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Effect of reducing the percentage of brown rice flour in formulation of gluten-free bread on bread properties

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Abstract : The aim of this work was to identify the effect of reducing a percentage of brown rice flour in the formulation of gluten-free brown rice bread by using equal percentages of gram dhall flour and corn flour on bread characteristics and morphological properties of bread crumb. The morphological properties of bread crumb were performed by using Scanning Electron Microscope.The findings of this study were indicated to improving bread characteristics significantly ($p < 0.05$) by reducing brown rice flour percentage to be 60% and 50%. Volume, specific volume and height of slice were increased, while density and hardness were decreased. Moreover, external and internal appearances of the bread were enhanced. However, no significant variations ($p < 0.05$) were observed on baking loss and crumb moisture. Bread crust was darker by reducing brown rice percentage to be 70%-50%. Furthermore, a decrease the percentage of brown rice flour did not have a clear influence on morphological properties of crumb. Consequently, using brown rice flour by 50%-60% in gluten-free bread formula enhanced bread characteristics and improved bread appearance.
Key words : brown rice flour, gluten-free bread.

Introduction

Wheat is one of the major cereals crops for human diet around the world[1,2]. People who suffer from celiac disease (CD)cannot use wheat, rye or barley in their food because of containing gluten[3]. CDismalabsorption disorder ofintestines caused by the ingestion of gluten; the number of patients suffering from CD has grown up in the last several decades[4] .The gliadin fraction of gluten is the responsible pathogenic factor for CD[5].Wheat gluten consists of gliadin and glutenin, which are essential for makingbaked products such as bread [6]. Also, the gluten is responsible for viscoelastic properties of dough and its ability to retain gases that are produced during the yeast fermentation process, so gluten is a major component of the structure of bread [7,4]. The great challenge for the cereal technologist is the substitution of gluten in the development of gluten-free cereal products[8]. These products are based fundamentally on starch of different botanical origin such as corn, rice, soy and buckwheat flours [9, 10]. The supplementation of gluten-free bread dough with additives is difficult, because its structure is weaker than normal wheat bread dough that contains gluten network [9].

Ricehas useful properties for the production of gluten-free products such as the absence of gluten,the existence of the high amount of easily digested carbohydrates [5] and less allergenic food grain[4]. However, making bread using rice flour introduces poor quality products because rice flour does not have ability to improve a network of the product to be similar to gluten properties[4]. In general, Gluten-free bread has low nutritional quality since it is mainly starch based and contains low amounts of vitamins, minerals, protein and dietary fibre[11].

There are mainly two methods toraise the nutritional value of gluten-free products, first is using raw materials as wholegrain and the second is adding isolated dietary fibre sources to flour[11].Brown rice contains more nutritional components than milled rice[12]. Furthermore, Brown rice has high levels of functional compounds such as ferulic acid, c-aminobutyric acid (GABA), and c-oryzanol, these compounds provide antihypertensive, and antioxidant activities[13]. In addition, brown rice has a low rate of rice starch digestion resulting in very slow release of glucose into the bloodstream after consumption [14]. Consequently, brown rice flour should be an ideal raw material for the production of gluten-free bread[15].The consumption of high fibre bread is beneficial to reduce the risks of some medical conditions and used in diet for losing weight [16]

The most of the rice proteins are very hydrophobic and therefore resist swelling in the water [6].Variousmaterials like soybean and corn have been used as an ingredient in gluten-free formulations to introduce good structure and gas-retaining properties [4]. Legumes are one of the major sources of food proteins; they contain high levels of lysine, leucine, glutamic acid, aspartic acid and arginine, also legumes provide perfect balanced essential amino acid profiles when consumed with foods that are rich in sulphur containing amino acids and tryptophan [17]. Consequently, legume and cereal proteins are complementary to introduce essential amino acids [18]. Legume proteins such as chickpea flour, pea protein isolate, and carob germ flour have beneficial functional properties to prepare and develop bakery products [17]. Moreover, the addition of soybean or pea proteins to rice flour introduce a great modification of dough mechanical properties [18].Also, the bread with legume flours shows good physicochemical characteristics and asuitable sensory profile[17]. The purpose of this study was to identify effect of reducing percentage of brown rice flour in formulation by replacing it with gram dhall flour and corn flour on bread properties.

Materials and methods

Materials

Local Malaysian Brown rice flour was obtained from Jabi Rice Mill SDN BHD (Kedah) in March 2014), Wheat flour (FFM GRAINS & MILLS SDN.BHD),Corn flour(DR.OETKER NONA MALAYSIA SDN BHD), Gram dhall flour(BABAS PRODUCTS(M) SDN BHD), salt (SENG HIN BROTHERS ENTERPRISES SDN. BHD), sugar (KILANG GULA FELDA PERLIS SDN. BHD and corn oil (YEE LEE EDIBLE OILS SDN BHD.) Were obtained from local market. Xanthan gum: From *Xanthomonas campestris* (SIGMA) product of USA. Guar gum: food grade guar gum (HIGUM 4500F)

Bread making

The formulation was prepared by 150 g flour, 3 g sugar, 3 g salt, 4.5 g yeast, 6 g corn oil, 1.5% xanthan gum, 0.5% guar gum, and 140% water (flour basis) [210 ml]. All dry ingredients were mixed in a mixer (800-C SPAR FOOD MACHINERY MFG.CO.,LTD) for 30 seconds, the oil was added and mixed for 20 seconds. Water was added then mixing until all ingredients mixed; mixing process was continued for 10 min. The conditions for making the bread were 30 min proofing time at 30 ºC, relative humidity 85%, 85.35 min baking time at 200ºC.All the analyses of bread were carried out two hours after baking.

Weight loss of bread (WL) and Dry off percentage of bread (DO)

Weight loss and dry off percentage were measured according to Ozolăet al.[19]and calculated as follows:

$$WL\% = \frac{\text{weight of the dough – weight of cooled bread}}{\text{weight of cooled bread}} \times 100$$

$$DO\% = \frac{\text{weight of bread directly after baking – cooled bread}}{\text{cooled bread.}} \times 100$$

Baking loss

The baking loss was determined according to Miňarro et al. [17] and calculated with this formula:

$$\%\ \text{baking loss} = \frac{\text{initial weight of the dough – weight of cooled bread}}{\text{initial weight of the dough.}} \times 100$$

Specific Volume

The volume of the loaf was determined by a rapeseed displacement method according to Sciarini et al. [20]. The seed was filled into a container, and then it measured the volume of container by measuring the seed

volume using graduated cylinder (V_1). Next, the loaf was put in the container then filled with seed and measured the volume of seed (V_2). The volume of the loaf was calculated by (V_1-V_2). Specific volume was calculated by dividing loaf volume on loaf weight.

Height of slice

The height of slice was measured using the middle three slices of the loaf by using a ruler to measure each slice and calculate the mean[21].

Colour of crust and crumb

The colour of crust was determined using Chroma Meter (CR-400, Minolta co., Ltd. Japan). The crust colour was identified at six points on the top of the loaf by L*, a*, b* system; L*(0 = black, 100 = white), a*(+value = red, - value = green), and b* (+ value = yellow, - value = blue); and using a white plate for calibration. The mean of the six points was calculated. The crumb colour was measured in three slices from the centre of loaf on both sides of each slice (15mm slicing) thickness [22], and the mean of two sides of the three slices colour value was calculated.

Brown Index

Brown index (BI) was calculated according to Das et al. [23] as follows:

$$BI = \frac{[100(x-0.31)]}{0.17}$$

$$\text{Where } x = \frac{a + 1.75\ L*}{5.645L* + a* - 3.012\ b*}$$

White Index (WI)

The White index was calculated according to Wu et al.[24] as follows:

$$WI = 100 - \sqrt{(100 - L*) + a* + b*}$$

Moisture of crumb and crust

The moisture content of crumb and crust were determined according to Primo-Martin et al. [25], the sample was drying at 105ºC for 24 hr. The crust and crumb were taken from the middle slices and cut into small pieces.

Morphological properties of bread crumb

The morphological properties of the samples were studied using a Scanning Electron Microscope (SEM). The bread was sliced into 15 mm x 5 mm x 15 mm and dried at 60°C for 24 hours [16]. The samples were transferred into specimen basket, and then put into a critical dryer for about ½ hr.; thereafter,the specimen was stacked into the stub using double-sided tape. The samples were gold-coated in a SEM coating system.

Statistical analysis

The analyses were carried out in triplicate and data were expressed as means. The statistical analysis was performed by using SPSS program one way ANOVA, while significant differences samples were analysed using the Duncan method at the level of significant 0.05.

Results and discussion

Table (1) presents reducing the percentage of brown rice flour in the formula of gluten free bread from 100% to 50% by equal percentages of gram dhall flour and corn flour. Six formulations were done in triplicate and bread characteristics and morphological properties of bread crumb were identified.

Table (1) brown rice bread formulation with different percentage of adding gram dhall flour and corn flour.

Number of formula	Brown rice flour %	Gram dhall flour %	Corn flour %
F1	100	0	0
F2	90	5	5
F3	80	10	10
F4	70	15	15
F5	60	20	20
F6	50	25	25

Gluten free brown rice bread characteristics

Table (2) shows effect reducing the percentage of brown rice flour (% BR) in the formula of gluten free brown rice bread on the bread characteristics. No significant variations ($p < 0.05$) were observed on baking loss and weight loss between the formulations by reducing the percentage of brown rice flour from 100% to 50%. Dry off percentage of bread increased significantly ($p < 0.05$) by reducing the % of BR to be 80%, at the same time, no significant variations ($p < 0.05$) on this parameter when reducing %BR to 50%. The volume and specific volume of loaf were increasing ($p < 0.05$) by a decrease of %BR in the formula, also there were not significant differences ($p < 0.05$) on these parameters between the formulas contained 60% and 50% BR. On the other hand, the density (weight/volume) of loaf decreased significantly ($p < 0.05$) by those percentage (50% and 60% BR). The hardness of crumb decreased significantly ($p < 0.05$) by reducing %BR (70% to 50%) while no significant differences in the hardness between 100% BR, 90% and 80% BR in the formula. The height of slice grew up ($p < 0.05$) gradually with a decrease of % BR in the formulation. There was not a big effect of reducing the BR% in the formula on crust and crumb moisture. Therefore, reducing the percentage of BR in formula improved the bread characteristics. That may refer to decreasing the rice bran level with a decrease of BR% in the formulation;Kadan et al.[6] found that specific volume decreased with adding the rice bran. Furthermore, involving of wheat bran in a bread formula led to a decrease of specific volume and an increase of crumb moisture [26]. However, Phimolsiripol et al.[11] found that addition of rice bran to gluten free bread formulation improved the bread properties by an increase of specific volume and getting softer bread, these findings were not in agreement of this study's results if the reason for the findings was related to rice bran, which is normal existence in brown rice flour, also, whole grain bread is denser than normal one [16], that was in agreement with the results in table (2), which indicated to decreasing the density with reducing of %BR in formula. As a result, probably the effects were not related only to the presence of the bran but also to interactions of other gluten free flours (gram dahall flour and corn flour). Kawamura-Konishi et al. [4] demonstrated that soya bean and corn have been added to gluten-free formula to enhance gas-retaining and structure properties in rice batter; this finding supported the explanation above.

Table (2) brown rice bread characteristics with different formula

NO/ Formula	Baking loss %	Weight los %	Dry off % of bread	Volume cm	Specific volume ml/g	Density g/cm	Hardness N	Height of slices cm	Crust moisture %	Crumb moisture %
F1	21.54±0.6364^{a}	27.21±1.378^{a}	0.99±0.077^{b}	595.83^{dc}± 0.00	2.08±0.141^{b}	0.475±0.353^{a}	7.41±0.00^{a}	5.06±0.332^{d}	26.83±1.152^{ab}	55.55±0.028^{b}
F2	23.77±0.608^{a}	31.23±0.982^{a}	0.845±0.007^{b}	575±0.00^{d}	2.06±0.007^{b}	0.48±0.006^{a}	7.29±0.622^{a}	5.74±0.0212^{c}	25.33±1.371^{b}	57.67±0.169^{a}
F3	21.90±0.954^{a}	28.05±1.548^{a}	2.12±0.155^{a}	627.5^{bc}±0.00	2.225±0.035^{b}	0.445±0.007^{a}	7.04±0.130^{a}	5.58±0.02828^{cd}	29.62±0.035^{ab}	57.93±0.770^{a}
F4	22.67±1.470^{a}	29.34±2.460^{a}	1.83±0.353^{a}	638.75^{b}±12.37	2.29±0.028^{b}	0.435±0.007^{a}	5.495±0.176^{b}	5.98±0.028^{c}	30.86±2.39^{a}	57.10±1.180^{a}
F5	23.88±0.700^{a}	31.39±1.209^{a}	2.40±0.235^{a}	810±35.35^{a}	2.94±0.169^{a}	0.335±0.021^{b}	2.165±0.063^{d}	6.63±0.466^{b}	29.41±2.100^{ab}	57.45±0.289^{a}
F6	22.85±1.286^{a}	29.64±2.163^{a}	2.10±0.417^{a}	790±0.00^{a}	2.825±0.049^{a}	0.354±0.007^{b}	3.35±0.205^{c}	7.28±0.071^{a}	31.26±3.15^{a}	57.62±0.502^{a}

Data (mean± St. Deviation) in the same column with different letter differ significantly ($p < 0.05$),

Colour characteristics of brown rice bread

Table (3) presents the colour parameters of crust and crumb of brown rice bread. The lightness of crust (L* value) dropped significantly ($p < 0.05$) with a decrease of BR% in the formula, that means the crust colour was darker in the formulations containing less percentage of BR flour, which has the bran. With addition legume flour (gram dhall flour) and corn flour to brown rice bread formula the color of crust was darker, that may be due to the Maillard reaction were stronger with presence of more protein (amino acids) and saccharides, which are the substrates of the reaction.Elgeti et al.[27] stated the similar explanation when they got darker crust colour by addition of Quinoa flour to the formula of rice, corn flour and corn starch. a* values and b* values of crust for all formulations were positive, which is meaning redness and yellowness respectively. a* value grew up when the percentage of BR flour in the formulas decreased. No clear pattern of the values of b* crust and brown index values, they were increasing then decreasing throughout the F1 to F6. White index values were dropped significantly ($p < 0.05$) with decreasing of BR flour percentage. The lightness of crumb (L*) value did not affect significantly ($p < 0.05$) when the BR% decreased from 100% to 80%, then increased by 50% BR in the formula. That indicated to lighter crumb by reducing %BR and increasing gram and corn flour in the formula. a* values of crumb were negative for all formulations, which means green colour, and b* values were positive indicating to yellowness [11]. a* value decreased with dropping the percentage of brown rice in the formula. On the other hand, b* value increased when the percentage of brown rice flour decreased from 100 % to 50 %. This may be because of adding gram dhall flour, which has yellow colour.

Table (3) Colour characteristic of brown rice bread with different formula

NO. formula	Crust L*	Crust a*	Crust b*	Brown index	White index	Crumb L*	Crumb a*	Crumb b*
F1	55.05 ± 0.721^{a}	9.35 ± 0.113^{d}	23.105 ± 0.134^{c}	64.405 ± 0.417^{c}	49.72 ± 2.312^{a}	70.57 ± 0.148^{b}	-0.06 ± 0.098^{ab}	15.26 ± 0.120^{c}
F2	54.05 ± 0.728^{ab}	10.49 ± 0.282^{c}	25.69 ± 0.134^{a}	78.5 ± 2.121^{a}	46.06 ± 0.155^{bc}	70.08 ± 0.770^{b}	0.244 ± 0.0586^{a}	15.50 ± 0.007^{c}
F3	54.61 ± 1.025^{ab}	10.11 ± 0.219^{c}	24.47 ± 0.714^{ab}	70.58 ± 0.00^{b}	47.51 ± 0.615^{ab}	69.96 ± 0.127^{b}	-0.25 ± 0.167^{b}	15.77 ± 0.169^{bc}
F4	51.07 ± 1.131^{c}	11.04 ± 0.205^{b}	23.59 ± 0.622^{bc}	76.17 ± 0.417^{a}	44.56 ± 0.692^{c}	72.81 ± 0.544^{a}	-1.79 ± 0.000^{c}	17.64 ± 0.799^{abc}
F5	53.005 ± 0.134^{b}	11.14 ± 0.353^{b}	24.59 ± 0.841^{ab}	77.93 ± 0.412^{a}	45.52 ± 0.106^{bc}	70.31 ± 0.176^{b}	-1.92 ± 0.34^{c}	18.13 ± 1.378^{ab}
F6	49.25 ± 0.332^{c}	11.81 ± 0.212^{a}	21.21 ± 0.098^{d}	72.35 ± 0.834^{b}	43.74 ± 0.311^{c}	73.47 ± 1.506^{a}	-2.52 ± 0.296^{d}	19.06 ± 1.788^{a}

Data in the same column with different letter differ significantly ($p < 0.05$),

Morphological properties of brown rice bread

Figure (1) shows the external and internal appearance of brown rice bread with different of reducing of brown rice flour percentage (from 100% to 50%). As the picture presented the external and internal appearance of the bread improved with a decrease of %BR in the formula and replacing by addition of gram dahall flour and corn flour as table (1) showed, the formulations with 60% and 50% BR were the best in external and internal appearance whereas the loaf top of was level, also making slices was easier and the slices were more consistency compared to other formulations. Figure (2) presents the morphological properties (number of pores and the pore size) of brown rice bread slices with different formulas. Brown rice bread (100% BR) had a mean of pores size 606.89 µm, and the formulations containing different percentages of brown rice flour (90%, 80%, 70%, 60% and 50%) had pores size (512.1 µm, 484.62 µm, 631.84, 1017.58 µm, and 507.06 µm) respectively. The formulations with (90% and 80% BR) had unfamiliar and not uniform pores, also compact areas could be observed. The formula with 70% BR had lower pores number and having unfamiliar pores. The bread characteristics of the formula (50% BR) (table 2),as well as the bread picture (figure1) were the best compared to other formulations , but the morphological properties of this formula was not the best, alsothe number and the size of pores did not give clear indicator. In general, all the formulas had a high number of closed pores. This probably related to weak internal bread structure. Martínez& Gómez [28] stated that making dough by starch produced a more uniform continuous phase than flour based crumb, and those investigators were indicating to the role of gelatinization during baking process, which is introducing a continue crumb structure. As a result, it was possible to say that the gelatinization process of brown rice bread was not complete since the crumb of the loaf was not baked completely. Moreover, the existence of bran had bad effects on the morphological of crumb. Van Dyck et al.[29]demonstrated that presence the bran in whole wheat bread provided a high number of closed pores and thick cell wall. Therefore, reducing the percentage of brown rice flour in the formula of bread did not have a clear effect on the morphological properties of the bread crumb; however, it had good effect in the external and internal appearance of the loaf.

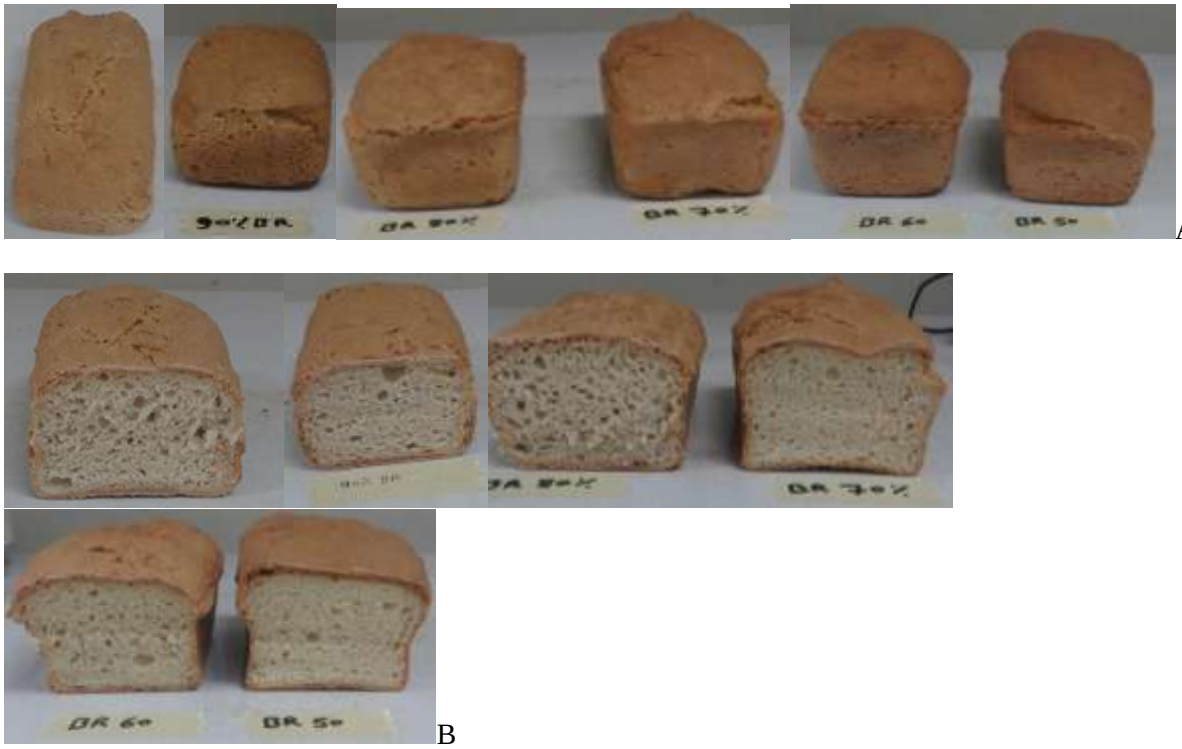

Figure (1) External (A) and internal (B) appearance of brown rice bread with reducing % BR (100% to 50%). BR (brown rice flour).

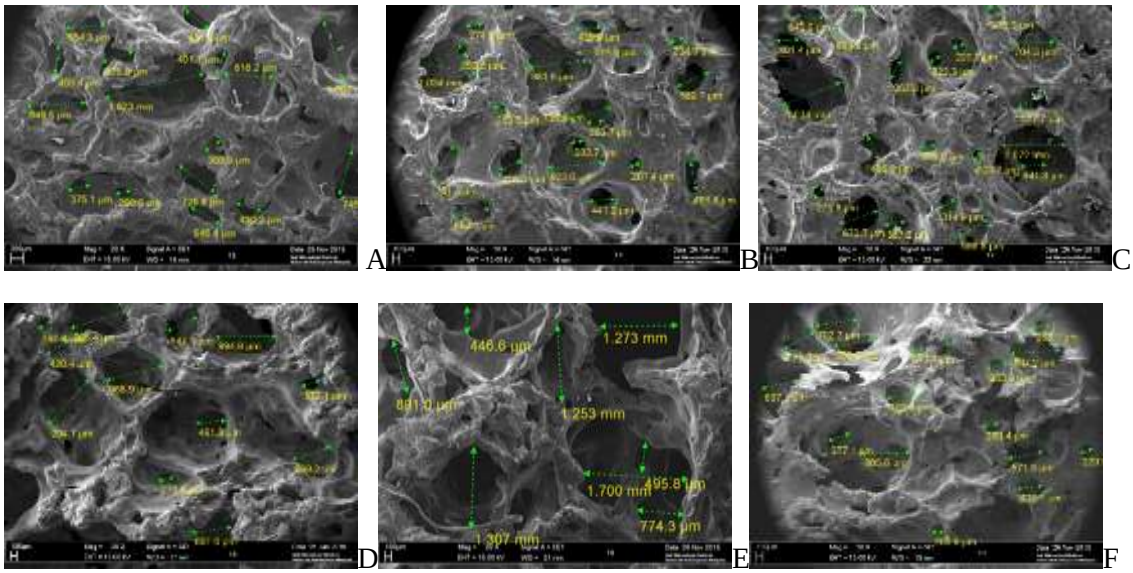

Figure (2)Scanning electron micrographs of brown rice bread slices. A (100% BR), B (90%BR), C (80%BR), D(70%BR), E (60%BR) and F (50% BR)

Conclusion

Reducing the percentage of brown rice flour (BR) in the formulation and replacing the reduce percentage by equal percentages of gram dhall flour and corn flour improved the characteristics of the loaf such as volume, specific volume, density, and height of slice. The baking loss and weight loss were not affected by reducing % BR. The lightness of crust was decreased by (70% to 50% BR), while the lightness of crumb was increased by 50% brown rice. The external and the internal appearance of the bread were better compared to the bread with 100% brown rice flour. the morphological properties of the bread crumb did not improve by

reducing the percentage of brown rice flour in the formula of bread; however, dropping brown rice flour percentage had good effect in the external and internal appearance of the loaf.

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Reference

1. AL-Ganeer F., Sabboh M., and Lawand S., Determination of the Genetic similarity among some Genotypes of Durum Wheat (Triticumsp) and Wild species using (ISSR). International Journal of ChemTech Res. 2015, 8(10), 211-216.
2. Afify A., Abbas M.S., Abd El-Lattefi B.M., and Ali A.M., Chemical, Rheological and Physical properties of Germinated Wheat and Naked Barley. International Journal of ChemTech Research, 2016,9(9), 521-531.
3. Hager A., Wolter A., Jacob F., Zannini E., and. Arendt E.K.,Nutritional properties and ultra-structure of commercial gluten free flours from different botanical sources compared to wheat flours. Journal of Cereal Science, 2012,56, 239-247.
4. Kawamura-Konishi Y., Shoda K., Koga H., and Honda Y., Improvement in gluten-free rice bread quality by protease treatment. Journal of Cereal Science, 2013, 58, 45-50.
5. Sivaramakrishnan H.P., Senge B., and Chattopadhyay P.K., Rheological properties of rice dough for making rice bread. Journal of Food Engineering, 2004, 62,37–45.
6. Kadan R.S., Robinson M.G., Thibodeaux D.P., and Pepperman A.B., Texture and Other physicochemical properties of whole rice bread. Journal of Food Science, 2001, 66(7), 940-944.
7. Hamada, S.; Suzuki, K.; Aoki N. and Suzuki, Y., Improvements in the qualities of gluten-free bread after using a protease obtained from Aspergillusoryzae. Journal of Cereal Science, 2013, 57, 91-97.
8. Renzetti S., Bello F.D., and Arendt E.K., Microstructure, Fundamental Rheology and Baking Characteristics of Batters and Breads from Different Gluten Free Flours Treated with Microbial Transglutaminases. Journal of Cereal Science, 2008, 48, 33-45.
9. Korus J., Witczak M., Ziobro R., and Juszczak L., The Impact of Resistant Starch on Characteristic of Gluten Free Dough and Bread. Food Hydrocolloids, 2009, 23,988-995.
10. Juszczak L., Witczak T., Ziobro R., Korus J.,´slik E.C. , and Witczak M., Effect of inulin on rheological and thermal properties of gluten-free dough. Carbohydrate Polymers, 2012, 90, 353– 360.
11. Phimolsiripol, Y.; Mukprasirt, A. and Schoenlechner, R., Quality improvement of Rice Based gluten free bread using different dietary fiber of rice bran. Journal of Cereal Science, 2012, 56(2), 389-395.
12. Wu F., Chen H.,YangN.,Wang J.,Duan X., Jin Z., and Xu X., Effect of germination time on physicochemical properties of brown rice flour and starch from different rice cultivars. Journal of Cereal Science, 2013, 58(2), 263-271.
13. Matsuo A.,Sato ., Park E.Y., Nakamura Y., and Ohtsuki., Control of amylase and protease activities in a phytase preparation by ampholyte-free preparative isoelectric focusing for unrefined cereal-containing bread. Journal of Functional Foods, 2012, 4,513-519.
14. Rattanamechaiskul C., Soponronnarit S., and Prachayawarakorn S., Glycemic response to brown rice treated by different drying media. Journal of Food Engineering, 2014, 122, 48–55.
15. Renzetti S., and Arendt E.K., Effect of protease treatment on the baking quality of brown rice bread: From textural and rheological properties to biochemistry and microstructure. Journal of Cereal Science, 2009, 50, 22–28
16. Amir, I.Z., Hanida, H.S. and Syafiq, A., Development and physical analysis of high fiber bread incorporated with cocoa (Theobroma cacao sp.) pod husk powder. International Food Research Journal, 2013, 20(3), 1301-1305.
17. Minărro B., Albanell E., Aguilar N., Guamis B., and Capellas M., Effect of Legume Flour on Baking Characteristics of Gluten Free Bread. Journal of Cereal Science, 2012, 56, 476-481.
18. Marco C., Rosell C.M., Functional and rheological properties of protein enriched gluten free composite flours. Journal of Food Engineering, 2008,88, 94–103.

19. Ozolã L., straumite E.,Galoburda R., and Dace K., Application of Extruded Maize Flour in Gluten Free Bread Formulation. World Academy of science, Engineering and Technology, 2012, 64, 883-888.
20. Sciarini, L.S.; Ribotta, P.D.; Leon, A.E. and Perez, G.T., Incorporation of several additives into gluten-free breads: effect on dough properties and bread quality. Journal of Food Engineering, 2012, 111, 590-597.
21. Hüttner E. K., Bello F.D., and Arendt E.K., Rheological properties and bread making performance of commercial wholegrain oat flours. Journal of Cereal Science, 2010, 52, 65-71.
22. Schober T.J., Messerschmidt M., Bean S.R., Park S., and Arendt E.K., Gluten Free Bread from Sorghum: Quality Differences among Hybrids. Cereal Chem., 2005, 82(4), 394-404.
23. Das L.,Raychaudhuri U., and Chakraborty R., Effect of Baking Conditions on the Physical Properties of Herbal Bread Using RSM. International of Food, Agriculture and Veterinary Science, 2012, 2(2), 106-114.
24. Wu K., Sung W., and Yang C., Characteristics of Dough and Bread as Affected by the Incorporation of Sweet Potato Paste in the Formulation. Journal of Marine Science and Technology, 2009, (17) (1),13-22.
25. Primo-Martin C. Beukelaer H.,HamerR.J.,andVliet T.V. Fracture Behaviour of Bread Crust: Effect of Bread Cooling Conditions. Journal of Food Engineering, 2008, 89, 285 290.
26. Foschia M.,Peressini D., SensidoniA.,and Brennan C.S., The effects of dietary fibre addition on the quality of common cereal products. Journal of Cereal Science, 2013, 58, 216-227.
27. Elgeti D., Nordlohne D.S., Föste M., Besl M., Linden M.H., Heinz V., Jekle M., and Becker T., Volume and texture improvement of gluten-free bread using quinoa white flour. Journal of Cereal Science, 2014, 59: 41-47.
28. Martínez M.M., and Gómez M., Rheological and microstructural evolution of the most common gluten-free flours and starches during bread fermentation and baking. Journal of Food Engineering, 2017, 197, 78-86.
29. Van Dyck T., Verboven P., Herremans E., DefraeyeT.,VanCampenhout L., Wevers M., Claes J., and Nicolaï B., Characterization of structural patterns in bread as evaluated by X-ray computer tomography. Journal of Food Engineering, 2014, 123, 67–77.

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