Research Article

Development of Instant Rice for Young Children

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Received September 28, 2011; Accepted February 12, 2012

Abstract

The objective of this research was to find a suitable method for producing an instant rice product from Thai Jasmine rice for young children aged 1-3 years old. Different methods of rice cooking, pre-treatment prior to drying, and rehydration were studied. Volume expansion, rehydration ratio, rehydration time, colour, texture, and sensory characteristics of instant rice product were compared. The results showed that the instant rice product prepared by boiling followed by freezing for 24 h at –20 °C, drying at 70 °C, and rehydration by boiling for 3 min showed no significant difference in hardness, adhesiveness, or cohesiveness from the freshly cooked rice. The hardness, adhesiveness and cohesiveness were 349.75 ± 3.94 N, –23.09 ± 1.30 N.s, and 0.49 ± 0.01, respectively. The sample also received the highest scores for stickiness, softness, and overall acceptability for use as food for young children. Boiling followed by 24 h of freezing prior to drying is recommended for producing instant rice for young children.

***Key Words**:* Instant food; Rice; Young children

Introduction

Rice is the staple food for over half the world's population, including the Thai population. Khao Dawk Mali 105 or Thai Jasmine Rice is the most popular variety for consumption in Thailand because of its pleasant fragrance when cooked as well as its good texture. Rice is also a suitable food for young children because it is easy to digest; it contains many essential nutrients and no gluten.

The recommended diet for babies for the first six months is mother's milk exclusively, after which complementary foods may be introduced in addition to mother's milk. Traditionally in Thailand the popular complementary foods are mashed banana and mashed rice porridge. Young children aged one to three years rely more on staple foods like cooked rice or rice porridge that is not mashed so they can get used to chewing soft rice. Most Thai families prepare their own children's food. However, these days many families do not have time to prepare their own young children's food and prefer to buy ready prepared food products that are convenient to serve. Many families also rely on child care centers to supply their young children's nutrition. A preliminary survey of the foods for young children available on the market showed that the selection is limited. Most are instant products that have a liquid or paste-like consistency when rehydrated. These types are suitable in the early stages when babies are first given complementary food but are not suitable for young children. The other instant rice products on the market are also mostly not intended for young children.

Previous investigations have proposed instant rice preparation processes consisting of methods of soaking, cooking, pre-treatment prior to drying, drying, and rehydration. The method of soaking, boiling, washing prior to freezing, and drying was suggested by Kongseree et al. (2002). Rewthong et al. (2011) suggested that the boiling method for cooking rice was better than the application of electric rice cooker and washing step prior to freezing gave poorer eating quality. The washing step prior to freezing was shown to be unnecessary for instant rice cooked by boiling (Carlson et al.,1979). It has also been reported that the texture of many rehydrated instant rice products is harder and less chewy than freshly cooked rice (Luangmalawat et al., 2008). None of the previous research specified use for young children.

Therefore, the objective of this research was to find a suitable method to produce an instant rice product from Thai Jasmine rice for young children by comparing the methods previously reported. Such a product would be helpful for families and nurseries or child centers that require rice which can be prepared quickly for young children, and it would also provided added value to Thai Jasmine rice.

Materials and Methods

Materials

The raw material for all the experiments was Thai Jasmine rice purchased from a local distributor in Bangkok.

Preparation of Instant Rice

Five hundred grams of uncooked Thai Jasmine rice was pre-washed with water before cooking, then water was added at the ratio of one part rice to 1.5 parts water by volume, and the mixture was left to stand for 10 min. Methods of cooking and preparation of instant rice recommended by previous research (Kongseree et al., 2002; Rewthong et al., 2011) were compared, as shown in Figure 1.

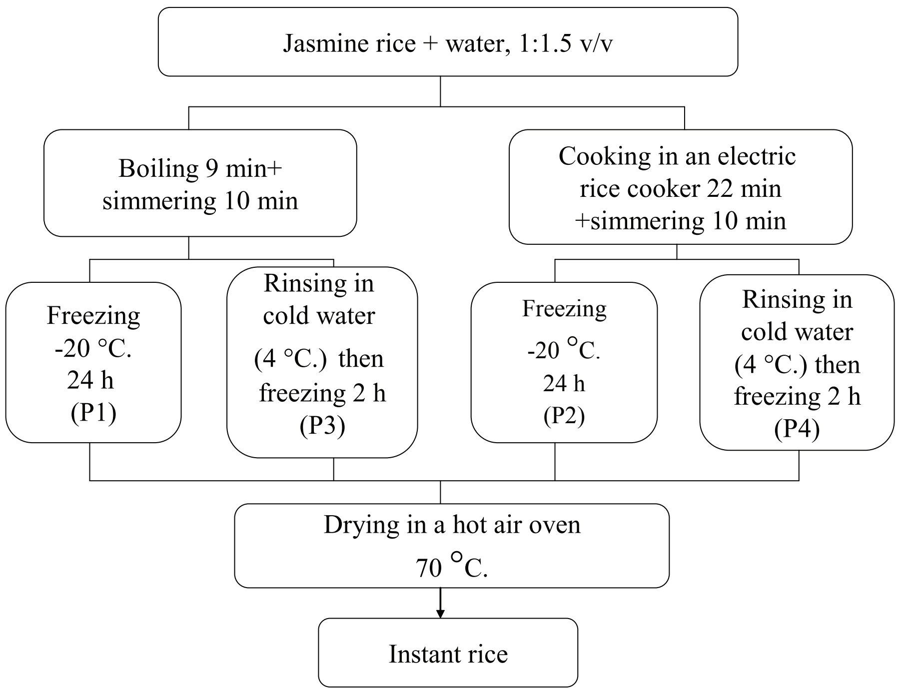

Figure 1 Methods for preparing instant rice

Two methods of cooking rice were compared: boiling and cooking in an electric rice cooker (Sharp, model KS-11E). Two methods for pre-treatment rice before drying was conducted by 1) freezing at -20 ˚C for 24 h and 2) rinsing in cold water for 30 sec and then freezing at -20 ˚C for 2 h.

The prepared rice was then spread over aluminum drying screens and placed in a hot air dryer (Binder, FD115 model) at 70 ˚C until the moisture content was reduced to about 5% by weight. The resulting instant rice product was analysed for moisture content (AOAC, 2000), volume expansion (Kongseree et al., 2002), rehydration ratio, and rehydration time.

To find the most appropriate method for rehydration of the resulting instant rice for use as a food for young children, the samples were boiled for 3, 4, or 5 min and then left to simmer for 8 min. After rehydration, the samples were analysed for colour and texture compared to the freshly cooked rice. The sensory evaluation was undertaken by a sensory panel of 10 panelists with experience in preparing food for infants and young children at the Kasetsart University child care center.

Quality Evaluation

1. The moisture content of the rehydrated instant rice and freshly cooked Thai Jasmine rice were measured by drying in a hot air oven at 105 ± 2 °C for 6 h, following the method of AOAC (2000).

2. The volume expansion was measured following the method of Kongseree et al. (2002). Twenty grams samples of each instant rice product were placed in a volumetric cylinder and the volume was noted, water at a temperature of 95 ˚C was added, and the expanded volume was measured every 2 min for 40 min. Three replications were carried out.

$$\text{Volume expansion} = \frac{\text{volume of reconstituted product (ml)}}{\text{starting volume (ml)}}$$

3. The rehydration ratio was measured following the method of Prasert and Suwannaporn (2009). One hundred millilitres of water at 95 ˚C were added to 10 g of instant rice. Excess water was dabbed away and the samples were weighed every 2 min for 40 min. After three replications, the water rehydration ratio was calculated thus:

$$\text{Rehydration ratio} = \frac{\text{weight of instant rice after absorption of water (g)}}{\text{starting dry weight (g)}}$$

4. The rehydration time was measured following the method of Kongseree et al. (2002). One hundred grams of each instant rice product were boiled in boiling water, then removed from the water with a sieve spoon, and left to drain. Excess water was dabbed away and the moisture content was measured by heating in a hot air oven (AOAC 2000) and measuring samples once per minute for 10 min. Three replications were carried out.

5. The colour of rehydrated instant rice was compared to that of freshly cooked rice using a Hunter Lab Color Flex colorimeter using the CIE Lab (1976) L*a* and b* system.

6. A texture profile analysis (TPA) was done for the rehydrated instant rice compared to freshly cooked rice, testing for hardness, adhesiveness, and cohesiveness using a method adapted from Kiathanapaiboon (2008) on the TA-XT.plus texture analyser (Stable Micro Systems, UK). Samples of 14 g were placed in the cylindrical blocks and readings were taken with a 100-mm diameter cylindrical probe at the rate of 1.0 mm/sec. Five replications were carried out.

Sensory Evaluation

The samples were evaluated by 10 panelists using a nine-point hedonic scale. The panelists all have an experience in preparing food for infants and young children at the Kasetsart University child care center.

Statistical Analysis

Data obtained from all the tests were analyzed by using one-way analysis of variance (ANOVA) and followed by Duncan multiple range test.

Results and Discussion

Analysis of the Quality of Instant Rice Products

Volume Expansion

There was a statistically significant difference in volume expansion among the rice products prepared by the four different methods ($p < 0.05$). The volume expansion of rice samples which were frozen for 24 h (P1 and P2) was higher than that of samples frozen for 2 h after rinsing with cold water (P3 and P4), as shown in Figure 2.

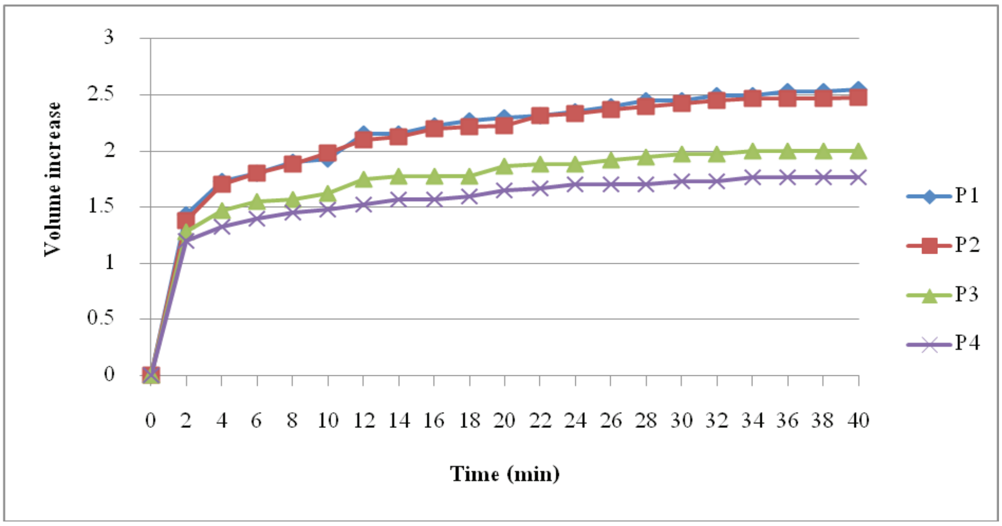

Figure 2 Volume expansion of instant rice products after reconstitution

P1 = rice boiled + frozen for 24 h

P2 = rice cooked in an electric rice cooker + frozen for 24 h

P3 = rice boiled + rinsed + frozen for 2 h

P4 = rice cooked in an electric rice cooker + rinsed + frozen for 2 h

Lu et al. (1997) and Mohamed et al. (2006) reported that the gelatinized starch could become retrograded after being kept at the optimal temperature of approximately 4 °C. It is possible that when the cooked rice was rinsed in cold water, the particles in the rice kernel that gelatinized during the cooking process may have begun to bond together again, creating a more cohesive structure. That could explain why the rice that was rinsed in cold water before freezing had a lower volume expansion rate than rice that was not rinsed in cold water before freezing.

Rehydration Ratio

The rehydration ratios of all samples were different during rehydration for 2-40 min. The instant rice cooked in an electric rice cooker and frozen for 24 h (P2) had the highest water rehydration ratio while the instant rice that was cooked in an electric rice cooker, rinsed with cold water, and then frozen for 2 h before drying (P4) had the lowest water rehydration ratio. The water rehydration ratios of the instant rice products that were frozen for 24 h and cooked either by boiling (P1) or by using an electric rice cooker (P2) were very similar. The water rehydration ratios of these samples were higher than those of the samples that were rinsed with cold water and frozen for 2 h (Figure 3).

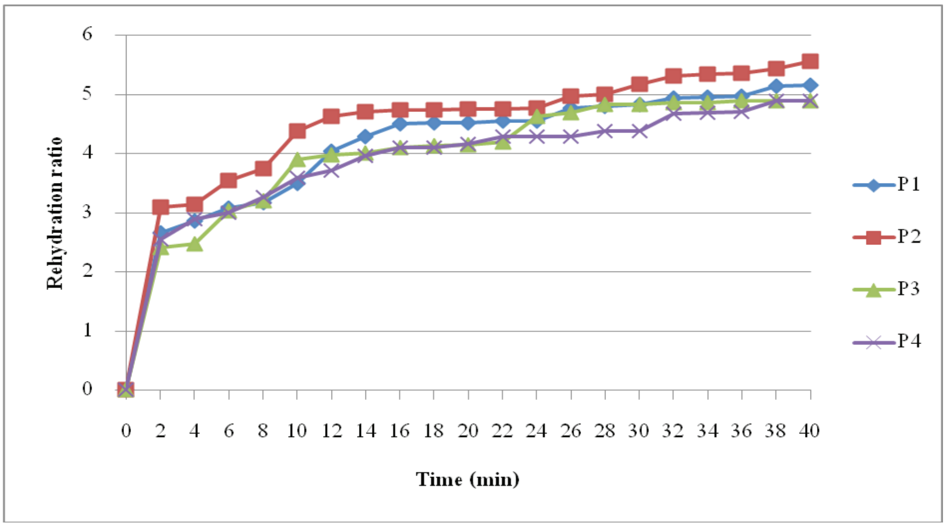

Figure 3 Rehydration ratio of instant rice

P1 = rice boiled + frozen for 24 h

P2 = rice cooked in an electric rice cooker + frozen for 24 h

P3 = rice boiled + rinsed + frozen for 2 h

P4 = rice cooked in an electric rice cooker + rinsed + frozen for 2 h

Rehydration Time

All the instant rice samples showed their rehydration pattern in the similar manner. The moisture contents of all samples reached 50–63% in one minute and increased throughout the duration of the testing period (Figure 4). The instant rice cooked by using an electric rice cooker and frozen for 24 hours before drying (P2) absorbed more water than other samples and its moisture content reached the same level of moisture as in the freshly cooked rice (65%) in 1.5 min. While the rehydration time to reach the same level of moisture content in freshly cooked rice for P1, P3 and P4 were 3, 3.5 and 3.5 min, respectively.

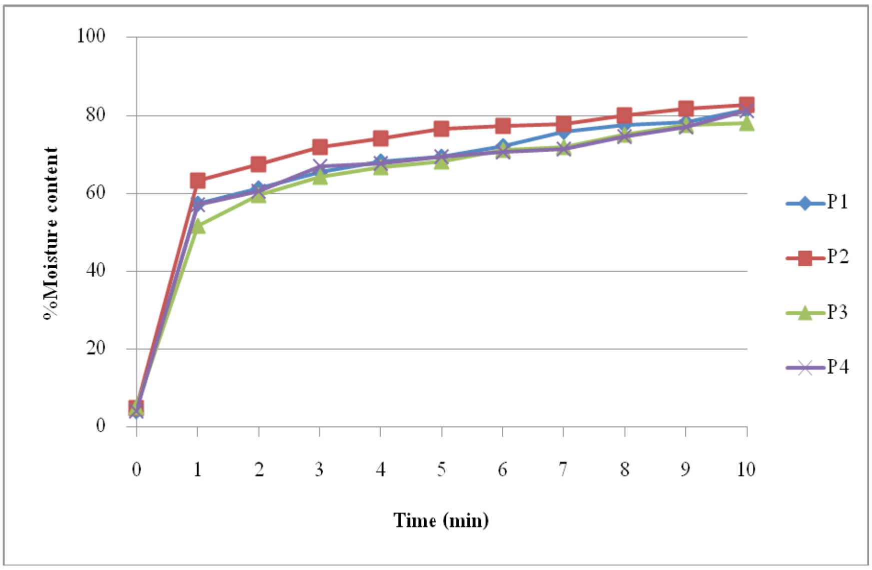

Figure 4 Rehydration times of instant rice

P1 = rice boiled + frozen for 24 h

P2 = rice cooked in an electric rice cooker + frozen for 24 h

P3 = rice boiled + rinsed + frozen for 2 h

P4 = rice cooked in an electric rice cooker + rinsed + frozen for 2 h

Quality Evaluation of Instant Rice Products

Colour

The colour of the instant rice cooked by boiling, frozen for 24 h prior to drying (P1), and rehydrated in boiling water for 3 min showed no statistically significant difference in L* (lightness) from freshly cooked rice. The other instant rice samples showed a statistically significant difference ($p < 0.05$) in L* (lightness) from the freshly cooked rice. As for the a* (redness) and b* (yellowness) values, P2, P3 and P4 showed significantly lower values ($p < 0.05$) than the freshly cooked rice (Table 1).

Table 1 Colour values of rehydrated instant rice compared to freshly cooked rice

Method	Colour value		
	L*	a*	b*
Freshly cooked rice	74.73 ± 0.11^{b}	-1.86 ± 0.07^{a}	5.03 ± 0.04^{b}
Boiled–frozen (24 h)–dried (P1)	75.01 ± 0.20^{b}	-2.03 ± 0.05^{c}	5.63 ± 0.05^{a}
Cooker–frozen (24 h)–dried (P2)	75.58 ± 0.15^{a}	-1.98 ± 0.02^{b}	4.12 ± 0.10^{c}
Boiled–rinsed–frozen (2 h)–dried (P3)	72.10 ± 0.29^{c}	-1.95 ± 0.03^{b}	4.42 ± 0.06^{d}
Cooker–rinsed–frozen (2 h)–dried (P4)	71.70 ± 0.19^{d}	-1.96 ± 0.02^{b}	4.80 ± 0.17^{c}

Note: values are means ± standard deviation from three replications

The different superscripts of values in the same column signify that the values differ to a statistically significant degree ($P < 0.05$).

Texture

The texture of instant rice products after rehydrated by boiling at 3, 4 and 5 min were evaluated in order to find the suitable rehydration time.

With regard to hardness, rice cooked by boiling showed significantly higher hardness values ($p < 0.05$) than rice cooked by the electric rice cooker (Table 2). A similar result was found by Rewthong et al. (2011). Tester and Morrison (1990) explained the difference in textural characteristics of cooked rice is probably related to the amount of leached starch during cooking. The longer cooking time resulted in a larger amount of leached starch (Chiang and Yeh, 2002). Therefore this could explain the higher hardness values for rice cooked by boiling than rice cooked by the electric rice cooker since rice cooked by the electric rice cooker took longer time; 22 min versus 9 min for rice cooked by boiling. Similar result was observed with the hydration time. Instant rice products rehydrated at 5 min gave lower hardness values than instant rice products rehydrated at 3 and 4 min (Table 2).

Rewthong et al. (2011) also suggested that rinsing rice with cold water prior to freezing helped to reduce leached starch during cooking. The samples that were rinsed in cold water prior to freezing (P3 and P4) were observed to have a significant higher hardness values ($p < 0.05$) than samples that were not rinsed before freezing (P1 and P2).

When compare to the freshly cooked rice only the instant rice product P1 showed no statistically significant difference in hardness from the freshly cooked rice either rehydration at 3, 4 or 5 min.

Table 2 Hardness of rehydrated instant rice products compared to freshly cooked rice

Method	Hardness over boiling time (N)		
	3 min	4 min	5 min
Freshly cooked rice	$346.03 \pm 7.64^{C,a}$	$346.03 \pm 7.64^{B,a}$	$346.03 \pm 7.64^{A,a}$
Boiled–frozen (24 h)–dried (P1)	$349.75 \pm 3.94^{C,a}$	$345.97 \pm 5.06^{B,a}$	$330.93 \pm 0.61^{AB,b}$
Cooker–frozen (24 h)–dried (P2)	$310.27 \pm 0.95^{D,a}$	$306.20 \pm 6.50^{C,a}$	$275.93 \pm 9.48^{C,b}$
Boiled–rinsed–frozen (2 h)–dried(P3)	$454.62 \pm 7.99^{A,a}$	$419.03 \pm 1.38^{A,b}$	$344.54 \pm 5.98^{A,c}$
Cooker–rinsed–frozen (2 h)–dried (P4)	$376.46 \pm 0.33^{B,a}$	$342.58 \pm 1.05^{B,b}$	$314.35 \pm 2.07^{B,c}$

Note: values are means ± standard deviation from five replications

Different upper case superscripts in the same column signify that the values differ to a statistically significant degree ($P < 0.05$).

Different lower case superscripts in the same row signify that they differ to a statistically significant degree ($P < 0.05$).

With regard to adhesiveness, the rice cooked by the electric rice cooker showed significantly higher values ($p < 0.05$) of adhesiveness than the rice cooked by the boiling method when rehydrated at 3 min (Table 3). This could be a result of the larger amount of leached starch when cooked longer time by the electric rice cooker (Chiang and Yeh, 2002). The adhesiveness tended to increase with rehydration time from 3 to 5 min, however, the significant difference was only found with the adhesiveness values of P1 and P2 when rehydrated at 3 minutes from 4 and 5 min and no significant difference were found with the adhesiveness values of P3 and P4. The pre-rinsed samples with cold water before freezing tended to have lower values of adhesiveness than the no-rinsed samples. However, the significant differences ($p < 0.05$) were only found between P1 and P3 when rehydrated at 3, 4 and 5 min and between P2 and P4 when rehydrated at 4 min. The instant rice product whose adhesiveness was the most similar to that of freshly cooked rice (–21.25 ± 6.65 N.s) was the product prepared by the boiling method, frozen for 24 h, and rehydrated by boiling for 3 min (Table 3).

Table 3 Adhesiveness of rehydrated instant rice compared to freshly cooked rice

Method	Adhesiveness over boiling time (N.s)		
	3 min	4 min	5 min
Freshly cooked rice	–21.25 ± 6.65^{B,a}	–21.25 ± 6.65^{B,a}	–21.25 ± 6.65^{AB,a}
Boiled–frozen (24 h)–dried (P1)	–23.09 ± 1.30^{B,a}	–53.80 ± 3.01^{E,b}	–59.30 ± 8.26^{D,b}
Cooker–frozen (24 h)–dried (P2)	–36.19 ± 1.27^{C,a}	–45.34 ± 1.67^{D,b}	–43.45 ± 2.90^{C,b}
Boiled–rinsed–frozen (2 h)–dried (P3)	–12.74 ± 2.68^{A,a}	–8.67 ± 0.90^{A,a}	–8.50 ± 1.37^{A,a}
Cooker–rinsed–frozen (2 h)–dried (P4)	–30.55 ± 4.80^{C,a}	–33.29 ± 4.77^{C,a}	–31.40 ± 5.45^{BC,a}

Note: values are means ± standard deviation from five replications.

The minus sign indicates the values obtained from the area below the graph.

Different upper case superscripts in the same column signify that the values differ to a statistically significant degree ($P < 0.05$).

Different lower case superscripts in the same row signify that the values differ to a statistically significant degree ($P < 0.05$).

The cohesiveness data obtained from the tests showed that the instant rice samples produced by boiling method tended to have greater cohesiveness than the samples produced by using the electric rice cooker (P1>P2 and P3>P4) (Table 4). No major difference in cohesiveness was noted between samples of instant rice that were rinsed with cold water before freezing and those that were not. All the instant rice samples except P3 had lower cohesiveness than the freshly cooked rice. The instant rice whose cohesiveness value was the most similar to that of freshly cooked rice (0.50±0.01) was the product that was prepared by the boiling method, frozen for 24 h (P1), and rehydrated by boiling for 3 or 4 min.

Table 4 Cohesiveness of rehydrated instant rice compared to freshly cooked rice

Method	Cohesiveness over boiling time		
	3 min	4 min	5 min
Freshly cooked rice	0.50 ± 0.01^{B,a}	0.50 ± 0.01^{A,a}	0.50 ± 0.01^{A,a}
Boiled–frozen (24 h)–dried (P1)	0.49 ± 0.01^{B,a}	0.48 ± 0.01^{A,ab}	0.47 ± 0.01^{B,b}
Cooker–frozen (24 h)–dried (P2)	0.48 ± 0.01^{B,a}	0.45 ± 0.01^{B,b}	0.45 ± 0.02^{C,b}
Boiled–rinsed–frozen (2 h)–dried (P3)	0.58 ± 0.02^{A,a}	<0.01 ± 0.00^{C,b}	<0.01 ± 0.00^{D,b}
Cooker–rinsed–frozen (2 h)–dried (P4)	0.01 ± 0.00^{C,a}	0.01 ± 0.00^{C,a}	0.01 ± 0.00^{D,a}

Note: values are means ± standard deviation from five repetitions.

Different upper case superscripts in the same column signify that the values differ to a statistically significant degree ($P < 0.05$).

Different lower case superscripts in the same row signify that they differ to a statistically significant degree ($P < 0.05$).

From the texture data above it can be concluded that the different methods of preparing instant rice have an effect on their texture when rehydrated. The texture is related to the amount of starch and the components of starch that are released from starch granules in the rice when it is heated (Rewthong et al., 2011). Ong and Blanshard (1995) reported that the amounts of amylose and short-chain amylopectin, major components of the leaching starch, affect the hardness and stickiness of cooked rice. The morphology of rice cooked by using an electric rice cooker showed more deformation of the porous structure at the external surface than the rice cooked by boiling, which indicates that more starch leached out during cooking (Rewthong et al., 2011). This could be due to the longer cooking time by the electric rice cooker (Chiang and Yeh, 2002) and could explain why P2 and P4 had lower hardness and cohesiveness but greater adhesiveness values than P1 and P3, respectively. When the cooked rice was rinsed with cold water before freezing, this may have reduced the amount of leaching starch (Rewthong et al., 2011), causing the instant rice samples that were rinsed before freezing and drying to have greater hardness compared to freshly cooked rice. The results of texture analysis showed that the instant rice sample prepared by boiling and freezing gave no significant difference in hardness, adhesiveness, and cohesiveness values from the freshly cooked rice similar to the result of Rewthong et al. (2011).

Sensory Evaluation

When the samples were tested by 10 panelists who have experience in preparing food for infants and young children at the university child care center, the products that were boiled and frozen for 24 h before drying (P1 and P2) were given significantly higher liking scores ($p < 0.05$) for stickiness, softness, and overall acceptability than those that were pre-rinsed with cold water and frozen for only 2 h before drying (P3 and P4) except the overall acceptability for P4. The boiled-frozen for 24 h (P1) sample received the highest scores ranging between 7-8 from 9-point score (like moderately- like very much) for use as rice for young children (Table 5). The panelists also gave their acceptance when the product was mashed for preparing complemenry food for the infant.

Table 5 Sensory evaluations of rehydrated instant rice

Method	Sensory evaluation scores		
	Stickiness	Softness	Overall acceptability
Boiled–frozen (24 h)–dried (P1)	7.72 ± 0.79^{a}	8.14 ± 0.69^{a}	7.86 ± 0.69^{a}
Cooker–frozen (24 h)–dried (P2)	7.71 ± 0.76^{a}	8.00 ± 0.82^{a}	7.14 ± 1.07^{a}
Boiled–rinsed–frozen (2 h)–dried (P3)	6.14 ± 1.10^{b}	6.43 ± 0.98^{b}	6.14 ± 0.69^{b}
Cooker–rinsed–frozen (2 h)–dried (P4)	6.57 ± 0.98^{b}	6.43 ± 0.98^{b}	7.29 ± 0.95^{a}

Note: values are means ± standard deviation from the scores given by 10 panelists.

Different superscripts in the same column signify that the values differ to a statistically significant degree ($P < 0.05$).

Conclusion

A comparison of methods for preparing instant rice products from Thai Jasmine rice for young children showed that the method of cooking and the method of pre-treatment before drying had an effect on the water rehydration ratio, volume expansion, rehydration time, and texture of the finished product when it was rehydrated. The instant rice prepared by boiling, pre-frozen for 24 h before drying, and then rehydrated by boiling for 3 min gave hardness, adhesiveness, and cohesiveness values that were not significantly different from those of freshly cooked rice. The sensory panelists also gave the highest scores for stickiness, softness, and overall acceptability. It is therefore recommended that boiling and 24 h freezing prior to drying is suitable to be used as a method for producing instant rice for young children.

Acknowledgements

The authors would like to thank the National Research Council of Thailand for research funding.

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