# Strategies for Reducing Sodium in Instant Rice Porridge and its Influence on Sensory Acceptability

**Sujinda Sriwattana[1,2*], Israpong Pongsirikul[1,2], Thanyaporn Siriwoharn[1] and Napapan Chokumnoyporn[1]**

*[1]Faculty of Agro-Industry, Chiang Mai University, Chiang Mai 50100, Thailand*
*[2]Sensory Evaluation and Consumer Testing Unit, Chiang Mai University, Chiang Mai 50100, Thailand*

*[*]Corresponding author. E-mail: sujinda.s@cmu.ac.th, sujindapdt@gmail.com*

## ABSTRACT

***Health concerns associated with high sodium consumption have led to increased requirements for appropriate salt reduction techniques to create reduced-salt processed foods. The objective of this research was to develop a reduced-sodium instant rice porridge using multiple salt reduction strategies. The effects of partially substituting NaCl with 35% of soy sauce odor, potassium chloride (KCl), glycine, or KCl in combination with glycine (1:1) on consumer acceptance (9-point hedonic scale, n= 110) and some physicochemical properties (consistency, water activity, color, and proximate analysis) of this product were investigated using a completely randomized design. From the results, the most suitable formulation of a reduced-sodium instant rice porridge replaced 35% of the sodium with KCl in combination with glycine (1:1). This reduced-sodium product did not differ significantly (p>0.05) from the prototype formulation with scores for overall liking, color, overall flavor, saltiness, and viscosity at like slightly (6.2, 6.7, 6.1, 5.4, and 6.0, respectively). The developed product had 16.80 cm/min consistency and 0.384 water activity. The color values of L*, a*, and b* were 80.74, -0.64, and 12.24, respectively. The proximate analysis of the developed product was 4.0% ash, 77.3% carbohydrate, 1.3% fat, 7.4% moisture content, 10.0% protein, and 360 kcal energy/ 100 g sample. The sodium content was 1,148 mg/100 g sample, a reduction of 39.3% from the prototype formulation.***

**Keywords:** Instant rice porridge, Salt, Sodium reduction, Salt reduction strategies, Consumer acceptance

## INTRODUCTION

Instant rice porridge is designed for fast and simple preparation, providing an easy meal option. In Thailand, this porridge is usually made from Jasmine rice (Kao Dok Mali 105 (*Oryza sativa* L.)) with other added ingredients, such as dried meats, dried vegetables, and seasoning, that provide nutritional benefits. Given the benefits of rice porridge, it has become increasingly popular, especially with children and the elderly. However, instant rice porridge is high in sodium. The Food Safety Research and Risk Assessment Center, National Food Institute Thailand (2014) reported many instant rice porridge brands (packaged in a bag or cup) contain sodium in the range of 445-752 mg per serving size. The Bureau of Nutrition, The Ministry of Public Health Thailand (n.d.) reported sodium content in commercial instant rice porridge as high as 900-1,340 mg per serving size.

Sodium is an essential element and a component of salt. However, over-consumption has been correlated with the incidence of high blood pressure (hypertension), heart disease, stroke, and kidney disease (He and MacGregor, 2002; Dickinson and Havas, 2007). Approximately 11 million Thais have high blood pressure (Thepkham, 2014). Thais currently consume an average of 10.8 g salt/day (4,320 mg sodium/day), well in excess of the recommended maximum daily intake of 5-6 g salt, or 2,000-2,400 mg sodium/day (Bureau of Nutrition, Department of Health, 2011; World Hypertension League, 2012).

Due to the harmful effects and increasing consumption of sodium, health authorities are increasingly interested in reducing salt intake. Several methods are required to reduce sodium, given sodium sources can vary by types of product. One of the most common methods is to replace sodium with salt substitutes (Wilailux and Sriwattana, 2010; Thong-lor and Sriwattana, 2012). Other techniques include flavor enhancers (Bolhuis et al., 2011), odor induced saltiness enhancement (Chokumnoyporn et al., 2015), and combined approaches, for example, using a salt substitute with a flavor enhancer (Campagnol et al., 2012).

This research was undertaken to develop a reduced-sodium instant rice porridge by replacing sodium chloride with soy sauce odor, KCl, glycine, or a combination of KCl:glycine (1:1) and observing their effect on the physicochemical properties and consumer acceptability of the developed products.

## MATERIAL AND METHODS

### Materials

The main ingredient of the porridge was instant rice flakes from broken Thai jasmine rice (purchased from ChantongFoodco.th). Other ingredients included dried spring onion and dried ginger (Premium Foods Co., Ltd.), dried garlic powder (Bangkok Chili Limited Partnership), sodium chloride (Thai Refined Salt Co., Ltd.), monosodium glutamate (Ajinomoto Co., (Thailand) Ltd.), sugar (Mitr Phol Sugar Corp., Ltd), dried white pepper powder (United Progress (Thailand) Co., Ltd.), disodium 5'-ribotide (Foodsfield International Co., Ltd.), soy sauce odor powder (A2B Food), potassium chloride (Srichand United Dispensary Co., Ltd.), and glycine (Chemipan Corporation Co., Ltd.). Dried pork powder

was prepared according to Thong-lor (2012). To prepare the fried garlic, fresh garlic was purchased from a local market and the edible portion was homogenized with a blender. The blended garlic was fried in hot oil (180°C) until golden brown, being careful not to burn, then removed quickly to avoid over-browning or burning, and kept in an aluminum foil bag.

**Development of an instant rice porridge prototype**

The instant rice porridge prototype was formulated in accordance with previous studies (Yaieiam et al., 2003; Mahannoppakun, 2010; Thong-lor, 2012) and commercial instant rice porridges. The instant rice porridge prototype was produced with the ingredients as shown in Table 1. All ingredients were weighed and mixed thoroughly in a conventional mixer for 5 min, before storing in an aluminum foil bag. This experiment used a Completely Randomized Design (CRD) with three replications. The instant rice porridge prototype was compared with two commercial rice porridge samples: Commercial A and B. The ingredients and sodium content of commercial instant rice porridges A and B were as follows:

• Commercial A: Sodium content 910 mg/35 g (1 serving size)

Ingredients: jasmine rice, salt, sugar, soy protein, spice, dried pork, dried spring onion, garlic powder, dried vegetable monosodium glutamate, ribo nucleotide

• Commercial B: Sodium content not shown on packaging

Ingredients: dried rice, dried pork, rice flour, salt, sugar, fried noodle, soy sauce powder, monosodium glutamate, disodium 5'- inosinate, disodium 5'-guanylate

A consumer acceptance test and just-about-right scale were used as diagnostic instruments to formulate the instant rice porridge and compare it with the commercial products. All samples were prepared with hot water at a ratio of 1:1 and kept at a controlled temperature of 60°C. Thirty grams of each sample were presented in 90 ml white plastic cups coded with 3-digit numbers. For the consumer acceptance test, 110 consumers evaluated overall liking, color, overall flavor, saltiness, and viscosity using a 9-point hedonic scale, where 1 = dislike very much, 5 = neither like nor dislike, and 9 = like extremely (Peryam and Pilgrim, 1957). The same consumers evaluated only color and saltiness attributes with a 5-point "Just-About-Right" scale, where 1 = decrease it very much, 3 = leave it as it is (or just about right, JAR), and 5 = increase it very much (Somthawil and Sriwattana, 2012). Just About Right (JAR) tests identify whether the level of the intensity of an attribute is above, at, or below an optimum amount (Lawless and Hayman, 2010).

**Table 1.** Ingredients of instant rice porridge samples.

| Ingredients | Amount (%) | | | | |
|---|---|---|---|---|---|
| | Prototype | Soy sauce odor | KCl | Glycine | KCl:glycine (1:1) |
| Instant rice | 86.43 | 86.43 | 86.43 | 86.43 | 86.43 |
| Dried pork | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 |
| Dried spring onion | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 |
| Dried ginger | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 |
| Fried garlic | 0.74 | 0.74 | 0.74 | 0.74 | 0.74 |
| Seasoning ingredients | | | | | |
| - NaCl | 4.90 | 3.19 | 3.19 | 3.19 | 3.19 |
| - monosodium glutamate | 2.04 | 2.04 | 2.04 | 2.04 | 2.04 |
| - sugar | 2.86 | 1.26 | 1.26 | 1.26 | 1.26 |
| - dried pork powder | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 |
| - dried garlic powder | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 |
| - dried white pepper powder | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| - disodium 5'-ribotide | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| - salt substitute | 100 | 3.31 | 3.31 | 3.31 | 3.31 |
| **Total** | | 100 | 100 | 100 | 100 |

Note: One serving size of instant rice porridge was 35 g. The instant rice porridge ingredients were mixed together according to Mahannoppakun (2010) and Yaieiam et al. (2003). The seasoning ingredients were prepared according to Thong-lor (2012).

The prototype product was evaluated for their physical and chemical properties: color (L*, a*, and b*) using a color meter (CR-410, Konica-Minolta, Japan), water activity ($a_w$) using AQUA LAB (Model series 3, Decagon Device Inc., Pullman, USA.), consistency using a Bostwick consistometer (CSC Scientific Company, Inc., USA), proximate analysis (AOAC, 2012), and sodium content (AOAC, 2005).

**Study of the effect of salt reduction strategies on reduced-sodium instant porridge**

This experiment studied the influence of salt reduction strategies, including odor-induced saltiness enhancement (OISE) using soy sauce odor, salt substitution using KCl, flavor enhancement using glycine, and a combination strategy of salt substitute and flavor enhancer using KCl:glycine in a ratio of 1:1, on qualities of instant rice porridge. Each salt reduction sample was formulated to decrease sodium by 35%. Five samples were used following a Completely Randomized Design (CRD) with three replications. The formulation of all samples is shown in Table 1. Similar to the previous experiment, all ingredients in each formulation were weighed and mixed. The samples were then prepared for the consumer acceptance test using a 9-point hedonic scale with 100 consumers and physicochemical property analysis (color, aw, consistency, proximate composition, and sodium content).

**Statistical analysis**

All statistical analyses were performed using the Statistical Package for Minitab version 16 (Minitab Inc., USA) program. All data in this study were analyzed using ANOVAs. All effects with a P-value of 0.05 or lower are reported as significant. Post hoc multiple comparisons were performed using the Tukey test.

## RESULTS

**Quality of the instant rice porridge prototype**

The sensory evaluation of each attribute of the instant rice porridge samples (not sodium reduction) are illustrated in Table 2. The mean consumer acceptance scores differed significantly ($p<0.05$) for all attributes among the three instant rice porridges. However, the consumer acceptance scores for overall liking, color, overall flavor, saltiness, and viscosity did not differ significantly ($p\geq0.05$) between the prototype and Commercial A samples. The prototype had sensory scores in the range "like slightly" (6.4-6.7 scores). The Commercial B sample had the lowest scores in all attributes.

**Table 2.** Consumer acceptance scores of instant rice porridges.

| Instant rice porridges | Overall liking | Color | Overall flavor | Saltiness | Viscosity |
|---|---|---|---|---|---|
| Prototype | 6.7±1.1a | 6.7±1.3ab | 6.7±1.2a | 6.7±1.0a | 6.4±1.3ab |
| Commercial A | 6.8±1.3a | 6.9±1.2a | 6.7±1.3a | 6.6±1.5a | 6.5±1.5a |
| Commercial B | 5.9±1.4b | 6.5±1.2b | 5.8±1.5b | 5.7±1.5b | 5.8±1.5b |

Note: Mean ± standard deviation in same column with different letters are significant different ($p<0.05$). Data collected from 100 consumers using a 9-point hedonic scale.

The consumer percentages and net effect of instant rice porridges reporting scores on the 1-5 just-about-right scale for color and saltiness attributes are shown in Table 3. Most of the respondents, over the established agreed-on acceptability of 70%, regarded the intensity of the color as "leave it as it is (JAR)" for all samples. However, the percentages at "leave it as it is (JAR)" of all instant rice porridges for saltiness did not reach the established agreed-on acceptability of 70%. Both commercial instant rice porridges had net effect scores of more than 20%. Commercial A should decrease saltiness while commercial B should increase saltiness. The prototype had a net effect of less than 20%, indicating its saltiness was suitable.

**Table 3.** Degree-of-change scale (just-about-right scale) of instant rice porridges.

| Parameters | Decrease it very much | Decrease it slightly | Leave it as it is (JAR) | Increase it slightly | Increase it very much | Net effect |
|---|---|---|---|---|---|---|
| **Prototype** | | | | 28.00 | 0 | - |
| Color | 0 | 2.00 | 70.00 | 27.00 | 0 | 11.00 |
| Saltiness | 6.00 | 10.00 | 57.00 | 5.00 | 0 | - |
| **Commercial A** | | | | 8.00 | 0 | 33.00 |
| Color | 0 | 10.00 | 85.00 | 20.00 | 1.00 | - |
| Saltiness | 4.00 | 37.00 | 51.00 | 32.00 | 19.00 | 43.00 |
| **Commercial B** | | | | | | |
| Color | 0 | 4.00 | 75.00 | | | |
| Saltiness | 0 | 8.00 | 41.00 | | | |

Note: Data collected on a JAR (Just About Right) 5-point scale using 100 consumers.

From the physiochemical analysis of the prototype product, the color values of L*, a*, and b* were 78.34, -0.67, and 11.14, respectively. Consistency was 22.9 cm/30 s and water activity 0.373. The proximate composition of this prototype was 5.4% ash, 77.1% carbohydrate, 1.2% fat, 7.4% moisture, 8.9% protein, and 355 kcal energy/100 g sample. The sodium content was 1,891 mg/100 g sample, or 662 mg/35 g (1 serving size).

Due to the prototype's high consumer acceptability scores and appropriate saltiness, we can use it in the next experiment to study the effect of salt reduction strategies in reduced-sodium instant rice porridge.

**Effect of salt reduction strategies on the sensory and physiochemical qualities of reduced-sodium instant rice porridge**

The results obtained from the consumer acceptability test of overall liking, color, overall flavor, saltiness, and viscosity by 110 consumers are shown in Table 4. All samples with reduced sodium (containing different ingredients) and the prototype (100% salt) differed significantly ($p<0.05$) in overall liking, overall flavor, saltiness, and viscosity. The mean scores of overall liking, overall flavor, saltiness, and viscosity for the reduced-sodium sample using KCl:glycine (1:1) did not differ significantly ($p\geq0.05$) compared with the prototype. The following lowest scores were for the glycine, KCl, and soy sauce odor formulations, which were significantly different from the prototype ($p<0.05$).

**Table 4.** Consumer acceptance scores of instant rice porridges using different salt reduction strategies.

| Instant rice porridges | Overall liking | Color | Overall flavor | Saltiness | Viscosity |
|---|---|---|---|---|---|
| Prototype | 6.6±1.5a | 6.8±1.5 | 6.6±1.7a | 6.1±1.8a | 6.3± 1.7a |
| Soy sauce odor | 4.4±2.0c | 6.4±1.7 | 4.2±2.0c | 4.2±1.9c | 5.4± 2.2b |
| KCl | 5.6±2.0b | 6.7±1.4 | 5.3±2.1b | 5.2±1.8b | 5.8± 1.8ab |
| Glycine | 6.0±1.5ab | 6.8±1.3 | 5.7±1.6ab | 5.1±1.8b | 6.0± 1.7ab |
| KCl:glycine (1:1) | 6.5±1.4a | 6.8±1.5 | 6.3±1.5ab | 5.9±1.7a | 6.3± 1.7a |

Note: Mean ± standard deviation in same column with different letters are significantly different ($p<0.05$). Data collected from 110 consumers using a 9-point hedonic scale.

To investigate the physiochemical properties of all reduced-sodium porridge (some data not shown), the color values of L*, a*, and b* of all reduced-sodium products did not differ significantly ($p\geq0.05$) compared with the prototype (L* value 78.34-81.32, a* value -0.64 - -0.52, and b* value 10.74-12.24). The consistency (15.9-22.9 cm/30 s) and $a_w$ (0.362-0.373) of most reduced-sodium products differed from the prototype. The proximate composition of all reduced-sodium products were 3.3-5.3% ash, 75.5-77.4% carbohydrate, 1.2-1.9% fat, 7.3-7.8% moisture, 8.4-12.6% protein, and 359-363 kcal energy/100 g sample. The sodium content of reduced-sodium instant rice porridge with soy sauce odor, KCl, glycine, and KCl:glycine (1:1) formula was 491, 323, 277, and 402 mg/35 g (1 serving size), respectively.

## DISCUSSION

This study showed that it was possible to reduce the sodium content in rice porridge samples according to the Notification of the Ministry of Public Health, (No. 182) Nutrition Labeling (The Ministry of Public Health, 1998) and still maintain acceptable sensory perception by using salt reduction methods. However, different salt reduction strategies affected consumer acceptability of the rice porridge samples differently. Consumer acceptability scores of the rice porridge sample containing a combination of KCl and glycine (1:1) substitution was higher than those of other methods and similar to that of the prototype. The use of this combination as a salt replacer has been found successful in other applications, such as soup (Thong-lor, 2012) and sausage (Wilailux and Sriwattana, 2010). The reason that KCl alone was not as efficient may be due to the bitter and metallic taste of the substance itself, which imparted to the taste of the final product (Thong-lor and Sriwattana, 2012; Wilailux and Sriwattana, 2010; Thong-lor and Sriwattana, 2012). However, when used in combination with flavor enhancers, such as glycine, overall taste perception of KCl could be improved. Although glycine does not have a salty taste, it can mask a bitter taste and at the same time enhance the perception of saltiness by activating receptors in the mouth and throat, which helps improve the qualities of reduced- or low-salt products (Desmond, 2006).

Among the tested methods, samples substituted with soy sauce odor (tasteless odorant) received the lowest consumer acceptability scores. This may be due to several limitations of the method. Odor induced saltiness enhancement (OISE) generally compensates for salt reduction through multisensory-integration mechanisms (Salles, 2006). It has low efficiency in high salt/sodium food and requires all odors to be congruent and suitable for each salty food product. Therefore, the OISE results can be easily influenced by many factors, such as cultural difference, knowledge, and experience of consumers (Djordjevic et al., 2004; Lawrence et al., 2009).

## CONCLUSION

The partial replacement (35%) of NaCl by soy sauce odor, KCl, and glycine in instant rice porridge creates a healthier product containing significantly less sodium (277-491 mg sodium / 1 serving size of all reduced-sodium instant rice porridge samples versus 662 mg sodium / 1 serving size of normal sodium instant rice porridge). The product with KCl:glycine at 1:1 had the best sensory acceptance. In contrast, the reduced-sodium samples using only soy sauce odor, KCl, or glycine had consumer acceptance scores lower than the normal sodium product, because of the limitations of each salt reduction technique. This study has shown the potential for using a combination of salt reduction strategies in instant rice porridge. However, a further study of the suitable level for each ingredient is recommended.

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## REFERENCES

AOAC. 2005. Official Method of Analysis of AOAC International, method 984.27, (pp. 17-18). AOAC International, USA.

AOAC. 2012. Official Method of Analysis of AOAC International. AOAC International, USA.

Bolhuis, D.P., E.H. Temme, F.T. Koeman, M.W. Noort, S. Kremer, and A.M. Janssen. 2011. A salt reduction of 50% in bread does not decrease bread consumption or increase sodium intake by the choice of sandwich fillings. Journal of Nutrition. 141: 2249-2255. doi: 10.3945/jn.111.141366

Bureau of Nutrition, Department of Health. 2011. Manual of reduced sweet, fat, salt, overweight/obesity and diseases for Thai people (pp. 21). The War Veterans Organization of Thailand Publisher, Bangkok. (in Thai).

Campagnol, P.C.B., B.A. Santos, N.N. Terra, and M.A.R. Pollonio. 2012. Lysine, disodium guanylate and disodium inosinate as flavor enhancers in low-sodium fermented sausages. Meat Science. 91: 334-338. doi :10.1016/j.meatsci.2012.02.012

Chokumnoyporn, N., S. Sriwattana, Y. Phimolsiripol, D.D. Torrico, and W. Prinyawiwatkul. 2015. Soy sauce odour induces and enhances saltiness perception. International Journal of Food Science and Technology. 50: 1-7. doi: 10.1111/ijfs.12885

Desmond, E. 2006. Reducing salt: a challenge for the meat industry. Meat Science. 74: 188-196. doi:10.1016/j.meatsci.2006.04.014

Dickinson, B. D., and S. Havas. 2007. Reducing the population burden of cardiovascular disease by reducing sodium intake: a report of the Council on Science and Public Health. Archives of Internal Medicine. 167: 1460-1468. doi: 10.1001/archinte.167.14.1460

Djordjevic, J., R.J. Zatorre, and M. Jones-Gotman. 2004. Odor-induced changes in taste perception. Experimental Brain Research. 159: 405-408. doi: 10.1007/s00221-004-2103-y

He, F.J., and G.A. MacGregor. 2002. Effect of modest salt reduction on blood pressure: a meta-analysis of randomized trials. Journal of Human Hypertension. 16: 761-770. doi: 10.1038/sj.jhh.1001459

Lawless, H.T., and H. Heymann. 2010. Sensory Evaluation of Food-principles and practices. Sprinker, New York. doi: 10.1007/978-1-4419-6488-5

Lawrence, G., C. Salles, C. Septier, J. Busch, and T. Thomas-Danguin. 2009. Odor-taste interactions: a way to enhance saltiness in low-salt content solutions. Food Quality and Preference. 20: 241-248. doi: 10.1016/j.foodqual.2008.10.004

Mahannoppakun, W. 2010. Rice Processing Technology: production of rice in can packaging. URL (lib3.dss.go.th/fulltext/dss_manual /M038.pdf) (30 September 2015).

National Food Institute Thailand. 2014. Sodium content in rice porridges. URL (http://www.thairath.co.th /content/401674) (25 November 2015).

Peryam, D.R., and P.J. Pilgrim. 1957. Hedonic scale method of measuring food preference. Food Technology. 11: 9-14.

Salles, C. 2006. Odour-taste interactions in flavor perception. In A. Voilley, P. Etiévant (Eds.). Flavour in Food (pp. 345-368). Woodhead Publishing Ltd., Cambridge. doi: 10.1533/9781845691400.3.345

Somthawil, S., and S. Sriwattana. 2012. The Use of Just About Right Scales inReformulation of Thai Northern Style Sausage. In Proceedings of 50th Kasetsart University Annual Conference: Agro-Industry, Bangkok, Thailand (in Thai).

The Ministry of Public Health Thailand. 1998. Notification of the Ministry of Public Health, (No.182) Nutrition Labelling. URL (http://iodinethailand.fda.moph.go.th/food_54/law/data/announ_moph/V.English/No.182-41%20Nutrition%20Labelling.pdf) (25 November 2015).

The Ministry of Public Health Thailand. n.d. Reduing sugar, fat and salt. URL (http://health.spr.go.th/images/MED/MED81.pdf) (25 November 2015).

Thepkham, P. 2014. 11 million Thai peoples have high blood pressure. URL (http://www.thaihealth.or.th/microsite/content/5/ncds/181/24127-html) (25 November 2015) (in Thai).

Thong-lor, C. 2012. Development of monosodium glutamate free and reduced sodium pork seasoning powder. Chiang Mai University, Chiang Mai (in Thai).

Thong-lor, C., and S. Sriwattana. 2012. Development of pork seasoning powder using potassium chloride and potassium lactate partially substituted sodium chloride. In Proceedings of 50th Kasetsart University Annual Conference: Agro-Industry, Bangkok, Thailand (in Thai).

Wilailux, C., and S. Sriwattana. 2010. Effects of sodium chloride replacement with potassium chloride on qualities of frankfurter In Proceedings of 48th Kasetsart University Annual Conference: Agro-Industry, Bangkok, Thailand (in Thai).

World Hypertension League. 2012. Healthy lifestyle healthy blood pressure. URL (http://www.worldhypertensionleague.org/Documents/WHD/2012/WHD%202012%20brochure.pdf,) (27 July 2012).

Yaieiam, S., C. Teangpook, W. Wirivutthikorn, and J. Siripanporn. 2003. Development of instant brown fragrance rice porridge. Food Journal. 34: 240-246.