Original article

Measurement of satiety responses of different types of rice

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ABSTRACT

Rice is a staple grain in Thailand, which is one of the world's largest rice exporters. Recently, Thai researchers have developed a few new Thai rice strains with more nutritional values. Obesity has emerged as a major public health issue in Thailand, which mainly caused by excessive energy intake and lack of physical activities. This study was designed to investigate the effect of four different types of rice (White Jasmine rice, Sinlek rice, Riceberry rice, and Germinated Brown rice) on satiety responses (hunger, fullness, satisfaction, and desire to eat) and the effect of food intake at lunch. Twelve healthy women were studied in a within-subject preload with repeated measures, crossover design. Each participant completed four conditions, presented in random order. The test meals at breakfast containing 165 g of White Jasmine rice, Sinlek rice, Riceberry rice, or Germinated Brown rice. Pre and post-prandial satiety responded using 100 mm Visual Analog Scale (VAS) was measured at baseline (t-15), t0, t15, t30, t45, t60, t90, t120, t180, and t240 minutes. Energy intake was measure at the lunch using plate waste. There were no differences in the area under the time curve in modified VAS scores among types of rice in any parameter. However, the energy intake at lunch was significantly decreased in Riceberry rice compared to White Jasmine rice ($p < 0.01$). All four types of rice were not differ significantly in the satiety response. Riceberry rice is the only rice that can decrease the energy intake at lunch.

Key words: Thai rice, Satiety, Hunger

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นิพนธ์ต้นฉบับ

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บทคัดย่อ

ข้าวเป็นธัญพืชพื้นฐานหลักของประเทศไทย ซึ่งเป็นหนึ่งในผู้ส่งออกข้าวของโลกที่ใหญ่ที่สุด เมื่อไม่นานนี้นักวิจัยไทยได้พัฒนาสายพันธุ์ข้าวไทยบางส่วนใหม่ให้มีคุณค่าทางโภชนาการมากขึ้น ปัจจุบันโรคอ้วน เป็นปัญหาสาธารณสุขที่สำคัญในประเทศไทยเกิดจากการบริโภคอาหารที่ให้พลังงานมากเกินไปและขาดการออกกำลังกาย การศึกษาครั้งนี้เพื่อศึกษาผลของการรับประทานข้าวสี่ประเภทที่แตกต่างกัน (ข้าวขาวหอมมะลิ ข้าวสินเหล็ก ข้าวไรซ์เบอรี่และข้าวกล้องงอก) ในการตอบสนองต่อความเต็มอิ่ม (ความหิว ความอิ่ม ความพึงพอใจ และความปรารถนาที่จะรับประทาน) และผลกระทบต่อการรับประทานอาหารในมื้ออาหารกลางวัน ผู้เข้าศึกษาผู้หญิงจำนวนสิบสองคนที่มีสุขภาพดี เข้าศึกษาด้วยวิธีการวิจัยเชิงทดลองแบบวิเคราะห์ซ้ำและสลับกลุ่ม ผู้เข้าร่วมแต่ละคนต้องได้รับข้าวทั้งสี่ชนิดในลำดับแบบสุ่ม อาหารที่ใช้ในการทดสอบคืออาหารเช้าที่มีปริมาณ ข้าวขาวหอมมะลิ ข้าวสินเหล็ก ข้าวไรซ์เบอรี่และข้าวกล้องงอก 165 กรัม หลังจากนั้นมีการวัดความเต็มอิ่มก่อนและหลังการรับประทานอาหารโดยใช้แบบสอบถามการตอบสนอง (Visual Analog Scale) 100 มิลลิเมตร วัดที่ค่าพื้นฐาน (t-15), t0, t15, t30, t45, t60, t90, t120, t180, และ t240 นาที ปริมาณพลังงานจากการรับประทานอาหารในมื้ออาหารกลางวันวัดจากอาหารที่เหลือในถาดอาหารไม่มีความแตกต่าง ในพื้นที่ใต้กราฟที่เวลาที่แตกต่างกันในแต่ละประเภทของข้าว อย่างไรก็ตามปริมาณพลังงานในมื้อกลางวันลดลงอย่างมีนัยสำคัญทางสถิติในกลุ่มผู้ที่รับประทานข้าวไรซ์เบอรี่ เมื่อเทียบกับข้าวขาวหอมมะลิ ($p<0.01$) สรุปข้าวทั้งสี่ชนิดไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติต่อการตอบสนองความเต็มอิ่ม ข้าวไรซ์เบอรี่เป็นข้าวชนิดเดียวที่สามารถลดปริมาณพลังงานที่รับประทานในมื้ออาหารกลางวัน

คำสำคัญ : ข้าวไทย ความเต็มอิ่ม ความหิว

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Introduction

Rice *(Oryza sativa L.)* is a major cereal crop in the developing world and an importance staple food source for over half of the world's population. In Asia alone, more than 2,000 million people obtain 60-70 percent of their calories from rice and its products. In Thailand, rice is not only importance as a staple food but also as an economic crop. Thailand is one of the world's biggest rice producers, with paddy output of 27 million tons in 2003. As well as the world's biggest rice exporter; with annual shipments worth more than 2,000 million dollars and has reached 7.5 million tons in 2013[1]. Although widely consumed as white rice, there are many special cultivar of rice that contain color pigments, such as White Jasmine rice, Sinlek rice, Riceberry rice, brown rice, black rice and red rice.

Rice is not only a source of high quality proteins but also rich sources of fibre, antioxidant vitamins and bioactive compounds. Several studies have demonstrated the abundant bioactives with corresponding high antioxidant, anticarcinogenic and antimutagenic activities in rice bran extracts[2-4]. In the rice consuming world, nutritious rice grains can become a main ingredient in designing food for specific neutraceutical and functional food formulations. Recently, Rice Science Center of Thailand has developed some new Thai rice strains with increasing nutritive values by using plant biotechnology technique. Some rice varieties such as Sinlek brown rice and Riceberry pigmented rice showed high contents and activities of various antioxidants especially in bran portions.

Rice Berry, a cross-bred unmilled rice producing dark violet grain, is a combination of Hom Nin Rice, with well-known antioxidant properties, and Thai Hom Mali Rice, also known as Thai Jasmine/ Fragrant Rice or Khao Dawk Mali 105[5].

Sinlek is cross-bred between Hom Nin Rice and Thai Hom Mali Rice but its grains are white and yellowish, so it is soft and delicately scented when cooked, thanks to the properties of Thai Hom Mali Rice[5].

In addition to Rice Berry, Sinlek, or the so-called 'rice against diabetes', is another variant which has low glycemic index. The dietary fiber in its bran has properties that help decreasing the absorption of sugar into the blood, making it suitable for patients with diabetes. Consuming Sinlek rice also helps reduce the body's barriers against insulin, lower the average of triglyceride in the body, and improve the function of the pancreatic system[5].

Germinated brown rice (GBR) were soaked long enough for the process of germination (growing a seed) to start. According to Japanese Food Economist Ito Shoichi in his 2004 presentation for the Rice Conference held by the Food and

Agriculture Organization of the United Nations, it is likely that ancient people in Japan ate their brown rice soaked. The most highly touted nutrient that is doubled or even magnified ten times in germinated brown rice is an amino acid called gamma-aminobutyric acid or GABA for short[6]. Other remarkable improvements are shown in the amounts of dietary fiber, magnesium, potassium, zinc, Vitamin E and many B vitamins[6]. Researchers Kayahara and Tukahara concluded in 2000 that "continuous intake of GBR" can lower blood pressure, improve brain function, and relieve some symptoms of menopause. It also may prevent headaches, relieve constipation, regulate blood sugar, and even prevent Alzheimer's disease and some cancers, including colon cancer and leukemia[6].

These differences in satiety may provide an important insight into obesity and may provide a way to help people consume fewer calories. If people consumed foods that provided more satiety per calorie, then their overall calorie intake might be reduced without sacrificing the feelings of satiety and satisfaction from higher calorie foods. There has been an increasing trend, in both academic and industry settings, to measure the satiety that foods provide. One strategy for consuming fewer calories and thus helping in the reduction of obesity is to consume foods that give a higher satiety to calorie ratio. Satiety has been broadly defined as the feeling of fullness and/or inhibition of hunger sensations after food ingestion[7-9].

Materials and Methods

Methodology

ANOVA was used in this cross-over design study to investigate the effect of four different types of rice namely; White Jasmine rice, Sinlek rice, Riceberry rice, and Germinated Brown rice on satiety responses such as; hunger, fullness, satisfaction, desire to eat, and the effect of food intake at lunch.

Study design

A self-administered cross-over design study was conducted to measure their satisfaction namely; hunger, fullness, satisfaction, and desire to eat on the different types of rice. The last moment in time at which relevant differences in satiety were present was determined to decide on the timing of the lunch. The second study consisted of the same preload consumptions as in the first study, with Visual Analogue Scale (VAS) ratings of the appetite profile in a within-subject preload with repeated measures, the preload and a test meal at the relevant moment in time, at baseline (t-15), t0, t15, t30, t45, t60, t90, t120, t180, and t240 minutes. Energy intake was measure at the lunch using plate waste.

Population and sample

The study was conducted among healthy subject volunteers who were recruited by means of an advertisement in social media such as; line, facebook, notice and so on. Subjects who were willing to participate in the study were subsequently screened by means of a detailed medical history. All subjects were in good health, aged 18 to 45 years, with BMI between 18.5 and 22.9 kg/m^2, regular breakfast consumers and no restrained eaters. Excluded from the study; those not regular breakfast consumers, had food allergies, vegetarians, with history of drug or alcohol abuse, chronic disease (diabetes, kidney disease, liver disease, metabolic syndrome, gastroin-testinal conditions that may affect digestion and absorption, etc) and/or treat and/or taking drug during of the intervention study, allergic of rice, disagree and did not sign the consent, and those who incline to answering questionnaire.

Method of data collection

Visual Analogue Scale (VAS) as developed by the researchers. Permission for data collection of each healthy subject volunteers are obtained. Healthy subject volunteers were explained on the objectives and significance of the study until they are clearly understood. Objectives and significance of the study as well as risk and benefit were explained until all of them are clearly understood. If they agree to participate in the study, they are asked to sign the inform consent form. Then trial and questionnaires will be handed to those who agree to participate and ask them to answer questions accordingly.

The day before each visit, participants were instructed to avoid food and water since 8.00 pm at night. They were required to fast at least 12 hours before study.

The visit started at 8:00 am in the lounge, Mahidol University, where subjects could read or work quietly during the four-hour session. Upon arrival, subjects were instructed to take and complete the computerized Visual Analogue Scales (VAS) for baseline subjective satiety feelings. They were then instructed to finish the treatment breakfast within 15 minutes. Subjects used VAS to rate hunger, satisfaction, fullness, and desire to eat on the different types of rice at baseline, 15, 30, 45, 60, 90, 120, 180, and 240 minutes after breakfast. In addition, energy intake was measure at the lunch using plate waste.

The data collections were done by researcher and colleagues who were students of the Department of Nutrition, Mahidol University, after obtaining an ethical clearance an ethic committee of the Faculty of Public Health, Mahidol University.

Results

Participant characteristics

Twenty-one healthy subjects were willing to undergo the study, but only 12 females participated were including in this intervention study. Overall mean age was 21.5 years, average weight was 51.6 kgs, mean height was 161.3 cms and mean BMI was 18.4 kg/m^2; there were no differences in age or BMI.

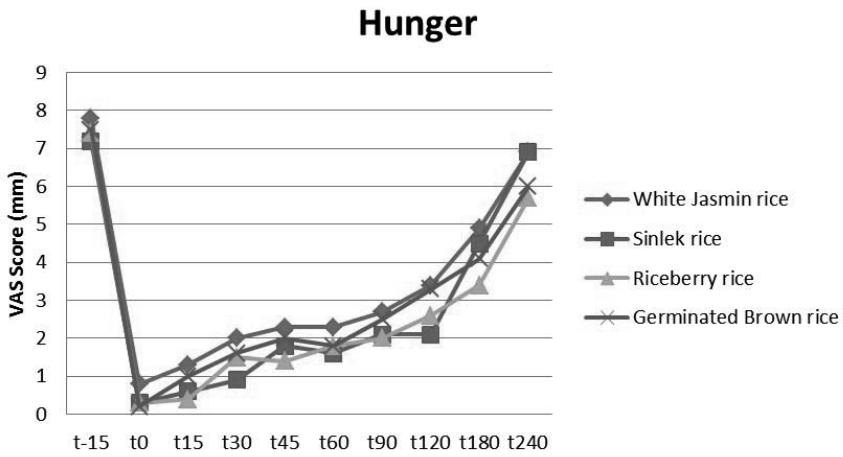

Figure 1: mean hunger of the difference rice

The figure 1, mean hunger indicated in response to treatment from baseline (t-15) to 240 minutes. The higher level of mean score of hunger was at the baseline (t-15). After breakfast, level of VAS score was lowest and after that trend of score were increasing. The hunger score was significantly higher ($p<0.05$) at t120, t180 and t240 for VAS score than t0 (reference group).

The higher level of VAS score of hunger was White Jasmine rice, followed by Sinlek rice, Germinated Brown rice and Riceberry rice, respectively.

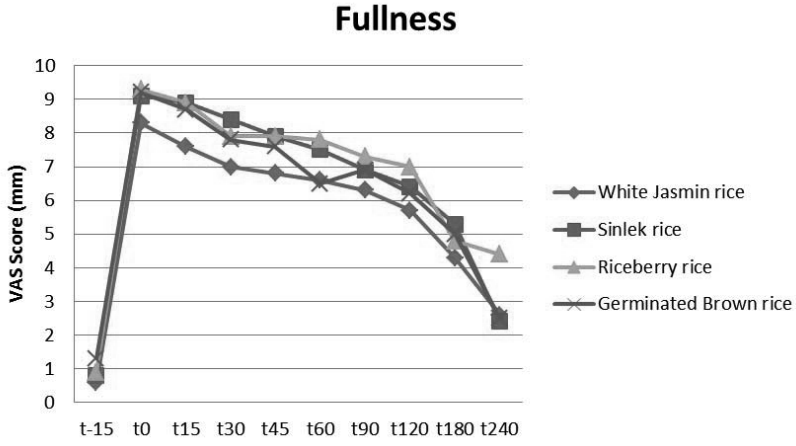

Figure 2: Mean fullness of the difference rice

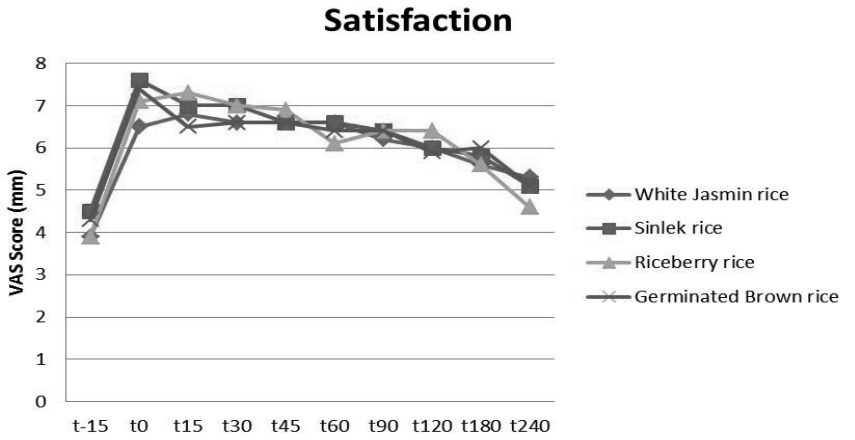

Figure 3 : Mean satisfaction of the difference rice

From the graph (Figure 2) mean fullness indicated in response to treatment from baseline (t-15) to 240 minutes. The higher level of mean score of fullness was at t0 (finished breakfast). After finished breakfast, trend of VAS score of fullness were decrease. The fullness score was significantly lowers ($p<0.05$) at t120, t180 and t240 for VAS score than t0 (reference group).

The higher level of VAS score of fullness were Riceberry rice, followed by Germinated Brown rice, Sinlek rice, and White Jasmine rice, respectively.

Figure 3, mean satisfaction indicated in response to treatment from baseline (t-15) to 240 minutes. The higher level of VAS score of satisfaction was at t0 (finished breakfast). After finished breakfast, trend of VAS score of satisfaction were decrease. The satisfaction were significantly lower ($p<0.05$) at t240 for VAS score than t0 (reference group). Lines with different letters were none significantly different from each other.

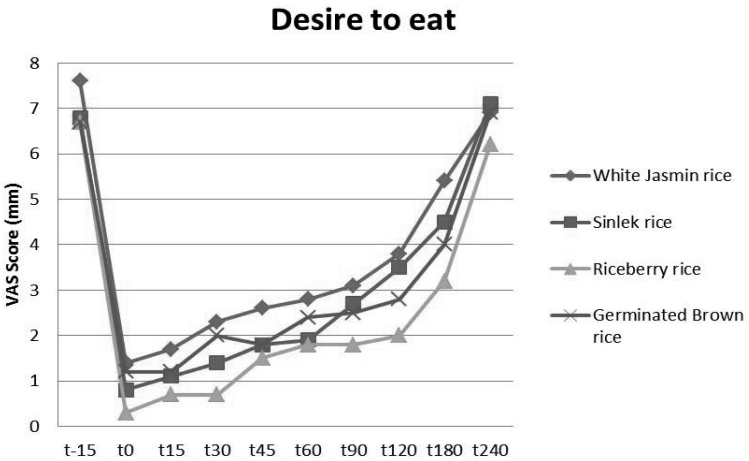

Figure 4 : Mean desire to eat of the difference rice

From figure 4, mean desire to eat indicated in response to treatment from baseline (t-15) to 240 minutes. The higher level of VAS score of desire to eat were at the baseline (t-15). After breakfast, level of VAS score was lowest and after that trend of score were increasing. The desire to eat was significantly higher ($p<0.05$) at t120, t180 and t240 for VAS score than t0 (reference group).

The higher level of VAS score of desire to eat were White Jasmine rice, followed by Sinlek rice, Germinated Brown rice and Riceberry rice, respectively.

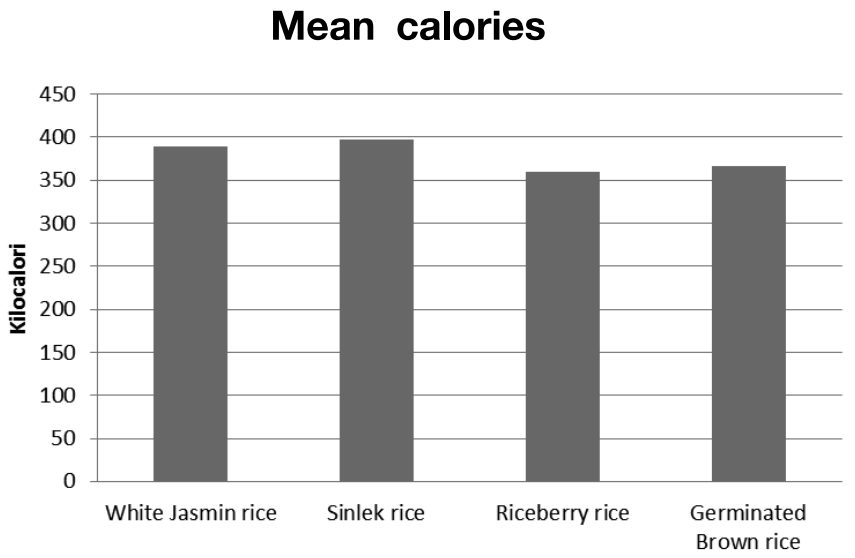

Figure 4 : Mean desire to eat of the difference rice

The mean calorie intakes during lunch buffet shown that the higher calories were Sinlek rice (397.5 kcal), followed by White Jasmine rice (389.7 kcal), Germinated Brown rice (366.4 kcal) and Riceberry rice (359.6 kcal), respectively.

The comparison of mean calorie intakes during lunch buffet among Sinlek rice, Germinated Brown rice, Riceberry rice with White Jasmine rice, the results revealed that the energy intake at lunch were significantly decreased in Riceberry rice compared to White Jasmine rice ($p<0.01$).

Discussion

This was a cross-over design study to investigate the effect of four different types of rice namely; White Jasmine rice, Sinlek rice, Riceberry rice, and Germinated Brown rice on satiety responses such as; hunger, fullness, satisfaction, desire to eat and the effect of food intake at lunch.

Considering satisfaction of this study, there were no significantly different among four different types of rice. After breakfast, level of VAS of the hunger and desire to eat score was lowest and after that trend of score were increasing. The hunger and

desire to eat score were significantly higher ($p<0.05$) at t120, t180 and t240, respectively. For the fullness, the higher level score of fullness was at finish breakfast. After finished breakfast, trend of VAS score of fullness were decreasing which were similar form the study of Joanne L Slavin and Michelle J Clark[10] found that the fullness were significantly decreased in White rice and Brown rice compared to Glucose ($p<0.5$).

Riceberry rice, Sinlek rice, and Germinated Brown rice contain higher nutrient than White rice, including antioxidants, fibers, a good source of vitamins, minerals and other bioactive compounds[11] to effect on enhanced satiety. Riceberry rice contains highest nutrient than the others. This finding is the same as previous study[12] which reported that the Pigmented rice bran had significant higher content of antioxidant activities than White rice bran whereas vitamin E and beta carotene in White rice bran were similar to the value of purple rice bran.

Not only that the lower calorie intakes during lunch buffet were related to higher fiber and, low to moderate index sucrose, but also that were affected to hunger, fullness, satisfaction, and desire to eat. This study shown that the lower calories were Riceberry rice, followed by Germinated Brown rice, White Jasmine rice and Sinlek rice, respectively. This imply that the lowest calories of Riceberry rice can protect the obesity and decrease hunger which were similar form the study of Liza AH Rozen in 2011[13] from 10 healthy subjects were served breakfast meals (50 g of available starch) with endosperm-or whole grain rye breads, with and without lactic acid, boiled whole grain rye-(RK) or wheat (WK) kernels, or white wheat bread reference (WWB) in random order in a cross-over design. The RK breakfast improved satiety in the early postprandial phase (0-60min) compared to WWB, and induced a lower EI at lunch. A high content of indigestible carbohydrates in the breakfast products was related to improved satiety.

The varieties of participant, time and number of sample size is limited in this study. For the future study, the comparison of more varieties of rice is suggested to demonstrate a causal relationship between feeling, or hormone to the hunger and fullness.

Conclusion

All four types of rice; White Jasmine rice, Sinlek rice, Riceberry rice, or Germinated Brown rice did not differ significantly in the satiety response. Riceberry rice is the only rice that can decrease the energy intake at lunch.

References

1. Food and Agriculture Organization. All about rice. 2014 [cited 2014 August 31]. Available from: http://www.fao.org/rice2004/en/aboutrice.htm.
2. Nam SH, Choi SP, Kang MY, Kozukue N, Friedman M. Antioxidative, antimutagenic, and anticarcinogenic activities of rice bran extracts in chemical and cell assays. J Agric Food Chem. 2005; 53(3): 861-22.
3. Kaneda I, Kubo F, and Sakurai H. Anti-oxidative compounds in the extracts of black rice brans. J Health Sci. 2006; 52(5): 495-511.
4. Renuka Devi R, Arumughan C. Antiradical efficacy of phytochemical extracts from defatted rice bran. Food Chem Toxicol. 2007; 45: 2014-21.
5. MCOT digitally beyond. Rice Berry, Sinlek: Two new Thai rice breeds with more minerals. 2014 [cited 2014 August 31]. Available from: http://www.mcot.net/site/content?id=4ff671540b01dabf3c00746a#.Vl5gQMscSUk.
6. Wu F, Yang N, Touré A, Jin Z and Xu X. Germinated brown rice and its role in human health. Crit Rev Food Sci Nutr. 2013; 53(5): 451-63.
7. Blundell J. Pharmacological approaches to appetite suppression. Trends Pharmacol Sci. 1991; 12: 147-57.
8. Green SM, Delargy HJ, Joanes D and Blundell JE. A satiety quotient: A formulation to assess the satiating effect of food. Appetite.1997; 29(3): 291-304.
9. Sœrensen LB, Mœller P, Flint A, Martens M and Raben A. Effect of sensory perception of foods on appetite and food intake: A review of studies on humans. Int J Obes. 2003; 27(10): 1152-66.
10. Clark MJ, Slavin JL. The effect of fiber on satiety and food intake: A systematic review. J Am Coll Nutr. 2013; 32(3): 200-11.
11. Nakornriab M, Sriseadka T, and Wongpornchai S. Quantification of carotenoid and flavonoid components in brans of some Thai black rice high-performance liquid chromatography-mass spectrometry. J Food Lipids. 2008; 15: 488-503.
12. Chanphrom, P. Antioxidants and anti-oxidant activities of pigmented rice and varieties and rice bran. MS [thesis]. Bangkok: Faculty of Graduate Studies, Mahidol University; 2007.
13. Rosén LA, Östman EM, and Björck IM. Effects of cereal breakfasts on postprandial glucose, appetite regulation and voluntary energy intake at a subsequent standardized lunch; focusing on rye products. Nutr J. 2011; 10(7): 1-11.