

Iron Fortification in Developing of Extruded Thai Rice Snack

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ABSTRACT

To produce an acceptable snack of high nutritional quality for the programs against anemia and malnutrition, the direct expansion snack products were developed from extrusion process using Thai brown rice of two specialty hybridization (variety: 313 and 1000) as basic raw materials. For each variety of brown rice, the optimum operating conditions were investigated with twin-screw extruder at varying screw speed (300 and 350 rpm), type of iron fortificants (ferrous sulphate, ferrous lactate and ferrous fumarate) and level of iron content in snack product (20 and 100% RDI) in the 2×3×2 factorial experiment. Similarly, the optimum operating condition of snack production from each variety of rice had shown that increasing screw speed resulting in extrudate with higher expansion, lower density and broad peak or lower slope of the deformation curve from texture analyzer. The type of iron fortificant had no significant effect on palatability and metallic smell of snack product. Furthermore, the level of iron content had no significant effect on expansion and density of extrudate. It was concluded that all of snack products should be operated at 350 rpm of screw speed, ferrous sulphate as iron fortificant and level of 20% RDI for iron to provide the good appearance and meet the requirements of iron as well as lower production cost. In addition, the representative of the finished products were analyzed for the pattern of nutrition labeling microbiological test and shelf life between 0-4 months on the determination of moisture, a_w , TBA numbers, iron content and sensory test which correspond to nutrition claims of high iron and high potential for further commercial production.

Key words: iron, anemia, extrusion, rice, snack

INTRODUCTION

Iron deficiency is the primary cause of nutritional anemia leading to the lowering of growth rate, impairing cognitive scores in children and poor pregnancy. The fortification of food is often regarded as the most effective, long term approach to reduce the prevalence of iron deficiency (Hurrel, 1997). A combination of an

iron fortificant compound and food vehicle could be selected based on the acceptability by the target population, yet with no adverse effect on organoleptic qualities and shelf-life of the food vehicle, and at the same time providing stability and bioavailability form of iron. Staple foods such as rice or cereal flours are the excellent vehicles for iron fortification in cereal-based products especially for snack food (Martinez-Navarrete

et al., 2002). Some previous work invented ready-to-eat cereal product fortified with ferric EDTA (Humbert *et al.*, 1997) and highly acceptable snack products obtaining from extrusion cooking of admixed defatted chickpea, corn and bovine lung flours for malnutrition program (Cardoso Santiago *et al.*, 2001). Comprising with extrusion process had been used for developing novel convenience foods such as snack and because extrusion equipment offers many basic design advantages that result in minimizing time, energy and cost while at the same time increasing the degree of versatility and flexibility that was not previously available by other means (Harper, 1987; Riaz, 2000). Thus, the objectives of this work were to create an acceptable direct expanded extruded snack product which provided at least 20% of the iron RDA for health claims and preventing iron - deficiency anemia among the young child population.

MATERIALS AND METHODS

Raw materials

- Thai brown rice : Two specialty hybridization with high iron but different color (variety: 313 and 1000) were supplied from The Rice Science Center, Kasetsart University.

- Iron fortificant: Ferrous sulphate, ferrous lactate and ferrous fumarate were supplied from Asia Drug & Chemicals Ltd. Partn., Food Ingredient Technology Co., Ltd. and Maxway Co., Ltd., respectively

Experimental design

To study the optimum operating conditions of snack production from Hermann Berstorff Laboratory Co-rotating Twin - Screw Extruder ZE25×33D, the 2×3×2 in factorial experimental design was employed to determine the effect of screw speed (300 and 350 rpm), type of iron fortificant (ferrous sulfate, ferrous lactate and ferrous fumarate) and level of iron content in

snack product (20 and 100% RDI) on the extrudate. The chemical and physical properties of extrudates were examined such as expansion ratio, bulk density, texture measurement, colour measurement, iron content, including organoleptic properties. Data obtained were analyzed by computer programme and determined the optimum operating conditions.

Sensory evaluation, microbiological test, nutritional evaluation and physicochemical changes during storage time

The direct expansion extruded snack of each variety of Thai brown rice at the optimum operating condition was produced and flavored with oil / syrup and seasoning. The finished product was tested for sensory evaluation by the target group (school-children with aged between 6–14 years), microbiological test, nutritional evaluation in the pattern of “Nutrition Facts”. Additionally, the finished products were packed in metallize bags and kept at room temperature for 4 months, then testing for physicochemical changes of product such as moisture, a_w , color, hardness, TBA numbers, Fe content and sensory test during storage times.

Product analysis

Expansion ratio (Halek and Chang, 1992)

Expansion ratio was determined by applying a vernier caliper to measure the average width of extrudate (10 randomly chosen pieces of extrudates from each test run) and calculated as the ratio between the width of extrudates (heart shape) and the width of die hole (heart shape).

Bulk density (Rahman, 1995)

Bulk density is the density of a material when packed or stacked in bulk. It was determined by replacing the extrudate into a 500 ml graduated cylinder. The volume and weight of the extrudate were recorded to determine the bulk density as the weight of extrudate per volume occupied by

the extrudate.

Texture measurement (Claytor, 1996)

For measuring the textural quality of extrudate, the TA-XT2i texture analyzer was fitted with the Warner Bratzier blade set (HDP/BSK). Ten measurements were conducted on extrudate at each test run of each replicate for analyzing force-time curves to evaluate the maximum force, slope (gradient) and area which related to the crispness of extrudate.

Colour measurement

Colour of the finished product was measured using CIELAB 1976 L*, a*, b* color scale. The measurement was done by spectrophotometer (Spectraflash 600 plus, Datacolor International, USA). The CIE color values were recorded as L* = lightness (0 = black, 100 = white), a* (-a* = greenness, +a* = redness) and b* (-b* = blueness, +b* = yellowness).

Iron content (AOAC, 2000)

Iron in foods is readily determined by ICP-AES (Inductive Couple Plasma-Atomic Emission Spectrometer). Concentrations in most samples generally fall within the working range of the instruments. Both dry ashing and acid digestion can be used to prepare samples for analysis. For lower concentrations of iron ICP - AES can be used directly on digests, without the need for preconcentration.

TBA assays (Liu *et al.*, 2006)

The degree of oxidation of oil in finished product was measured by the 2-thiobarbituric acid (TBA) assay. The sample was distilled in hydrochloric acid to extract malonaldehyde, which was then subjected to the reaction with thiobarbituric. The absorbance was finally measured at 532 nm.

RESULTS AND DISCUSSION

Effect of the operating conditions on the chemical and physical properties of extrudates

The results showed that the operating

conditions varying at screw speed (300 and 350 rpm), type of iron fortificant (ferrous sulphate, ferrous lactate and ferrous fumarate) and level of iron content in snack product (20% and 100% RDI) effected similarly on the chemical and physical properties of extrudates at each varieties of Thai brown rice (variety 313 or 1000) as basic raw material as shown in Figures 1 and 2. The results suggested that screw speed had trends for significant effect on expansion ratio, bulk density and texture of the extrudates. At higher screw speed, the extrudates was increased in expansion but decreased in bulk density and decreased in the slope of the deformation curve from texture measurement or getting softer texture. These may be because the screw speed generally has positive effect on extrudate expansion due to the increase in shear, and thus decrease in melt viscosity induced by high screw speeds (Moraru and Kokini, 2003). Owing to small amount of iron fortificant in the feed mixture before extrusion process, type of iron fortificant did not have significant effect on the colour of extrudate although ferrous fumarate had red colour. In addition, no type of iron fortificant used in this study had lost during extrusion process because of stability of the selected iron fortificant in this experiment. Furthermore, the amount of iron fortificant that we used (20% or 100% RDI) had shown significant effect on iron content of extrudates. However, different amount of iron content did not affect the organoleptic properties such as metallic smell of the extrudates.

Sensory evaluation, microbiological test, nutritional evaluation and physicochemical changes during storage time

The finished products from each variety of Thai brown rice as shown in Figure 3 suggested that the optimum operating conditions should be at 350 rpm screw speed. Ferrous sulphate as the iron fortificant at the level of 20% of RDI showed good expansion and could lower the operating cost.

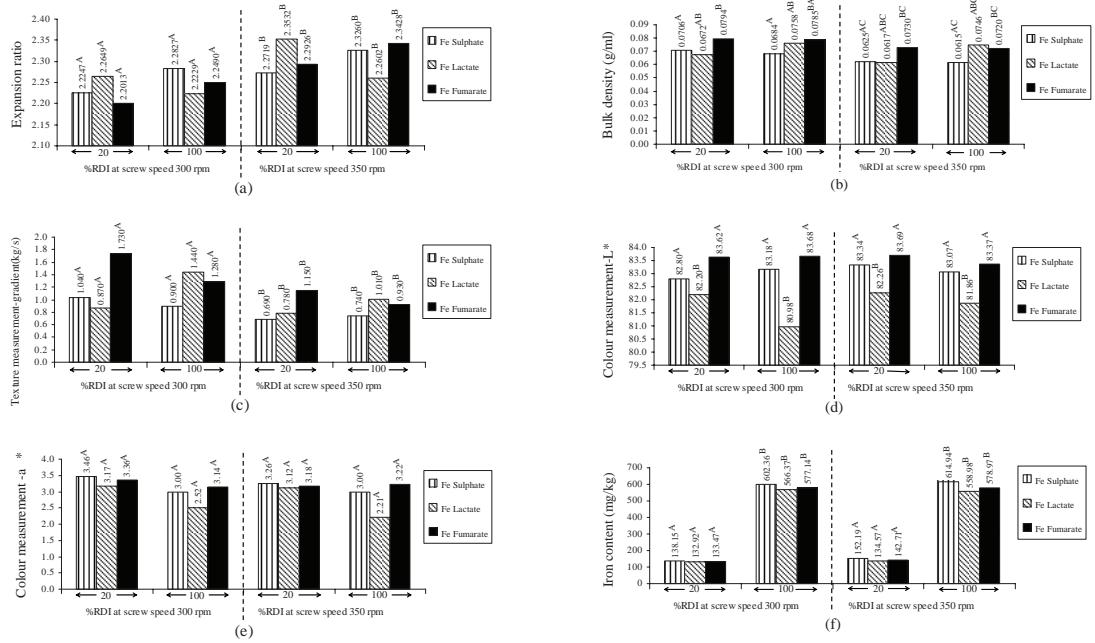


Figure 1 The chemical and physical properties of extrudates (variety 313 as basic raw material) at varying operating conditions :- (a) expansion ratio; (b) bulk density; (c) texture measurement - gradient (kg/s); (d) colour measurement - L*; (e) colour measurement - a*; (f) iron content.

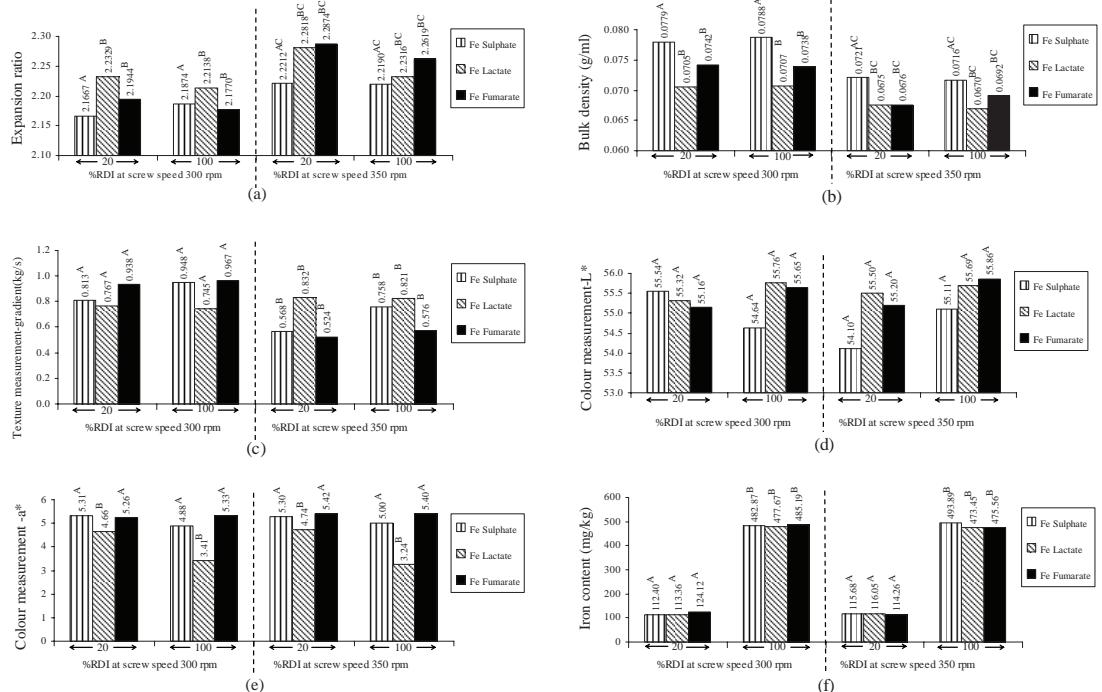


Figure 2 The chemical and physical properties of extrudates (variety 1000 as basic raw material) at varying operating conditions :- (a) expansion ratio; (b) bulk density; (c) texture measurement - gradient (kg/s); (d) colour measurement - L*; (e) colour measurement - a*; (f) iron content.

The stability of ferrous sulfate during extrusion was also observed. Similar to the former research, ferrous sulfate was found to be a suitable source of iron in a simulated rice extruded product because it did not change the color (Kapanidis and Lee, 1996). Then, these products were tested and shown that they were acceptable (82-96% likeness) for the target group (120 persons of school-children in Nakhon Ratchasima province with aged between 6-14 years) and free from

microorganisms numbers (total plate count, coliforms bacteria, yeast and mold). According to the recommended daily allowances and the results of "Nutrition Facts" of these finished products as shown in Figure 3, they should be claimed as high iron snack. Finally, the physicochemical changes during storage time confirmed that these products still maintained good performance and could be stored at room temperature for approximately four months as shown in Table 1.

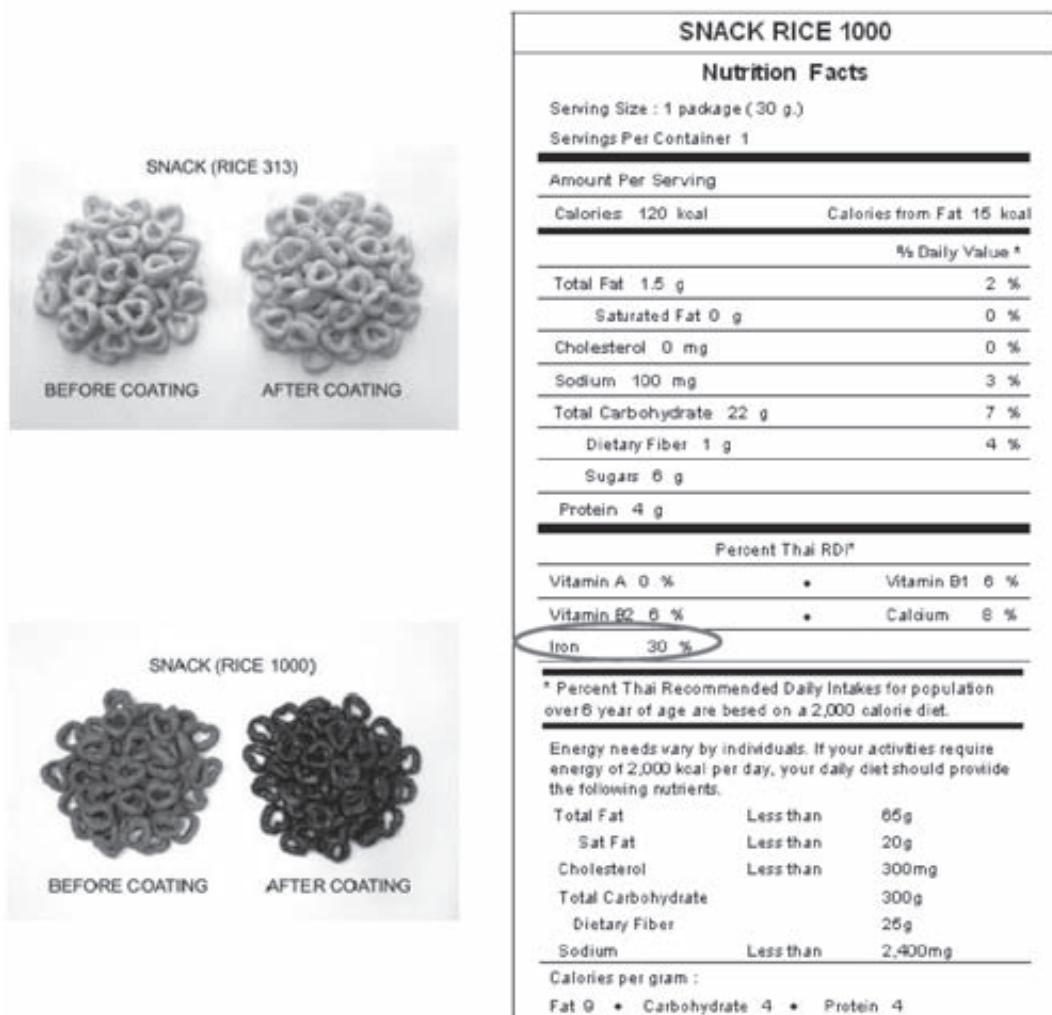


Figure 3 The finished products at each varieties of Thai brown rice and the "Nutrition Facts" of "SNACK (RICE 1000)".

Table1 The physicochemical changes and organoleptic test of the finished product during storage time (0 – 4 months).

Month	Moisture (%)	aw	Colour			Texture		TBA mg malonaldehyde per kg	Fe mg/kg	Organoleptic test			
			L*	a*	b*	Max Force (g)	Colour ¹			Flavor ¹	Rancidity ¹	Crispiness ¹	Acceptability
0	4.08 ^B	0.249 ^A	57.125 ^A	5745 ^A	8.335 ^A	2138.12 ^A	0.95 ^D	147.54 ^A	3.95 ^A	3.85 ^A	3.95 ^A	3.90 ^A	Accepted
1	4.20 ^B	0.282 ^A	57.730 ^A	5.535 ^A	7.960 ^A	2060.60 ^{AB}	1.55 ^C	159.90 ^A	3.80 ^A	3.60 ^A	3.85 ^{AB}	3.75 ^{AB}	Accepted
2	4.52 ^{AB}	0.304 ^A	58.270 ^A	5.615 ^A	8.215 ^A	2014.60 ^{AB}	1.54 ^C	161.13 ^A	3.85 ^A	3.45 ^{AB}	3.70 ^{AB}	3.80 ^{AB}	Accepted
3	4.79 ^A	0.302 ^A	55.380 ^A	5.595 ^A	7.270 ^B	1951.50 ^B	1.81 ^B	115.70 ^B	3.75 ^A	3.55 ^A	3.65 ^{AB}	3.85 ^A	Accepted
4	4.88 ^A	0.308 ^A	57.353 ^A	5.717 ^A	7.733 ^{AB}	1944.76 ^B	2.21 ^A	120.00 ^B	3.70 ^A	3.10 ^B	3.55 ^B	3.55 ^B	Accepted

¹ Organoleptic test based on 1 – 4 point scores comparing the difference of colour, flavor, rancidity and crispiness of tested sample with control (4 = not different from control, 3 = little different from control, 2 = moderate different from control, 1 = much different from control)

A, B.... In a column, means with the same letter are not significantly different (p>0.05)

CONCLUSIONS

This food fortification could create the acceptable direct expansion extruded snack from both varieties of Thai brown rice (variety 313 / variety 1000) by using the optimum operating conditions of 350 rpm screw speed with ferrous sulphate as iron fortificant and 20% RDI of the iron content. These may provide health claim of high iron snack under Thai standard regulations and may serve as the snacks for preventing-iron deficiency anemia in the risk group or young child population. This research is beneficial for transferring technology to food manufacturer and possibly for commercial production. However, further research should be carried out to test for bioavailability of these products.

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