ผลของอุณหภูมิในการแช่ต่อคุณค่าทางโภชนาการและการยอมรับของผู้บริโภคของข้าวนึ่งกล้อง
Effect of Soaking Temperature on Nutritional Quality and Consumer Acceptance of Parboiled Rice

กรกฤต สารีพวง[1] นเรศ มีโส[2] ละมุล วิเศษ[2] ศิริธร ศิริอมรพรรณ[1,2]
Korakrit Sareepuang[1], Naret Meeso[2], Lamul Wiset[2] and Sirithon Siriamornpun[1,2]

Abstract

The effect of soaking temperature on nutrition quality and sensory properties were studied. The 12-month storage paddy samples were soaked at 40 (PR40), 50 (PR50) and 60°C (PR60) for 3 hr, then autoclaved with steam at 121°C for 15 min and dried by cabinet tray dryer at 60°C to reach the moisture content of 23 g/100 g dry matter. Head milling rice yield was significantly increased from 59% in brown rice to 60-80% in parboiled rice. The results also showed that parboiling process resulted in protein, lipid and ash contents. The fatty acid composition of brown and parboiled rice were determined. A slightly significant change ($p<0.05$) of oleic acid (C 18:1), linoleic acid (C 18:2) and α-linolenic acid (C 18:3) was observed. Overall, soaking at 50°C (PR50) for 3 hr prior to steaming and drying was found to provide the most desirable quality of parboiled rice in our study in terms of nutritional quality and sensory properties.

Key words: Soaking temperature, Parboiled rice, Nutrition quality, Consumer acceptance

บทคัดย่อ

งานวิจัยนี้ ศึกษาผลของอุณหภูมิในการแช่ต่อคุณค่าทางโภชนาการและคุณสมบัติทางประสาทสัมผัสของข้าวนึ่ง ข้าวหอมมะลิ 105 ที่เก็บรักษาเป็นเวลา 12 จะถูกนำมาแช่ที่อุณหภูมิ 40, 50 และ 60 องศาเซลเซียส เป็นเวลา 3 ชั่วโมง จากนั้นนำไปนึ่งด้วยหม้อนึ่งความดันเป็นเวลา 15 นาที แล้วนำมาตากแห้งโดยใช้เครื่องอบลมร้อนแบบถาด จนให้มีความชื้นสุดท้ายที่ 23 กรัม ต่อ 100 กรัม ตัวอย่างแห้ง ผลการทดลองพบว่าเปอร์เซ็นต์ต้นข้าวของข้าวนึ่งเพิ่มขึ้นจาก 5ฃ1 เปอร์เซ็นต์ เป็น 60-80 เปอร์เซ็นต์ ในข้าวนึ่ง ด้านคุณค่าทางโภชนาการพบว่าอุณหภูมิการแช่ข้าวมีผลต่อปริมาณโปรตีน ไขมัน และเถ้า องค์ประกอบของกรดไขมันมีการเปลี่ยนแปลงเล็กน้อย ได้แก่ กรดโอเลอิก กรดลิโนเลอิก และกรดแอลฟาลิโนเลนิค จากผลการทดลองในงานวิจัยนี้ จะพบว่าการแช่ข้าวเปลือกที่อุณหภูมิ 50 องศาเซลเซียสเป็นเวลา 3 ชั่วโมงก่อนการนึ่ง จะทำให้ข้าวนึ่งมีคุณค่าทางโภชนาการและการยอมรับผู้บริโภคมากที่สุด

คำสำคัญ: อุณหภูมิการแช่, ข้าวนึ่ง, คุณค่าทางโภชนาการ, การยอมรับผู้บริโภค

Introduction

Rice is one of the most important crops in Thailand and worldwide. It is the staple food of more than three billion people, mainly in Asia (Deepa, Singh and Akhilender, 2007). The total rice paddy production area is about 154 million hectare and the annual production of rice is about 594 million tons. Rice accounts for over 22% of global energy intake. While the production and consumption of rice are concentrated in Asia, which accounts for about 92% of the world's total production, rice is also an important crop in specific regions of North and South America, Africa and Europe (Ohtsubo *et* al, 2004; Kainuma , 2004).

Parboiling is the process consisting of main three steps, namely soaking, steaming and drying of the rough rice. The advantages of parboiling rice include higher milling yields, higher nutritional value and resistance to spoilage by insects and microorganism (Elbert, Tolaba and Suárez, 2000). The parboiling process is applied to rice with a preliminary objective of hardening the kernel in order to maximize head rice yield in milling. Besides

[1] ภาควิชาเทคโนโลยีการอาหารและโภชนศาสตร์ คณะเทคโนโลยี มหาวิทยาลัยมหาสารคาม เขตพื้นที่ในเมือง มหาสารคาม 44000
[1] Department of Food Technology and Nutrition, Faculty of Technology, Mahasarakham University, Downtown campus, Mahasarakham 44000
[2] หน่วยวิจัยเทคโนโลยีการอบแห้งผลผลิตทางการเกษตร คณะวิศวกรรมศาสตร์ มหาวิทยาลัยมหาสารคาม เขตพื้นที่ขามเรียง จ.มหาสารคาม 44150
[2] Research Unit of Drying Technology for Agricultural Products, Faculty of Engineering, Mahasarakham Universty, Khamriang campus, Mahasarakham, 44150

milling yield, parboiled brown rice also gains more nutritional and health benefits compared to raw brown rice. This has lead to the awareness and importance of parboiling among consumers and vendor (Larsen, 2000).

Therefore this study aimed to investigate the effect of soaking temperature on nutritional quality and consumer acceptance of parboiled rice. We were especially interested in parboiling of fragrant rice which was quite fragile and kept for a long period of time.

Materials and Methods

Khao Dawk Mali 105 (KDML 105) was used for the experiments. Paddy samples were harvested at from the largest rice production region; "Tung Kula Rong Hai",

Samples of 100 g of rough rice were placed in an Erlenmeyer flask 500 ml. The samples were soaked in a water bath shaker with controlled temperature at 40 (PR40), 50(PR50) and 60°C (PR60) (±0.5°C) (Modified from Saif *et al*, 2004). After soaking, the rice was taken out of the water bath, rid and excess water and the container with sample were put in an autoclave for steam (121 °C, 15 min). After steaming, the paddy was removed to cabinet tray dryer at 60°C to 23 g/100 g dry matter.

Approximately one week after drying, the samples of parboiled rice were shelled and milled using a laboratory miller, which separates automatically whole and broken grains. The head rice yield (HRY%) was calculated as percentage of whole milled grains respect to the brown rice, the average value of duplicated was calculated (Indian Standard, 1971). Proteins and ash content was measured by the AOAC (2002) official method. Lipid content was determined gravimetrically. Fatty acid composition was analyzed using GLC by standard methods (Siriamornpun *et al*, 2005).

The parboiled brown rice were cooked and served to a discriminatory and communicative panel of 50 people to compare with cooked brown rice (Kar, Jain and Srivastav, 1998) by hedonic 9 scale test. The scores were statistically analyzed.

Results and Discussion

Cereals are the major source of carbohydrates, proteins, fats and bioactive compounds to the vegetarian population worldwide. The proximate compositions of brown and parboiled brown rice are presented in Table 1. The results also showed that parboiling process resulted in protein, lipid and ash content.

Table 1 Proximate composition of brown rice and parboiled brown rice (% dry basis)

Parameters	Brown rice	Soaking temperature of brown parboiled rice		
		PR40	PR50	PR60
Total protein (%)	7.74±0.34^{b}	7.84±0.32^{b}	8.19±0.12^{a}	7.86±0.18^{b}
Lipids content (%)	1.99±0.08^{c}	2.39±0.09^{a}	2.19±0.05^{b}	2.08±0.01^{c}
Ash (%)	1.21±0.3^{b}	1.25±0.02^{b}	1.34±0.02^{a}	1.30±0.03^{a}
Head rice yield (HY%)	50.92±0.03^{d}	59.22±0.19^{c}	82.98±0.59^{b}	84.46±0.12^{a}

Values within a row followed by the same letter are not significantly different ($p<0.05$) (Duncan's)

Ohtsubo et al. (2005) reported that proximate analysis in brow rice and germinated brown rice, the germinated brown rice showed higher amount of proteins at 8.2% than those from polished rice (6.6%) and brown rice (7.8%). Similar result was found in lipids content, significant were increased during germination processes.

Parboiling process provided higher head rice yield as compared to unparboiled rice. Head milling rice yield was significantly increased from 51% in brown rice to 59, 83 and 84 % in PR 40, PR 50 and PR60, respectively (Table 1). Saif *et al.* reported that the increase in length, width and thickness due to parboiling process, leading to some advantages over the unparboiled one such as the strengthening of kernel integrity, increase of milling recovery and decrease of cooking losses.

The fatty acid composition of brown and parboiled rice was determined and is presented in Table 2. A minor change of oleic acid (C 18:1), linoleic acid (C 18:2) and α-linolenic acid (C 18:3) was observed.

Table 2 Fatty acid composition (%) of brown rice and brown parboiled rice

Parameters	Brown rice	Soaking temperature of brown parboiled rice		
		PR40	PR50	PR60
Palmitic acid (16:0)	17.88±0.25[a]	16.42±1.05[ab]	15.84 ±0.55[b]	15.17±0.85[b]
Stearic acid (18:0)	3.77 ±0.04[c]	1.29±0.01[d]	9.03 ±0.02[a]	4.13±0.07[b]
Oleic acid (18:1)	34.15 ±0.61[c]	36.39±1.26[b]	39.82 ± 0.69[a]	35.71±1.25[bc]
Linoleic acid (18:2)	30.94 ±0.62[a]	31.91±0.95[a]	25.50 ±0.14[c]	28.83±1.85[b]
α-Linolenic acid (18:3)	4.74 ±0.02[b]	4.32±0.32[c]	5.93 ±0.03[a]	3.46±0.25[d]

Values within a row followed by the same letter are not significantly different ($p<0.05$) (Duncan's)

In parboiled rice grains, hydrolytic enzymes are activated and they decompose starch, non starch polysaccharides and proteins, which leads to the increase of oligosaccharides, and amino acids in rice (Manna, Naing, and Pe, 1995),barley (Rimsten *et al*, 2003), wheat (Yang, Basu and Ooraikul, 2001), and oat (Mikola, Brinck, and Jones, 2001). The decomposition of the high molecular weight polymers during germination leads to the generation of bio-functional substances and the improvement of the organoleptic qualities due to softening of texture and increase of flavor in barley (Beal and Mottram, 1993), finger millet (Subba Rao and Muralikrishna, 2002), oat (Heinio) and rye (Karppinen *et al*, 2000). Problems usually associated with the cooking of brown rice have been resolved and more bio-functional substances have been generated by germination. Various promising foodstuffs, such as rice-balls, rice bread and soups, have been developed using pregerminated brown rice as primary material (Ito and Yukihiro. 2004).

Table 3 Sensory evaluation of cooked brown rice and cooked brown parboiled rice (n=50)

Parameters	Brown rice	Soaking temperature of brown parboiled rice		
		PR40	PR50	PR60
Color	6.95±0.28[a]	5.63±0.16[c]	6.53±0.56[b]	5.82±0.61[c]
Odor	6.37±1.31[a]	5.69±0.02[b]	6.32±0.16[a]	4.37±0.09[b]
Texture	5.91±1.54[b]	5.66±0.22[b]	6.49±0.56[a]	6.47±0.45[ab]
Taste	6.17±0.39[c]	6.00±0.01[c]	6.58±0.01[a]	6.42±0.01[bc]
Overall	6.84±0.14[a]	5.69±0.05[d]	6.51±0.1[b]	5.95±0.03[c]

Values within a row followed by the same letter are not significantly different ($p<0.05$) (Duncan's)

Fifty panelists evaluated the cooked parboiled brow rice of three treatments and normal brown rice (control). Summary of the data obtained from these 50 panelists is given in Table 3. The mean scores of color, odor, texture taste and overall acceptance of parboiled rice were between 4.4 to 6.6, while those of brown rice were between 6.2 to 7.0. The results showed that PR50 gave the highest scores (6.51 out of 9) among all treatments but slightly lower than brown rice. Although, other attributes including texture and taste of PR50 were given higher preference scores than brown rice, the negative value for color of parboiled rice affected the overall acceptance by the panelists as compared to brown rice.

Summary

Soaking temperature is one of the most important processes of rice parboiling. Our present findings have demonstrated that significant differences were found in nutrition quality and consumer acceptance of parboiled rice compared to brown rice. Soaking temperature also resulted in nutrient changes such as protein, lipid and ash contents. However, optimum soaking temperature is to be considered to achieve consumer acceptability. According to present data, we specially recommend the parboiling process for damaged fragrant rice for improvement of head rice yield and cooking quality. Besides, greater nutritional values of parboiled rice is to be considered as a functional food.

Acknowledgements

The authors gratefully acknowledge the Thailand Research Fund (TRF) with Office of Small and Medium Enterprises Promotion (OSMEP) for their financial support to this work. We also thank Commission on Higher Education and Mahasarakham University for financial support.

Literatures cited

AOAC. 2002. Official Method of Analysis. A.O.A.C. Inc., Washington, D.C.

Beal, A.D., and D.S Mottram, 1993. An evaluation of the aroma characteristics of malted barley by free-choice profiling. *Journal of Science, Food and Agriculture*, 61, 17–22.

Deepa, G. Vasudeva Singh, and K. Akhilender Naidu, 2007. Nutrient composition and physicochemical properties of indian medicinal rice-Njavara. *Food Chemistry*, 106 : 165–171

Elbert, G. M. P. Tolaba and C. Suárez, 2000. Effects of drying conditions on head rice yield and browning index of parboiled rice. *Journal of Food Engineering*, 47: 37-41.

Heinio, R.L., K.M. Oksman-Caldentey, K. Latva-Kala, P. Lehtinen, and K. Poutanen, 2001. Effects of drying treatment conditions on sensory profile of germinated oat. *Cereal Chemistry*, 78, 707–714.

Indian Standard, 1971. Guide for Sensory Evaluation of Foods, IS: 6273 (Part-I), Indian Standards Institution Manak Bhawan, New Delhi.

Ito Shoichi and Yukihiro Ishikawa. 2004. *Marketing of Value-Added Rice Products in Japan*: Germinated brown rice and rice bread, presented at FAO international rice year, 2004 Symposium Rome, Italy February 12, 2004.

Kainuma, K., 2004. *Rice its potential to prevent global hunger*. Proceedings of the third session of the workshop on suitable use of agricultural resources and environment management with focus on the role of rice farming. Japan FAO Association, pp.41–46.

Kar, N., R.K. Jain, and P.P. Srivastav, 1998. Parboiling of dehusked rice. *Journal of Food Engineering*, 39 : 17-22

Karppinen, S., K. Liukkonen, A.M. Aura, P. Forssell, and K. Poutanen, 2000. In vitro fermentation of polysaccharides of rye, wheat and oat brans and inulin by human faecal bacteria. *Journal of Science, Food and Agriculture*, 80, 1469–1476.

Larsen H. N., 2000. Glycaemic index of parboiled rice depends on the severity of processing: study in type 2 diabetic subjects. *European Journal of Clinical Nutrition*, 54(5) : 380–385

Manna, K.M., K.M. Naing, and H. Pe, 1995. Amylase activity of some roots and sprouted cereals and beans. *Food and Nutrition Bulletin*, 16, 1–4.

Mikola, M., O. Brinck, and B.L. Jones, 2001. Characterization of oat endoproteinases that hydrolyze oat avenins. *Cereal Chemistry*, 78, 55–58.

Ohtsubo, Kenichi. Keitaro Suzuki, Yuji Yasui, and Takafumi Kasumi, 2004. Bio-functional components in the processed pre-germinated brown rice by a twin-screw extruder. *Journal of Food Composition and Analysis*. 18, 303–316

Rimsten, L., A.K. Haraldsson, R. Andersson, M. Alminger, A.S. Sandberg, and P. Aman, 2003. Effects of malting on beta-glucanase and phytase activity in barley grain. *Journal of Science, Food and Agriculture*. 82, 904–912.

Saif, S. M.H., Dwayne A. Suter, and Yubin Lan, 2004. Effects of processing conditions and environmental exposure on the tensile properties of parboiled rice. *Biosystems Engineering*, 89 (3) : 321–330

Siriamornpun, S., D. Li, L. Yang, W. Kanchanamayoon, and M. Suttajit, 2005. Thai jute seed oil: a potential polyunsaturated fatty acid source. *Songklanakarin Journal of Science and Technology*, 28 : 11-15.

Subba Rao, M.V.S.S.T., and G. Muralikrishna, 2002. Evaluation of the antioxidant properties of free and bound phenolic acids from native and malted finger millet. *Journal of Agriculture, Food and Chemistry*, 50, 889–892.

Yang, F., T.K Basu, and B. Ooraikul, 2001. Studies on germination conditions and antioxidant contents of wheat grain. International *Journal of Food Science and Nutrition*, 52, 319–330.