40, and 60% w/w of total weight). Green tea concentrate (90 g) was then added to the mixture. The mixture sample was pureed for 5 min at medium speed in a kitchen blender before being heated in a double boiler at 73±2ºC and held for 15 min. The custard spread mixture was blended again in a sterile blender for another 3 min. Then, sensory assessment was performed on all custard spread samples.

Sensory assessments were carried out by 50 untrained panelists (18-45 years old) who appreciated and consumed custard spreads. In the plastic cup, 15 g of each sample was placed and labelled with a three-digit random number. The samples of custard spread were provided with plain bread and mineral water. Based on the appearance, colour, spreadability, taste, odour, and overall acceptability, the liking score was estimated using a 9-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely).

2.4 The effect of stevia as a sugar substitute on the sensory properties of custard spread incorporating jackfruit rag

In this study, the control sample was the custard spread with jackfruit rag that had the highest sensory score from the previous preparation. The custard spread with jackfruit rag was sweetened with varying amounts of stevia powder (0, 10, 20, 30 and 40% w/w) as a sugar replacement. The relative amounts of stevia (Green sweet, Green Foods Asia co., Ltd., Thailand) was calculated according to the sweetness level of sugar to create the same degree of sucrose sweetness in the final product. The acquired custard spread with jackfruit rag was assessed using the already-described 9-point hedonic scale.

2.5 Physicochemical properties of low-calorie sugar custard spread incorporating jackfruit rag

The physicochemical characteristics of the custard spread with jackfruit rag and stevia generating the highest sensory score were determined in comparison to the control sample (without stevia). Colour parameters (*L**, *a** and *b**) of the spread samples were recorded using a colourimeter (Model CR-400 Chroma Meter; Konica Minolta Sensing Inc., Osaka, Japan). The water activity (a_w) of the samples was measured by a LabMaster-aw neo (Novasina AG, Switzerland) at 25ºC. The moisture, protein, lipid, ash and fiber contents of samples were estimated by AOAC method [14]. The carbohydrate content was estimated using the formula: carbohydrate = 100% - (% moisture + lipid + protein + ash). Besides, the energy values were determined based on the chemical constitutions of the energy components (protein, lipid and carbohydrate) [15]. The total sugar contents were quantified by Method 982.14 [16]. Insoluble and soluble fiber were estimated according to Method 985.29 and 991.42, respectively [16].

2.6 Ethical statement

Ethics approval of this research was as per EC-KMITL_64_064. Informed consent was obtained from each subject prior to their participation in the study.

2.7 Statistical analysis

Experiments were carried out in triplicate. A completely randomized design (CRD) was used to analyse the physical and chemical characteristics of the jackfruit rag. Meanwhile, sensory evaluation was conducted using a randomized complete block design (RCBD). Furthermore, an SPSS program (SPSS for Windows version 21.0, IBM, USA) was used to examine the physicochemical parameters of the generated custard spreads across two samples using a paired T-test. Duncan's multiple range test was implemented to calculate significant differences among means at the 95% confidence level.

3. Results and Discussion

3.1 Chemical and physical characteristics of jackfruit rags

Table 1 shows the chemical and physical properties of the jackfruit rag. The contents of moisture, protein, fat, ash, carbohydrate and crude fiber in jackfruit rag were 61.37%, 2.07%, 0.94%, 2.11%, 33.51% and 4.21%, respectively. According to Amadi *et al*. [17], Nigerian jackfruit rag constituted 86.93% moisture, 10.06% protein, 1.49% lipid, 1.02% ash, 7.74% carbohydrate, and 3.01% crude fiber. It can be assumed that jackfruits of various species and from different locations have distinct physicochemical features. Moreover, the colour appearance of the jackfruit rag was yellow (Figure 1). Yellow colour of carotenoids was most likely responsible for the jackfruit rag colour. The *L**, *a** and *b**-values of the jackfruit rag were 85.19, -1.89 and 39.09, respectively.

3.2 Development of custard spread added with jackfruit rag

Figure 2 illustrates the sensory attributes of custard spreads at various amounts of added jackfruit rag. Custard spreads with and without jackfruit rag acquired sensory evaluation scores ranging from dislike moderately to like rather well. The results revealed that panellists favored the addition of

Table 1. Chemical and physical characteristics of jackfruit rag

Chemical and Physical Properties	Jackfruit Rag
Moisture (%)	61.37±0.85
Lipid (%)	0.94±0.07
Protein (%)	2.07±0.12
Ash (%)	2.11±0.13
Fiber (%)	4.21±0.19
Carbohydrate (%)	33.51±0.11
*L**-value	85.19±4.62
*a**-value	-1.89±1.25
*b**-value	39.09±8.17

Figure 1. The photograph of jackfruit rag

jackfruit rag owing to its great sweetness and scent. In fact, the bulb of jackfruit was sweet in taste [9]. In addition, Grimm and Steinhaus [18] reported that the aroma of ripe jackfruit pulp is thecombination of sweet, fruity, malty and cheesy undertone flavors. Therefore, the addition of jackfruit rag to custard spread would increase favourable scores, particularly for taste and colour. The sensory characteristics of the samples were significantly affected by the incorporation of diverse amounts of jackfruit rages. In the similar vein, Hamid *et al*. [19] reported that the application of jackfruit-by product improved the overall quality of meat analogue. Moreover, the results indicated that increasing the jackfruit rag to more than 60% of total weight resulted in lower liking scores for all sensory attributes. A large proportion of jackfruit rag generates a distinctive aroma. It tends to have a detrimental impact on the odour and overall appearance of the finished product. Custard spread with 40% jackfruit rag provided a higher liking score than other samples ($p<0.05$) probably because this proportion of jackfruit rag in custard spread delivered a distinctive appearance, colour, taste, odour, spreadability, and a high overall likeness score.

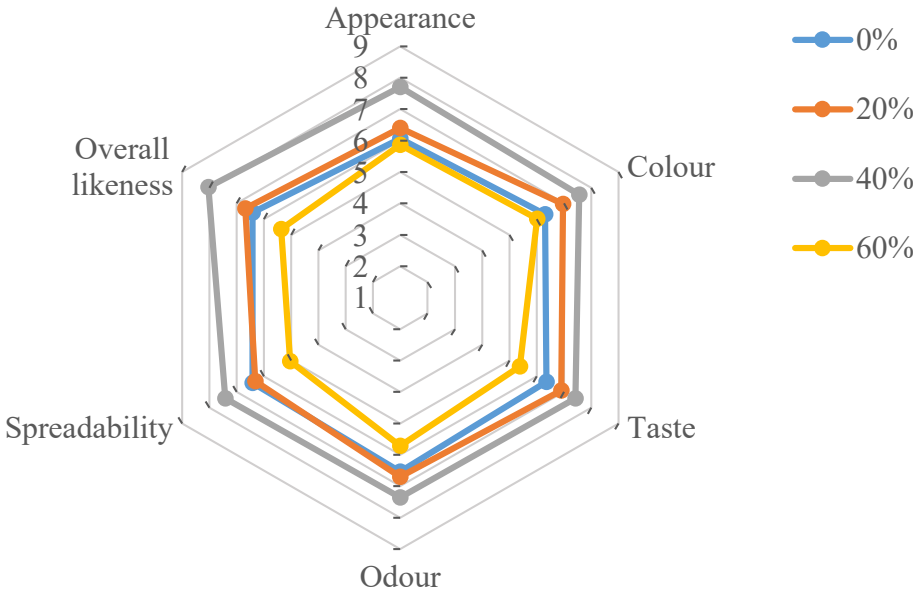

Figure 2. Overall sensory evaluation of custard spread with jackfruit rag added at different levels (0%, 20%, 40% and 60%). Appearance, colour, taste, odour, spreadability and overall likeness according to hedonic evaluation (1, "Dislike extremely"; 9, "Like extremely")

3.3 Effect of stevia on the characteristics of custard spread added with jackfruit rag

3.3.1 Sensory characteristics of low sugar custard spread added with jackfruit rag

The sensory attributes of a low sugar custard spreads prepared with 40% jackfruit rag and various amounts of stevia (10%, 20%, 30% and 40% w/w) instead of sucrose were investigated and reported as likeness scores in comparison to a control sample (0% stevia) (Figure 3). The jackfruit rag custard spread made with 20% stevia was really well accepted, with a likeness score of more than 7 points for all characteristics ($p<0.05$). It was found that the use of stevia as sucrose substitute affected sensory characteristics of the resulting custard spreads. Stevia levels of more than 20% (30% and 40% stevia) were associated with lower likeness scores. With the exception of spreadability likeness score, the custard spread with 30% and 40% sugar replacement stevia had the lowest likeness score for all aspects ($p<0.05$). The findings suggested that stevia addition seemed to have a negative influence on sensory qualities owing to its sweet with slightly bitter taste. Similarly, Alizadeh *et al.* [20] found that substantial amounts of sugar replacement with stevia reduced soft ice cream sensory scores. This might be due to the metallic, bitter, astringent and unpleasant flavors of stevia [21]. As a result, the usage of 20% stevia for sugar substitution in jackfruit custard spread was adopted and physicochemical characteristics and nutritional qualities were studied in comparison to the control.

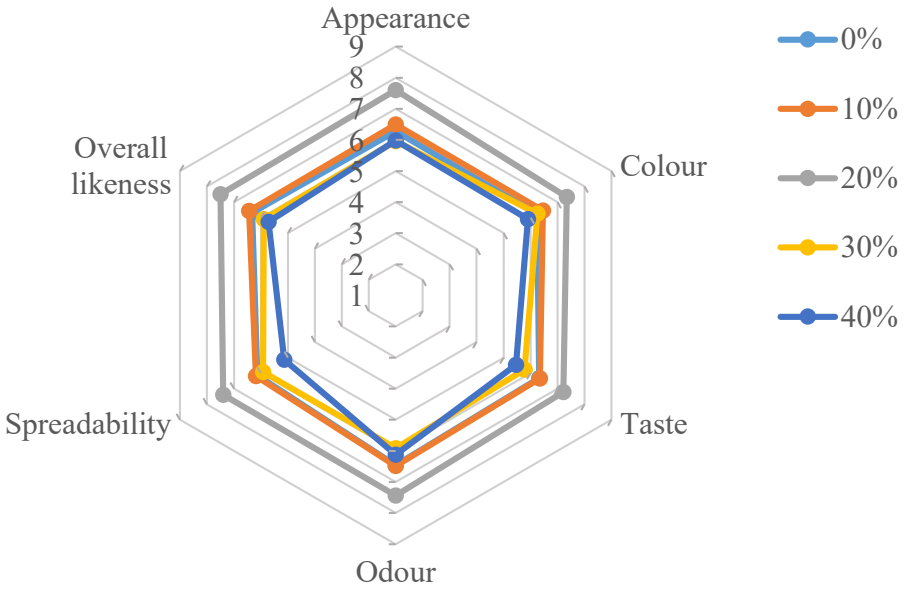

Figure 3. Overall sensory evaluation of custard spread added with 40% jackfruit rags at different stevia levels (0%, 10%, 20%, 30% and 40%). Appearance, colour, taste, odour, spreadability and overall likeness according to hedonic evaluation (1, "Dislike extremely"; 9, "Like extremely")

3.3.2 Physicochemical characteristics of low sugar custard spread added with jackfruit rag

Table 2 summarizes the results of water activity (a_w), pH, colour, and texture of jackfruit rag custard spread with 0% (control sample) and 20% stevia. The photographs of both samples are shown in Figure 4. It was found that all samples had a_w values ranging from 0.979 to 0.985. Increasing the amounts of stevia in custard spread contributed to a significant rise in a_w ($p<0.05$). In addition, Vatankhah *et al*. [22] discovered a similar trend for the a_w of sweet bread that had been fortified with stevia as a sugar substitute. For colour values (L^*, a^*, and b^*), decreasing sucrose level increased L^* and a^* but decreased b^* ($p<0.05$). These results indicated that the colour tone of jackfruit rag custard spread with 20% stevia exhibited a lighter shade of green and blue than the control sample. A reduction in sugar concentration was the explanation for the decreased development of colour in the custard spreads, most presumably due to the formation of less Maillard reaction products [23]. However, no significant differences in pH, texture, spreadability, stickiness, or adherence were discovered ($p>0.05$). As a consequence, the addition of stevia had no influence on pH and texture, but somehow it affected the a_w and colour of the custard spreads.

3.3.3 Nutritional values of low-calorie custard spread added jackfruit rag

The nutritional value of the control sample was examined and compared to the nutritional value of jackfruit rag spread utilizing the optimal stevia level achieved in the previous experiment (20% stevia). Table 2 shows the nutritional values of both samples. Moisture (50.85%) was the most abundant component of the control sample, followed by carbohydrate (39.66%) and ash (15.11%), respectively. The jackfruit rag custard spread with 20% stevia had lower carbohydrate (23.32%), total sugar (10.48%), and energy value (111.78 Kcal/g) than the control sample (carbohydrate

Table 2. Characteristics of jackfruit rag custard spread without and with 20% sugar substitute stevia

Characteristics	Custard without Stevia (Control)	Custard with 20% Stevia
Moisture (%)	50.85±0.23[b]	67.43±0.51[a]
Lipid (%)	4.36±0.78[a]	4.38±0.28[a]
Protein (%)	4.37±0.20[a]	4.10±0.14[a]
Ash (%)	15.11±0.02[b]	15.35±0.10[a]
Fiber (%)	0.76±0.04[a]	0.77±0.03[a]
Carbohydrate (%)	39.66±0.88[a]	23.32±0.69[b]
Energy (Kcal/g)	215.36±3.14[a]	111.78±0.32[b]
Insoluble fiber (g/100 g solid)	12.73±0.01[a]	12.86±0.10[a]
Soluble fiber (g/100 g solid)	2.38±0.07[a]	2.49±0.12[a]
Total dietary fiber (g/100 g solid)	15.11±0.15[a]	15.35±0.16[a]
Total sugar (%)	15.26±0.01[a]	10.48±0.10[b]
a_w	0.979±0.00[b]	0.985±0.00 [a]
pH	6.73±0.06[a]	6.85±0.07[a]
*L**-value	49.86±0.17[b]	55.44±0.37 [a]
*a**-value	-1.28±0.12[b]	-0.84±0.07[a]
*b**-value	33.55±0.06[a]	32.76±0.23[b]
Firmness (g)	106.12±4.73[a]	113.99±8.42[a]
Spreadability (g.s)	393.90±21.99[a]	399.66±38.56[a]
Stickiness (g)	-50.20±4.03[a]	-53.85±5.67[a]
Adhesion (g.s)	-68.17±6.34[a]	-71.16±6.76[a]

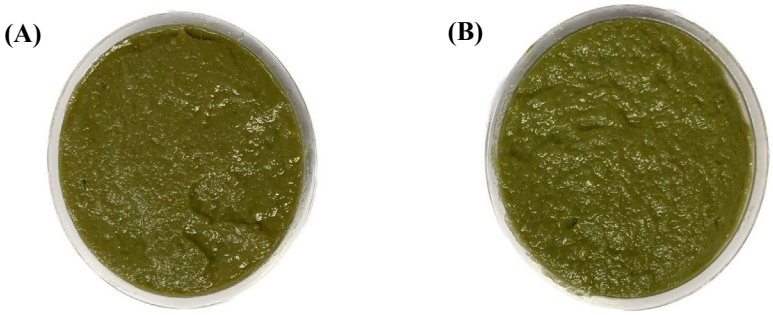

Figure 4. The photographs of jackfruit rag custard spread without (A) and with 20% sugar substitute stevia (B)

39.66%, total sugar 15.26%, and energy value 215.36 Kcal/g) ($p<0.05$). The results showed that stevia substitution at 20% was related with lower carbohydrate and total sugar contents in the jackfruit rag custard spread. Furthermore, because stevia has no energy value, replacement with 20% stevia reduced the energy value of jackfruit rag custard spread. Similar results were obtained by Salazar *et al*. [24] and Yildiz and Gocmen [25], who reported that stevia substitution was associated with the reduced carbohydrate and energy contents of cookies. Interestingly, the jackfruit rag custard spread with 20% stevia had greater moisture and ash concentrations ($p<0.05$). These findings were consistent with those of Salazar *et al*. [24], who demonstrated that the moisture and ash levels of oatmeal cookies prepared with partial substitution of sucrose by stevia were greater than those prepared with 100% sucrose. Because stevia has a high water retention capacity, the addition of stevia extract could enhance the moisture content of the food product [26]. Likewise, the substitution of sucrose with stevia had the same effect on ash levels according to the findings of Yildiz and Gocmen [25]. They found an increase in ash levels with the substitution of stevia in gluten-free cookies. The substitution was probably resulted in greater mineral concentrations. Mishra *et al*. [26] also reported that stevia was rich in important minerals. As a consequence, substituting sucrose for stevia in jackfruit rag custard spread formulations may have affected the proportion of those elements in the custard spread.

4. Conclusions

Jackfruit rag was used to fortify custard spread products. Fortification with jackfruit rag had an impact on the custard spread sensory properties. Additionally, the concurrent use of 20% stevia as a sucrose replacement and jackfruit rag spread at 40% (w/w) improved the nutritive values and sensory properties of the custard spread.

5. Acknowledgements

This work was supported by King Mongkut's Institute of Technology Ladkrabang [No. 2565-02-03-005].

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