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Effect of moisture content on extruded dough of green tea breakfast cereal

Kamonyanun Phawatwiangnak[1], Rajnibhas Samakradhamrongthai[1], Srisuwan Naruenartwongsakul[2] and Niramon Utama-ang[1, 3, *]

Abstract

The objective of this research was to investigate the effect of moisture content on properties of green tea breakfast cereal produced from rice bran using extrusion process. The main ingredients contained 93% rice flour, 2% green tea powder, 2% rice bran, 1% salt, 1% sugar and 1% calcium carbonate. The experiment was conducted by varying the initial moisture content (10, 11, 12, 13, 14, and 15% wet basis) of the mixed flour using the completely randomized design. The single screw extruder was operated at 45 rpm feed rate, 200 rpm screw speed and zone 1, 2 and 3 barrel temperatures at 115, 145 and 170°C, respectively. The RVA results showed that increasing moisture content provided the decreasing viscosity of mixed flour but increasing the setback of gels. The consumer acceptance test was examined using 9-point hedonic scaling (n=50). Result showed that consumer preferred the 10% initial moisture content of mixed flour which provided the highest acceptance percentage (83.83%) and the hedonic rating of overall liking, appearance, color, aroma, tea flavor, crispness and stickiness were 5.6±1.4, 5.1±1.4, 5.6±1.5, 5.1±1.8, 5.4±1.7, 6.9±1.4 and 6.5±1.3, respectively. The logistic regression showed that color, aroma, crispness and stickiness influenced the consumer acceptance with odd ratio at 1.32, 1.29, 1.41 and 1.38, respectively. The most acceptable extruded breakfast cereal consisted of 2.96±0.01% moisture content, L*, a* and b* of 64.23±0.81, 0.45±0.81 and 14.16±0.64, respectively, hardness of 5.88±0.09 g.f, expansion ratio of 1.72±0.09, bulk density of 0.17 ±0.00 g/ml, water solubility index of 97.08±0.02 and water absorption index of 2.31±0.01

Keywords: breakfast cereal, green tea, extrusion, moisture content, logistic regression

[1]Division of Product Development Technology, Faculty of Agro-Industry, Chiang Mai University, Chiang Mai 50100, Thailand

[2]Division of Food Engineering Development Technology, Faculty of Agro-Industry, Chiang Mai University, Chiang Mai 50100, Thailand

[3] Rice Product Research Unit, Faculty of Agro-Industry, Chiang Mai University, Chiang Mai 50100, Thailand

*Corresponding author. Tel/Fax: +66 5394 8233 E-mail: niramon.u@cmu.ac.th

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Food and Applied Bioscience Journal, 2013, 1(1): 11-23

1. Introduction

Rice is an important exported product of Thailand with value of exporting at least 80,000-100,000 millions baht per year. However, the price of rice has fluctuated because of the increment of competition. The cost of rice production in Thailand is higher than other countries. Therefore, the development of rice product in order to make the value added Thai rice is required (International Institute for Trade and Development, 2008).

Rice bran is a by-product of rice processing and the average content of rice bran is about 8% by weight of milled rice. The bran contains many valuable substances such as vitamin E and oryzanol (Gopala, 2002). However, during storage, rice bran undergoes oxidation reaction leading to rancid odor (Lin et al., 1998). Auto-oxidation involves a free radical chain reaction, which initiated by exposure to light, heat, metal ions, etc. Therefore, the inhibition of free radical oxidation by cooperating antioxidants is alternative choice in preserving lipids from deterioration.

Antioxidant substances from natural sources such as catechins are the great interest. Catechins are the highest ingredients of polyphenol compounds in fresh tea leaf. The major classes of catechins found in tea include epigallocatechin gallate (EGCG), epigallocatechin (EGC), epicatechin gallate (ECG), epicatechin (EC), gallocatechin (GC) and catechin (C) (Chu and Juneja, 1997). These polyphenolic compounds are comprised of aromatic rings with hydroxyl groups that possess strong antioxidant properties (Peterson and Totlani, 2005). The additions of green tea in food product not only enhance the nutrition value but also prevent lipid oxidation. Therefore, the objective of this research was to add value of rice product, by formulating the rice bran breakfast cereal with green tea. This work focused on the investigation of effect of moisture content on the properties of green tea breakfast cereal from rice bran using extrusion process.

2. Materials and Methods

2.1 Materials and preparation

Jasmine rice 105 was purchased from rice research center in Chiang Rai province, and milled at San Kam Phang rice mill, Chiang Mai province. Rice flour was produced by hammer mill (Brook Crompton Series 2000, Christy Hunt Agriculture Ltd., UK) and sieved into 60-100 mesh. Rice bran was dried in a hot air oven at 50°C for 12 h. All raw materials were collected in vacuum bags and stored at 4°C for further experiment. Assam tea *(Camellia sinensis* Var. Assamica) from Raming Tea Company, Chiang Mai province, was harvested in August–October 2009. Tea leave was dried using a vacuum microwave dryer (March Cool, Thailand), which obtained of tea leave and dried by 4000 watts for 30 min (2

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Food and Applied Bioscience Journal, 2013, 1(1): 11-23

kg) (Parnichakul and Utama-ang, 2009). Dried tea leaves were grounded by a hammer mill (Armfield FT2, Armfield Limited, England). The tea powder was packed in vacuum bags, and then stored at 4 °C for further experiment.

2.2 Raw material analysis

Physical and chemical properties of rice flour, rice bran and green tea were analyzed. The quality parameters included moisture, carbohydrate, crude lipid, crude protein, crude fiber and ash following the standard method of AOAC (2000). Water activity (a_w) using an AQUA LAB (Decagon, USA.) and color L*, a* and b* values using a colorimeter (Hunter Associates Lab. Inc., Reston, USA) were analyzed. Thiobarbituric acid reactive substances (TBARS) were determind for rancidity of rice bran following the method of Loypimai et al. (2009). Antioxidant activities and total phenolic content of green tea were analyzed according to the DPPH radical-scavenging method (Maisuthisakul et al., 2007) and the Folin-Ciocalteu procedure, respectively (Kahkonen et al., 1999). In addition, catechin content including EGCG, ECG, EGC and GC were analyzed using a gradient reverse phase high performance liquid chromatography (RP-HPLC) following the method of Masa and Vilanova (2008).

2.3 Moisture experiment of breakfast cereal formulation

Moisture content of mixed flour (93% rice flour, 2% green tea powder, 2% rice bran, 1% salt, 1% sugar and 1% calcium carbonate) was varied from 10%, 11%, 12%, 13%, 14% and 15% using Completely Randomized Design (CRD) with 3 replications. The ingredients were mixed using a Kitchen Aid mixer (Model 5KPM50, Kitchen Aid, St. Joseph, USA), and then water was added gradually. The mixture was mixed for 3 min and packed in polyethylene bags then stored at 4 °C for further process. Extrusion was operated using a single screw extruder (Do-Corder C3 DN19/20, Brabender, Germany) operated at 45 rpm of feed rate, 200 rpm of screw speed and zone 1, 2 and 3 barrel temperature were at 115, 145 and 170 °C, respectively. The breakfast cereal was dried in a hot air oven (Model nr600, Memmert, Germany) at 80 °C for 20 min, and packed in polypropylene bags.

2.4 Physicochemical measurements

Pasting properties of mixed flour were determined using a rapid visco analyzer (RVA-4D, Newport Scientific Pty. Ltd., Warriewood, NSW, Australia). The physicochemical properties of breakfast cereal consisted of hardness (TA-XTplus, Stable Micro Systems, surry, UK), color (L*, a*, b) were measured using a colorimeter (Hunter Associates Lab. Inc., Reston, USA). Water absorption index (WAI) and water solubility index (WSI) of breakfast cereal were

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Food and Applied Bioscience Journal, 2013, 1(1): 11-23

determined following the method of Anderson et al. (1969). Bulk density and expansion ratio were measured according to the method of Chevanan et al. (2007).

2.5 Consumer acceptance test

The consumer acceptance was examined by 9-point hedonic scaling (n=50) using computer program (SU Sense, Silapakorn University, Thailand) in Sensory Evaluation and Consumer Testing Unit, Faculty of Agro-Industry, Chiang Mai University. The consumer tasted the six samples with three replications, aside from 5 min break between each block of 6 samples, consumers were rinsed their mouths by water before proceeding to the next sample. The samples were randomly presented.

2.6 Statistical analysis

Physical and chemical data were analyzed by one-way analysis of variance (ANOVA) of the experimental data was performed to find out if the effect of different moisture of mixed flour were significant ($P \leq 0.05$) and Duncan's multiple range test was performed for post hoc multiple comparison. The consumer data were analyzed by logistic regression to identify variables which influenced the consumer acceptance ($P \leq 0.05$). The statistical analysis was done using SPSS 11.0 (SPSS Inc., Chicago, USA).

3. Results and Discussion

3.1 Properties of raw materials

Physicochemical properties of rice flour and rice bran are shown in Table 1. The rice flour consisted of 13.02% moisture, 89.32% db carbohydrate, 0.34% db crude lipid, 5.96% db crude protein, 1.23% db crude fiber and 0.42% db and ash. This was consistent with the report of Liang and King (2003). The rice bran consisted of 9.27% initial moisture, 1.93% moisture content they also included 62.72% db carbohydrate, 11.71% db crude lipid, 10.64% db crude protein, 12.59% db crude fiber and 0.41% db ash. The TBARS values of the fresh rice bran and dried rice bran was 1.19 and 1.18 µg malonaldehyde/g sample, respectively. Green tea produced by microwave vacuum dryer by 4000 watts for 30 min contained higher catechin contents (EGCG, ECG and GC) of green tea as shown in Table 1 when compared to drying conditions were varied the microwave and time. (Promjeen and Utama-ang, 2010)

3.2 Pasting behavior of rice flour and mixed flour

Rapid visco analysis of mixed flour showed that an increase of moisture content of mixed flour provided the decreased break down but resulted in increasing of setback of gels in

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Food and Applied Bioscience Journal, 2013, 1(1): 11-23

Table 2. The break down and setback gels ranged from 944.1 to 1200.3 cP and -272.7 to 616.7 cP, respectively as demonstrated in Table 2. Yang and Tao (2008) reported the increasing moisture content of mixed flour due to increase the setback value that affected to gel stability and retrogradation. Pasting behaviors of mixed flour with different moisture content (10, 11, 12, 13, 14 and 15%) present in Figure 1. Peak viscosity of the 10% moisture content of mixed flour was higher than that of other samples. The ranges of peak viscosity were 2700.7 to 4243.1 cP (Table 2). The moisture content of mixed flour was 15% had the highest of setback compared to the other treatments.

Table 1 physicochemical properties of rice flour, rice bran and green tea.

Properties	Rice flour	Rice bran*	Green tea powder
Moisture content (%)	13.02±0.13	1.93±0.07	6.65 ± 0.78
Carbohydrate (% db)	89.32±0.13	62.72±0.55	-
Crude lipid (% db)	0.34±0.04	11.71±0.23	-
Crude protein (% db)	5.96±0.03	10.64±0.21	-
Crude fiber (% db)	1.23±0.12	12.59±0.57	-
Ash (% db)	0.42±0.04	0.41±0.02	9.97 ± 0.01
a_w	0.31±0.00	0.23±0.01	0.65± 0.01
L*	92.38±0.25	72.55±0.49	-
a*	-0.16±0.03	2.96±0.12	-
b*	6.59±0.27	16.99±0.27	-
Antioxidant activity (mg/L)	-	-	1.61 ± 0.00
Total phenolic (mg GAE/g db)	-	-	120.23 ± 13.54
EGCG (%db)	-	-	3.24 ± 0.11
ECG (% db)	-	-	2.38 ± 0.15
EGG (% db)	-	-	3.58 ± 0.01
GC (% db)	-	-	0.02 ± 0.01

Values are mean ± S.D of triplicate determinations

* Rice bran was deactivated by dried in a hot air oven at 80 °C for 20 min.

3.3 Physical properties of green tea breakfast cereal

The qualities of green tea breakfast cereal were conducted by varying moisture content of the mixed flour. There were significant differences ($p<0.05$) in color a* and b* values which ranged from 64.23 to 64.84, 0.36 to 0.62 and 15.38 to 14.46, respectively (Table 3). However, the different moisture contents of mixed flour did not affect the lightness (L*) of the products.

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Food and Applied Bioscience Journal, 2013, 1(1): 11-23

There were significant differences ($p<0.05$) in hardness of the products with different moisture contents which ranged from 4.85 to 5.88 $x10^4$ (g.f) as shown in Table 3. The 10 % moisture contents of mixed flour was the highest hardness. The range of bulk density, and expansion ratio width were 0.17 to 0.37 g/ml, and 1.15 to 2.26, respectively. The higher moisture of mixed flour and process temperature would affect to decreased bulk density and increased expansion and crispness of products (Naivikul et al., 2002). The WAI and WSI values of extruded products ranged from 1.33 to 2.31 and 86.22 to 98.10, respectively. When the moisture of mixed flour increased, the WSI was increased and the WAI was decreased due to the moisture content of mixed flour was high was not evaporates on die in extruder (Jin, 1995).

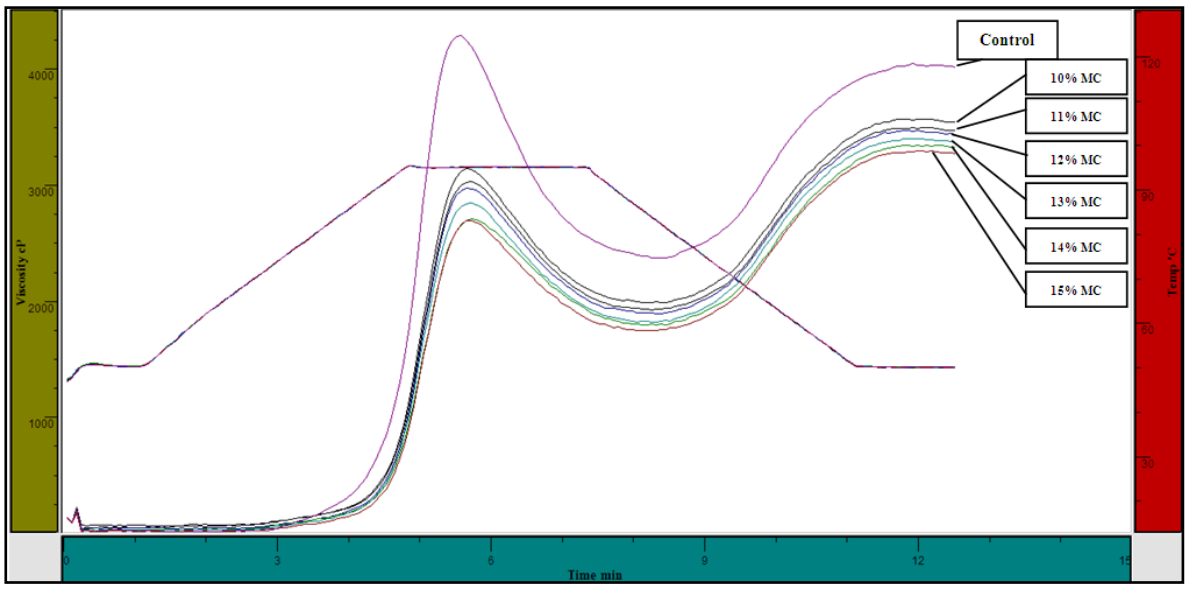


Figure 1. Pasting properties of mixed flour with different moisture contents.

3.4 Consumer acceptance of green tea breakfast cereal

Consumer most accepted the 10% moisture content of green tea breakfast cereal with the highest acceptances (83.8%) and the rating scores of overall liking, appearance, color, aroma, tea flavor, crispness and stickiness were 6.0±1.4, 5.1±1.4, 5.6±1.5, 5.1±1.8, 5.4±1.7, 6.9±1.4 and 6.5±1.3, respectively (Table 4). The products had high score in overall liking and acceptance due to high in expansion ratio and low in bulk density. Therefore, the low moisture content of mixed flour would be more accepted by the consumers (Sacchetti et al., 2004). The acceptance tests of green tea breakfast cereal were analyzed using logistic regression as shown in Table 5. The logistic regression model provided 79.2% possibility as following:

Y = -5.708+0.069*appearance + **0.280* color** + **0.257*aroma** -0.042*tea flavor

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Food and Applied Bioscience Journal, 2013, 1(1): 11-23

+ 0.342*crispness +0.325*stickiness

The logistic regression model showed that color, aroma, crispness and stickiness affected to consumer acceptance which odd ratio were 1.323, 1.293, 1.407 and 1.384, respectively (Table 5). Odd ratio indicates the acceptance of the product. When the liking score of each attribute increases as one score, the probability in consumer acceptance of the product will increase following by the odd ratio.

4. Conclusion

This study revealed that increasing moisture content of mixed flour decreased Peak viscosity but increased the setback of gels. Consumer test (n=50) showed that consumer accepted the breakfast cereal using 10% moisture content of mixed flour with the highest acceptance (83.83%) and the rating scores of overall liking, appearance, color, aroma, tea flavor, crispness and stickiness were 6.0±1.4, 5.1±1.4, 5.6±1.5, 5.1±1.8, 5.4±1.7, 6.9±1.4 and 6.5±1.3, respectively. The final extruded green tea breakfast cereal consisted of 2.96% moisture content and the color L*, a* and b* values were 64.23, 0.45 and 14.16, respectively. The effect of 10% moisture content of mixed flour make the product were hardness of 5.88±0.09 g.f, expansion ratio of 1.72±0.09, bulk density of 0.17±0.00 g/ml, water solubility index of 97.08±0.02 and water absorption index of 2.31±0.01.

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Food and Applied Bioscience Journal, 2013, 1(1): 11-23

Table 2. The pasting properties of mixed flour.

Mix powder formulation	Pasting Temperature (°C)	Peak time (min)	Peak viscosity (cP)	Break down (cP)	Setback (cP)	Final viscosity (cP)
Control	84.2±1.0^{b}	5.6±0.0^{c}	4243.1±75.8^{a}	1853.6±77.6^{a}	-272.7±42.3^{d}	3949.7±66.4^{a}
10%	87.3±0.5^{a}	5.6±0.0^{b}	3164.8±103.7^{b}	1200.3±106.5^{b}	421.7±23.9^{c}	3528.4±51.3^{b}
11%	87.6±0.7^{a}	5.7±0.0^{b}	3032.1±23.8^{c}	1101.1±30.7^{c}	453.1±16.0^{c}	3475.9±17.0^{c}
12%	87.6±0.3^{a}	5.7±0.0^{b}	3003.6±44.5^{c}	1103.4±25.1^{c}	454.6±12.7^{c}	3447.8±25.8^{c}
13%	87.9±1.3^{a}	5.7±0.0^{a}	2758.8±98.3^{d}	1001.3±38.1^{d}	548.0±23.0^{b}	3344.9±90.8^{d}
14%	88.0±0.6^{a}	5.7±0.1^{ab}	2722.3±97.1^{d}	950.7±66.7^{d}	599.0±49.7^{a}	3306.6±50.4^{de}
15%	87.6±1.1^{a}	5.7±0.0^{ab}	2700.7±120.2^{d}	944.1±25.0^{d}	616.7±49.7^{a}	3280.4±12.5^{e}

Mean and standard deviation of three samples. Mean values with different letters in the same column are significantly differences ($p \leq 0.05$).

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Food and Applied Bioscience Journal, 2013, 1(1): 11-23

Table 3. Physical properties of green tea breakfast cereal.

Moisture of mixed flour (%)	Moisture content (%)	Color value			Hardness x10^4 (g.f)	expansion ratio width	bulk density (g/ml)	WAI	WSI
		L*^{ns}	a*	b*					
10	2.96±0.01^{c}	64.23±0.81	0.45±0.09^{bc}	14.16±0.64^{bc}	5.88±0.09^{a}	1.72±0.09^{b}	0.17±0.00^{f}	2.31±0.00^{a}	97.08±0.02^{c}
11	2.97±0.01^{b}	64.84±0.93	0.36±0.04^{d}	14.30±0.61^{bc}	5.34±0.57^{ab}	2.25±0.26^{a}	0.18±0.00^{e}	2.03±0.00^{b}	98.10±0.01^{a}
12	2.95±0.01^{d}	64.57±0.43	0.62±0.07^{a}	15.38±0.22^{a}	4.86±0.57^{b}	1.26±0.12^{c}	0.19±0.00^{d}	1.42±0.00^{e}	96.56±0.10^{e}
13	2.93±0.010^{f}	64.79±0.20	0.48±0.02^{bc}	13.67±0.30^{d}	4.85±0.80^{b}	1.38±0.07^{c}	0.20±0.00^{c}	1.33±0.00^{f}	86.22±0.42^{f}
14	2.94±0.01^{e}	64.53±0.84	0.52±0.09^{b}	13.96±0.61^{cd}	5.22±0.74^{b}	1.15±0.09^{c}	0.29±0.00^{b}	1.57±0.00^{d}	96.91±0.01^{d}
15	3.02±0.01^{a}	64.52±0.64	0.42±0.06^{c}	14.46±0.18^{b}	5.44±0.13^{ab}	2.08±0.65^{a}	0.37±0.00^{a}	1.72±0.00^{c}	97.57±0.01^{b}

Mean and standard deviation of three samples. Mean values with different letters in the same row are significantly differences ($p \leq 0.05$).

ns indicates no significantly different ($p>0.05$)

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Food and Applied Bioscience Journal, 2013, 1(1): 11-23

Table 4. Sensory acceptance of green tea breakfast cereal (n=50).

Initial moisture (%)	Overall liking	Appearance	Color	Aroma	Tea flavor	Crispness	Stickiness	Acceptance (%)
10	6.0±1.4^{a}	5.1±1.4^{b}	5.6±1.5^{a}	5.1±1.8^{a}	5.4±1.7^{a}	6.9±1.4^{a}	6.5±1.4^{a}	83.3
11	4.7±1.7^{c}	4.9±1.4^{b}	5.0±1.7^{c}	4.6±1.7^{b}	4.8±1.8^{b}	4.3±1.8^{c}	4.2±1.7^{c}	35.3
12	5.6±1.5^{b}	4.9±1.6^{b}	5.3±1.5^{abc}	5.0±1.7^{a}	5.4±1.7^{a}	6.4±1.5^{b}	6.1±1.5^{b}	72.0
13	5.9±1.4^{ab}	5.5±1.6^{a}	5.5±1.5^{ab}	5.1±1.7^{a}	5.5±1.7^{a}	6.8±1.4^{a}	6.5±1.4^{a}	82.7
14	5.6±1.5^{b}	4.9±1.7^{b}	5.1±1.6^{bc}	5.0±1.7^{a}	5.4±1.6^{a}	6.3±1.5^{b}	6.0±1.5^{b}	77.3
15	5.6±1.6^{b}	5.2±1.6^{ab}	5.1±1.5^{bc}	5.1±1.6^{a}	5.4±1.6^{a}	6.2±1.5^{b}	6.0±1.7^{b}	70.0

Mean and standard deviation of three samples. Mean values with different letters in the same column are significantly differences ($p \leq 0.05$).

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Food and Applied Bioscience Journal, 2013, 1(1): 11-23

Table 5. Logistic regression coefficients for acceptance of green tea breakfast cereal.

Sensory attributes	Beta	Wald's Chi square	Significant ($p \leq 0.05$)	Odd ratio [Exp(B)]
Appearance	0.069	1.088	0.297	1.071
Color	**0.280**	**14.279**	**0.00016**	**1.323**
Aroma	**0.257**	**9.094**	**0.00256**	**1.293**
Tea flavor	-0.042	0.265	0.607	0.959
Crispness	**0.341**	**17.755**	**0.00003**	**1.407**
Stickiness	**0.325**	**15.889**	**0.00007**	**1.384**
Constant	-5.708	125.553	<0.01	0.003

Hit rate = 79.2%

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References

Anderson, R.A., Conway, H.F., Pfeifer, V.F. and Griffn, E.L. 1969. Gelatinization of corn grits by roll and extrusion cooking. Cereal Science Today. 14: 4-12.

AOAC. 2000. Official method of analysis of AOAC international: The association of official analytical chemists, 17th. Washington D.C.

Chevanan, N., Rosentrater, K.A. and Muthukumarappan, K. 2007. Twin-screw extrusion processing of feed blends containing distillers dried grains with soluble (DDGS). Cereal Chemistry. 84(5): 428-436.

Chu, D.C., and Juneja, L. R. 1997. General chemical composition of green tea and its infusion. In M. Kim (Ed.). Handbook of chemistry and applications of green tea. (PP. 13–22).

Gopala, K.A.G. 2002. Nutritional components of rice bran oil in relation to processing. Lipid Technology. 14: 80–84.

International Institute for Trade and Development (Public Organization). Rice. URL (http://www.itd.or.th) (accessed: November 23, 2008).

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Jin, Z., Hsieht, F. and Huff, H. E. 1995. Effects of soy fiber, salt, sugar and screw speed on physical properties and microstructure of corn meal extrudate. Journal of Cereal Science. 22: 185-194.

Kahkonen, M.P., Hopia, A.I., Vuorela, H.J., Rauha, J.P., Pihlaja, K., Kujala, T.S. and Heinonen, M. 1999. Antioxidant activity of plant extract containing phenolic compounds. Journal of Agricultural and Food Chemistry. 47: 3954-3962.

Liang, X. and King, J.M. 2003. Pasting and crystalline property differences of commercial and isolated rice starch with added amino acids. Journal of Food Science. 68: 832–838.

Lin, S., Akoh, C. C. and Reynolds, A. E. 1998. The recovery of used frying oil with various adsorbents. Journal of Food Lipid. 5: 1–16.

Loypimai, P., Moonggarm, A. and Chottanom, P. 2009. Effects of ohmic heating on lipase activity, bioactive compounds and antioxidant activity of rice bran. Basic and Applied Sciences. 3**:** 3642-3652.

Maisuthisakul, P., Suttajit, M. and Pongsawatmanit, R. 2007. Assessment of phenolic content and free radical-scavenging capacity of some Thai indigenous plants. Food Chemistry. 100: 1409-1418.

Masa, A. and Vilanova, M. 2008. Flavonoid and aromatic characterisation of cv. Albarin blanco (*Vitis vinifera* L.). Food Chemistry. 107: 273-281.

Naivikal, O., Boonyasirikool, P., Hengsawadi, D., Jangchud, K., Suwansichon, T. and Suksomboon, A. 2002. Functional snack food. Kasetsart Journal. (Natural science.). 36(1): 44-54.

Parnichakul, K. and Utama-ang, N. 2009. Green tea powder production by spray drying. In Proceedings of the first Agro fair Conference, Chiang Mai, Thailand.

Promjeen, K. and Utama-ang, N. 2009. Study of consumer acceptance and purchase intention on green tea mixed liquorices and lemongrass using logistic regression. In Proceedings of food innovation Asia: Value creation through innovation in food technology, Bangkok, Thailand

Peterson, D. G. and Totlani, V. M. 2005. Influence of flavonoids on the thermal generation of aroma compounds. In F. Shahidi (Ed.). Handbook of phenolics in foods and natural health products. Washington, DC.

Sacchetti, G., Pinnavaia, G., Guidalin, E. and Dalla Rosa, M. 2004. Effects of temperature and feed composition on the functional, physical and sensory properties of chestnut and rice flour-based snacked-liked products. Food Research International. 37: 527-534.

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Yang, Y. and Tao, W.T. 2008. Effect of lactic acid fermentation on FT-IR and pasting properties of rice flour. Food Research International. 41: 937-940.

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