Effect of rice bran and spent soymilk on the dough rheological properties and quality of bread.pdf

Unika Soegijapranata1

Document Details

Submission ID

trn:oid:::28973:123976192

Submission Date

Dec 8, 2025, 12:42 PM GMT+7

Download Date

Dec 8, 2025, 1:35 PM GMT+7

File Name

Effect of rice bran and spent soymilk on the dough rheological properties and quality of bread.pdf

File Size

512.8 KB

10 Pages

7,631 Words

37,203 Characters

8% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography
- Quoted Text
- Cited Text
- Small Matches (less than 10 words)

Exclusions

- 23 Excluded Matches

Match Groups

7 Not Cited or Quoted 8%
Matches with neither in-text citation nor quotation marks

0 Missing Quotations 0%
Matches that are still very similar to source material

0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation

0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks

Top Sources

8% Internet sources
1% Publications
1% Submitted works (Student Papers)

Integrity Flags

1 Integrity Flag for Review

Hidden Text
90 suspect characters on 10 pages
Text is altered to blend into the white background of the document.

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

Match Groups

- **7** Not Cited or Quoted 8%
  Matches with neither in-text citation nor quotation marks
- **0** Missing Quotations 0%
  Matches that are still very similar to source material
- **0** Missing Citation 0%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

8% Internet sources
1% Publications
1% Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1 Internet
www.myfoodresearch.com 7%

2 Internet
doi.org <1%

3 Submitted works
SDM Universitas Gadjah Mada on 2023-04-05 <1%

Food Research 7 (Suppl. 1) : 151 - 160 (2023)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

Effect of rice bran and spent soymilk on the dough rheological properties and quality of bread

[1]Wang, C.C.R., [2]Nugrahedi, P.Y. and [1,2,*]Johan, Y.

[1]*Department of Food and Nutrition, Providence University, Taichung, Taiwan*
[2]*Department of Food Technology, Soegijapranata Catholic University, Semarang, Indonesia*

Article history:
Received: 5 February 2022
Received in revised form: 6 April 2022
Accepted: 3 November 2022
Available Online: 2 July 2023

Keywords:
Spent soymilk,
Rice bran,
Rheology,
Bread quality

DOI:
https://doi.org/10.26656/fr.2017.7(S1).30

Abstract

The utilization of agricultural residues (ARs) has been involved in the bakery product, particularly due to the functional ingredients of AR. The concept of glycemic index (GI) is indicated to classify carbohydrate-based foods according to their postprandial glucose response. Long term consumption of food with high GI will lead to the risk of chronic disease. The objectives of this study are to investigate the effect of the substitution of AR on the physical properties of dough and physicochemical and sensory properties of breads. Spent soymilk (SS) and rice bran (RB) were used in this study. The results observed that SS and RB contain high fiber ranging from 9.16 to 20.48% (d.b.). The stability and extensibility of rheological properties of dough decreased with the increases of the substitution of AR. The substitution of SS significantly decreased the volume and height of bread but increased hardness and chewiness. The substitution of AR significantly ($p<0.05$) reduced the value of estimated glycemic index (eGI) from 94.6 to 62.9. Moreover, the breads containing 10%, 20% RB, and 10% SS were similar with the control sample according to the result of sensory evaluation, which can be used to improve the nutritional quality of bread.

1. Introduction

Agricultural residue (AR) is the by-products of food manufacture that constituted an economic problem and can lead to environmental problems. However, ARs could also be considered as a promising source of functional compounds (Redondo-Cuenca *et al*., 2008), i.e., most are rich sources of fiber, minerals, and phytochemicals (Martins *et al*., 2017). The applications of AR in food production have been reviewed, such as a food additive (Ayala-Zavala *et al*., 2011), as a substitute of the ingredients in extruded snack (Grasso, 2020) and in bakery products (Martins *et al*., 2017).

Bread has a good source of nutritional needs (Carocho *et al*., 2020), but, starch, as the main component, could potentially lead to a high value of glycemic index (GI) of the product (Zabidi and Aziz, 2009). Long term consumption of high GI foods will lead to the risk of chronic disease such as obesity, cardiovascular disease, and type II diabetes (Shumoy *et al*, 2018). Meanwhile, consumption of dietary fiber and resistant starch (RS) can help to decrease intestinal transit time and increase stools bulk, as well as to reduce total and/or LDL cholesterol levels of blood, and postprandial blood glucose level (Zabidi and Aziz, 2009; Altuna *et al*., 2015). The addition of fiber and RS to bread is expected to reduce the GI value of bread.

The addition of AR to bakery products has risen in popularity due to its high composition of fiber and nutritional functions to prevent chronic disease (Boukid *et al*., 2019; Torbica *et al*., 2019; Wirkijowska *et al*., 2020). For the recycling of ARs on the valued foods, spent soymilk or rice bran can be recovered from spent residues and become an important resource of additives or ingredients of food products. Ktenioudaki and Gallagher (2012) reported the composition of dietary fiber in rice bran is up to 40%. Soybean residues contain 12.2-55.5% (dry basis) of crude fiber (Li *et al*., 2013). However, the addition of these fibers may cause a significant effect on the quality of bread, particularly on the physiological functions of bread (Sudha *et al*., 2007; Rubel *et al*., 2015). The use of non-wheat flour can interfere with the gluten network, resulting in a weakened bread dough and deteriorating the quality of bread (Millar *et al*., 2019). Therefore, the objectives of this research were to study the influence of spent soymilk (SR) and rice bran (RB) flour on the dough's rheological properties and on the quality of bread.

*Corresponding author.
Email: *johanyosefine@gmail.com*

turnitin Page 4 of 13 - Integrity Submission Submission ID trn:oid:::28973:123976192

2. Materials and methods

2.1 Bread preparation

Fresh soy milk spent was offered by Mikely Food Co., Ltd. (Taichung, Taiwan.). Fresh Soy Milk Spent was dried in an oven dryer at 50°C for 10 hrs and continually dried at 60°C for 14 hrs. Dried soy milk spent was blended and sieved through 50 mesh. Rice bran flour and wheat flour were purchased from Shan Shui Me Co., (Miaoli, Taiwan) and Chyafa Enterprise Co., (Taichung, Taiwan), respectively. Milk powder, yeast, sugar salt, egg, and butter were purchased in local supermarkets (Taicung, Taiwan).

Sugar, salt, water, egg, flour, milk powder, and yeast were stirred well for 3 mins at a slow speed, then continued at a medium speed for another 10 mins. Butter was added and stirred at a slow speed for 3 mins and continued at a medium speed for another 7 mins. The dough was proved for 2 hrs. The dough was then baked for 35 mins at 150°C (top side)/200°C (bottom side). The ingredients for five types of the bread are shown in the Table 1.

Table 1. Ingredients in bread making.

Ingredients	0%(g)	10% RB (g)	20% RB2 (g)	10% SS (g)	20% SS (g)
Wheat flour	880	792	704	792	704
Spent soymilk	0	0	0	88	176
Rice bran	0	88	176	0	0
Milk powder	35	35	35	35	35
Yeast	11	11	11	11	11
Sugar	88	88	88	88	88
Salt	13	13	13	13	13
Water	458	458	458	484	546
Egg	70	70	70	70	70
Butter	88	88	88	88	88

0%: 100% wheat flour (control), RB: rice bran flour, SS: spent soymilk flour.

2.2 Dough rheological properties

2.2.1 Farinograph analysis

Farinograph analysis was determined by using Brabender Farinograph-AT (Duisburg, Germany) according to AACC Method 54-21.02 (AACC, 2010a, 2010b). Samples were prepared by mixing wheat flour with soy milk spent flour and rice bran flour at ratios of 100:0, 90:10, and 80:20 to 300.0 g and placed into a Farinograph's mixing bowl. Appropriate amount of water was continuously added until the curve levels off at a value of 500 farinograph units (FU) on a centered curve of 500±20 FU line.

2.2.2 Extensograph analysis

Extensograph analysis was based on AACC method 54.10.01 (AACC, 2010a, 2010b) using Brabender Extensograph-E (Duisburg, Germany). Dough samples from the mixture of wheat flour, soy milk spent flour, and rice bran flour (300.0 g), a 2% salt and optimum water based on Farinograph testing were mixed in Farinograph-AT to form dough. The cylinder dough was placed into the Extensograph dough cradle, secured with pins, and proved for 45, 90, and 135 mins at 30°C.

2.3 Chemical analysis of bread

The standard AACC (2000) was used to measure moisture content (AACC 44-15A), ash (AACC 08-01), crude fat (AACC 30-10), and crude fiber (AACC 32-10). The crude protein content was analyzed by a nitrogen analyzer LECO Truspec N (Michigan, USA). The total starch (AACC Method 76-13.01) and resistant starch (AACC Method 32-40.01) of the bread were measured respectively by the Megazyme Total Starch and Resistant Starch analysis kit (Wicklow, Ireland).

2.4 Physical properties of bread

The volume of the loaves was measured by a rapeseed displacement method according to the AACC 10-05 (2000) by using a bread volumeter equipment. Specific volume of the loaves was calculated from the measured volume obtained by direct measurement.

Texture properties were measured by using a Texture Analyzer TA-XT (England) including shear force and texture profiles, i.e., hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness, and resilience.

Colour of the crumb was measured by using a SE2000 colorimeter (Tokyo, Japan) based on the Hunter L, a, b scale. Each loaf was cut in a circle shape through the middle of the loaf. The total colour difference (ΔE) was calculated as follows:

$$\Delta E = \sqrt{(L_c - L_i)^2 + (a_c - a_i)^2 + (b_c - b_i)^2}$$

Where c: the colour parameters of the control sample and i: the colour parameters of the bread sample.

2.5 Estimated glycemic index

In vitro kinetics of starch digestion was determined according to the modified method of Goñi *et al.* (1997). Samples of bread (50 mg) were incubated in a shaking water bath at 40°C for 1 hour with 0.2 mL pepsin solution and 10 mL HCl-KCl buffer. After that, with tris-maleate buffer (pH 6.9) volume was adjusted to 25 mL and 5 mL of tris-maleate buffer containing 2.6 UI α-amylase was added. The sample solution was incubated in a shaking water bath at 37°C. One mL of each sample

https://doi.org/10.26656/fr.2017.7(S1).30

was taken every 30 mins (0, 30, 60, 90, 120, 150, and 180). The α-amylase was inactivated immediately by incubating at 100°C for 5 mins. A total of 3 mL of 0.4 M sodium acetate buffer pH 4.75 and 60 μL amyloglucosidase (AMG) were added, then the sample was incubated at 60°C for 45 mins in a shaking water bath. The volume was adjusted to 510 mL with distilled water. Triplicated aliquots of 8 μL were incubated with 240 μL GOPOD in an oven at 50°C for 20 mins. Glucose content was measured as mg of glucose × 0.9. The rate of starch digestion was expressed as the percentage of total starch (TS) hydrolyzed at different times.

The kinetics of in vitro digestion is determined by a nonlinear model with a first order equation of $C = C\infty(1-e^{-kt})$, where C = percentage of starch hydrolyzed at time t (min), $C\infty$ = equilibrium percentage of starch hydrolyzed after 180 min, k = the kinetic constant.

The area under the hydrolysis curve (AUC) was calculated using the equation:

$$AUC = C\infty(t\infty-t_0) - (C\infty/k)\ [1-e\hat{}(-k(t\infty-t_0)]$$

Where $t\infty$ = final time (180 min) and t_0 = the initial time (0 min).

The in vitro GI was calculated by using the equation:

$$eGI = 39.71 + (0.549\times HI)$$

2.6 Sensory evaluation

Sensory evaluation of the bread was carried out by using a nine-point hedonic scale (1 = dislike extremely; 5 = neither like nor dislike; 9 = like extremely) performed by 13 semi-trained panelists (4 males and 9 females) ranging from 20-30 years old. The panelist was trained twice before the sensory evaluation held. They were master students of Food and Nutrition Department, Providence University, Taiwan. The evaluated sensory attributes include golden brown colour, aroma, tenderness, stickiness after chewing, and overall acceptability of baked bread. The bread samples were sliced mechanically (1 cm thick) and divided into three parts prior to serving. The bread sample (encode) serving order was randomized. Distilled water was used to clean panelists' palate.

2.7 Data analysis

The data were expressed as mean and standard deviation by measuring at least triplicate, except for the total starch and resistant starch content. Statistical analyses were carried out with One-way ANOVA and followed by Duncan's multiple test ($P < 0.05$) using software SAS University Edition (SAS Institute Inc., Cary, NC).

3. Results and discussion

3.1 Dough rheological properties

Water absorption (WA) of dough with the substitution of AR increased significantly ($p<0.05$) from 61.6% to 82.0% (Table 2). The increase of WA was mainly attributed by the number of hydroxyl groups presenting in fiber that led to a more interaction between water and biomolecular activity. The increase of competition between water and other polymers, such as proteins and starch, could influence the water distribution in dough (Khalid *et al*., 2017; Wirkijowska *et al*., 2020). Moreover, the substitution of SS showed higher WA as compared to the RB substitution, which could be SS flour contained higher proportion of fiber and a greater amount of protein in SS flour. Accordingly, Kamble and Rani (2020) reported that SS possesses geometric structures with some gaps. The gaps are in charge of the high occurrence of permeable pores which were responsible for high WA.

Table 2. Farinograph properties of dough substituted with AR.

AR substitution	Water absorption (%)	Development time (min)	Stability (min)
0%	61.6±0.4^d	7.9±0.2^e	27.6±1.5^a
10% RB	62.0±0.1^d	9.4±0.2^c	20.3±0.5^b
20% RB	63.6±0.1^c	11.3±0.2^b	8.3±0.3^c
10% SS	74.5±0.8^b	8.4±0.3^d	21.6±1.9^b
20% SS	82.0±0.1^a	15.4±0.1^a	17.2±4.9^b

Values are presented as mean±SD (n = 3). Values with different superscripts within the same column are statistically significantly different ($p<0.05$). 0%: 100% wheat flour (control), RB: rice bran flour, SS: spent soymilk flour.

The dough development time (DDT) increased significantly ($p<0.05$) with the increase of substitution of both RB and SS (Table 2). The DDT significantly increased by the increase of AR substitution (0-20%). This could be due to the fiber content of RB and SS leading to the increase of the time of dough development. Martins *et al*. (2017) and Xing *et al*. (2021) reported that neither due to the dilution and hydration of gluten network, or presence of hydrophilic components in AR, nor increment of fiber that led to a greater number of hydroxyl groups available for interaction with water through hydrogen bond during dough development. Thus, the formation of hydrogen bonds and electronic forces in the dough system increase the DDT significantly.

Stability of dough (DS) in this study decreased significantly with the increase of AR substitution ($p<0.05$) (Table 2). Possibly, the AR components delay the hydration and extension of peptides that lead to the difficulties in the proper formation of the gluten matrix during mixing (Wirkijowska *et al*., 2020). In general, DS

https://doi.org/10.26656/fr.2017.7(S1).30

against mechanical factors could be decreased by damages imparted to the gluten structure by adding any fiber resource into the formulation of bread (Taghinia *et al*., 2016). The substitution of 20% RB showed the lowest DS. This phenomenon could be bran disrupted and changed the protein secondary structure that decreased gluten functionality.

Furthermore, these results meet the agreements with Taghinia *et al*. (2016) and Yaseen *et al*., (2009) that the higher substitution of AR caused the lower DS. However, there is no difference in the DS in the range of 10% and 20% SS substitution that could be due to a small particle size of SS incorporated into the dough formation. Chisenga *et al*. (2020) indicated that reducing the particle size could strengthen the gluten network resulting in longer mixing stability of the dough.

By the substitution of AR, all the parameter levels decreased significantly ($p<0.05$) (Table 3). The decreased values of E, Ex, and RE indicate either the reduction of protein content due to the deficiency of gliadin in RB and SS protein, or the decrease of protein quality disrupted by the substitution of AR. Bagheri and Seyedein (2011) and Yaseen *et al*. (2009) also observed the decrease of extensograph parameters by the substitution of RB and SS. On the other hand, the incorporation of large amounts of soy products had negative effects in gluten network formation, extensibility properties, gas retention of dough, and final bread quality (Yaseen *et al*., 2009). The results clarified the substitution of SS showing the lower value of all parameters. RE increased with the increase of time due to a direct effect in decreasing extension capacity as well as resistance to extension (Bagheri and Seyedein, 2011). Meanwhile, the decrement in Ex can be due to the increment of thiol group or a sulfhydryl group (SH) quantity, which oxidizes the dough with oxygen through the mechanical action (Mohammed *et al*., 2012). Mohammed *et al*. (2012) also reported the transformation of SH-bonds in disulfide bond (SS-bond) and this newly formed SS-bond managed to the solidification (increased elasticity) of the gluten and the dough.

3.2 Chemical properties of bread

Moisture content of bread increased significantly ($p < 0.05$) from 37.2% to 41.8% by the substitution of AR (Figure 1). Higher substitution of AR led to higher moisture content in bread. Bread contained SS have a higher moisture content rather than in RB bread, because SS have higher fiber and protein content. Porcel *et al*., (2017) reported the substitution SS in bread could lead to the increase of moisture content due to the hygroscopic nature in protein and fiber. Moreover, Zhao *et al*. (2021) reported that the moisture content in soy product was considerably higher than traditional wheat breads due to the high-water holding capacity. Sharif and Butt (2006) reported that RB contained more cellulose and non-starch polysaccharides to hold water up to several times of their weight.

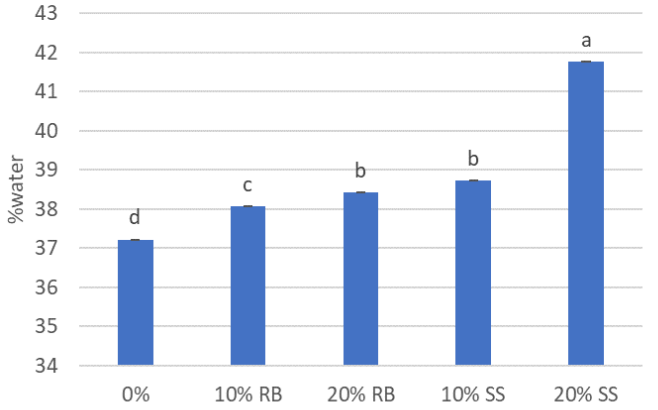

Figure 1. Moisture content of bread with AR substitution. Bars with different notations are statistically significantly different ($p<0.05$) ($n = 3$).

The content of crude fat, crude fiber, and ash increased with the increase of AR substitution in the bread (Table 4) that meet the agreement of the previous researches of Pauline *et al.* (2020) and Porcel *et al.* (2017). Crude fat and crude fiber content increased from 11.2% to 16.3% from 1.6% to 5.0% respectively, with the increase of AR in the ranges of 0-20%. Ash content increased from 2.9% to 4.7%. Crude protein content increased up to 16% in the substitution of SS, but slightly decreased to 14.7% in RB substitution. However, there was a slight decrease in crude protein for RB

Table 3. Extensograph properties of dough substitute with AR.

AR substitution	Energy (cm^2)			Extensibility (mm)			Resistance to Extension (BU)		
	45	90	135	45	90	135	45	90	135
0%	$233±5^a$	$203±40^a$	$187±22^a$	$171±8^a$	$119±15^a$	$109±2^a$	$625±75^a$	$1296±259^a$	$1437±174^a$
10% RB	$167±13^b$	$170±10^a$	$159±4^b$	$150±11^b$	$107±6^a$	$98±4^b$	$585±9^a$	$1149±45^a$	$1330±122^a$
20% RB	$82±2^d$	$101±4^b$	$97±5^c$	$133±4^c$	$105±2^a$	$95±1^b$	$381±27^b$	$709±52^b$	$802±33^b$
10% SS	$97±3^c$	$90±7^b$	$62±2^d$	$139±3^{bc}$	$116±3^a$	$112±4^a$	$419±8^b$	$530±25^b$	$400±18^c$
20% SS	$29±2^e$	$23±1^c$	$15±1^e$	$86±5^d$	$77±7^b$	$66±4^c$	$202±21^c$	$148±7^c$	$75±12^d$

Values are presented as mean±SD ($n = 3$). Values with different superscripts within the same column are statistically significantly different ($p<0.05$). 0%: 100% wheat flour (control), RB: rice bran flour, SS: spent soymilk flour.

https://doi.org/10.26656/fr.2017.7(S1).30

Table 4. Chemical composition of bread with AR substitution (% dry basis).

AR substitution	Crude fat	Crude fiber	Ash	Crude protein
0%	11.20±0.39[c]	1.60±0.10[d]	2.92±0.03[e]	15.25±0.18[c]
10% RB	13.44±0.34[b]	1.95±0.14[d]	3.81±0.09[c]	14.91±0.14[d]
20% RB	16.32±0.92[a]	2.51±0.09[c]	4.72±0.01[a]	14.69±0.11[d]
10% SS	13.97±0.50[b]	3.27±0.26[b]	3.40±0.08[d]	15.50±0.07[b]
20% SS	16.01±0.30[a]	5.01±0.49[a]	3.91±0.02[b]	16.04±0.17[a]

Values are presented as mean±SD (*n* = 3). Values with different superscripts within the same column are statistically significantly different (p<0.05). 0%: 100% wheat flour (control), RB: rice bran flour, SS: spent soymilk flour.

substitution which was also observed by Pauline *et al.* (2020). The decrease of protein could be due to heat treatment during bread production (Pauline *et al*., 2020).

Total starch content of bread decreased significantly (p<0.05) with the increase of AR substitution (Table 5). Total starch of bread decreased with the decrease of total carbohydrate from AR because of the lower starch content in AR. Although the resistant starch (RS) content seems to be varied among test samples, the substitution of AR resulted in a slight decreases of RS content of bread. Several factors, such as teat-moisture treatment and amylose content, influenced the RS content of starch. Eerlingen and Delcour (1995) reported that high moisture content could gelatinize more starch and led to more retrograded starch (RS type III). Moreover, amylose content in bread is another factor to affect the RS content (Eerlingen and Delcour, 1995).

Table 5. Total starch and resistant content in bread with AR substitution (% dry basis).

AR substitution	Total starch	Resistant starch
0%	82.80±1.61[a]	1.95±0.25[a]
10% RB	76.30±0.27[b]	1.73±0.01[a]
20% RB	71.67±0.71[b]	1.55±0.02[a]
10% SS	73.39±0.62[b]	1.58±0.04[a]
20% SS	60.40±4.33[c]	1.72±0.26[a]

Values are presented as mean±SD (*n* = 3). Values with different superscripts within the same column are statistically significantly different (p<0.05). 0%: 100% wheat flour (control), RB: rice bran flour, SS: spent soymilk flour.

In bread itself, the RS_1 could be obtained because the starch was encapsulated by the gluten network and led into the ungelatinized starch (Roman and Martinez, 2019). That might be one of the reasons in the control bread (0%) exhibited a higher content of RS. Normal wheat used for making bread contained more amylose (25%), compared to RB which contained only 5% amylose (Fabian *et al*., 2011). These phenomena could explain that higher substitution of RB decreased the RS content. Meanwhile, the substitution of SS decreased the RS as compared to the control. The higher substitution of SS (20%) resulted in the higher RS of bread. This phenomenon could be caused by the higher moisture content in bread with 20% SS which led to more starch gelatinization and produced the RS type III.

3.3 Physical properties of bread

Mass, volume, height, and specific volume (SV) of bread with substitution of RB were not significantly different (P<0.05) compared to the control (Table 6). The bread volume, height, and specific volume containing 10-20% SS significantly decreased (p<0.05). Mass of bread with 10% SS substitution indicated slightly heavier than the others that could be high water retention of SS. Yaseen *et al*. (2009) reported that the decrease of bread volume by SS substitution was due to the dilution of gluten. Fiber was the dominant factor to affect the physical properties of bread since fiber could breakdown gluten networks (Porcel *et al*., 2017). It can be explained that the gluten networks have the ability to retain the carbon dioxide produced by yeast during fermentation and early stages of baking, which determine the loaf volume (Huang *et al*., 2020; Chikpah *et al.,* 2021). However, SS and gluten in the bread were not sufficiently hydrated and thus did not develop optimally resulting in the decrease of bread volume (Pauline *et al*., 2020). Therefore, an appropriate amount of substitution AR could maintain the physical properties of bread. On other hand, the substitution of RB showed no significant difference (p<0.05) as compared to control.

The bread with the substitution of SS decreased the

Table 6. Physical properties of bread with AR substitution.

AR substitution	Weight (g)	Volume (cm^3)	Height (cm)	Specific volume (cm^3/g)
0%	482.79±1.13[bc]	1800±50[a]	12.93±0.13[a]	3.73±0.10[ab]
10% RB	480.79±1.18[c]	1833±76[a]	12.52±0.18[ab]	3.81±0.15[a]
20% RB	484.45±1.12[b]	1690±66[a]	12.20±0.14[b]	3.49±0.14[b]
10% SS	488.06±0.92[a]	1517±104[b]	10.06±0.67[c]	3.11±0.21[c]
20% SS	484.37±1.62[b]	733±76[c]	6.76±0.32[d]	1.51±0.16[d]

Values are presented as mean±SD (*n* = 3). Values with different superscripts within the same column are statistically significantly different (p<0.05). 0%: 100% wheat flour (control), RB: rice bran flour, SS: spent soymilk flour.

https://doi.org/10.26656/fr.2017.7(S1).30

height of bread, but there is no difference between the control and the RB substitution in the height of bread (Figure 2). Moreover, the substitution of RB significantly increased the size of air bucket as compared to control set (Figure 3). The bread incorporated with 10-20% SS substitution also showed evenly distributed air buckets similar with the control set. But, the structure of bread with 20% SS substitution became more contiguous and more compact than the other breads (Figure 3).

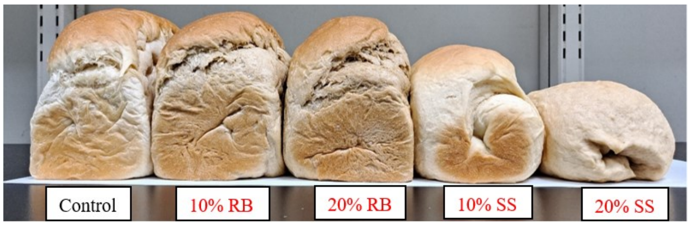

Figure 2. Loaf of bread

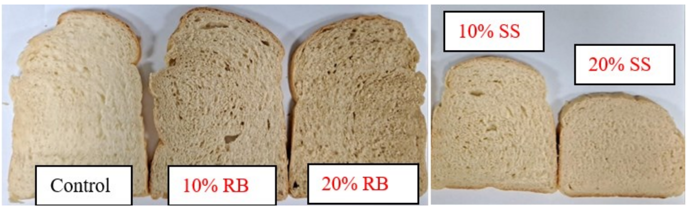

Figure 3. Slice of bread

The substitution of AR significantly decreased the L* value ($p<0.05$) (Table 7). Meanwhile, the value of a* (redness) and b* (yellowness) and ΔE (colour differences) increased significantly ($p<0.05$). Porcel *et al*. (2017) and Yaseen *et al*. (2009) reported the same results for crumb appearance of bread containing SS that was slightly darker (lower L value) and more red-yellow colored (higher a* and b* values) than the control sample. Yellow colour contribution might be due to rich yellow pigments in SS, such as xanthophylls (Yaseen *et al*., 2009). Ibidapo *et al.* (2020) reported higher b* (yellowness) value found in bread with SS substitution that might indicate the existence of a high amount of protein, which enhanced the Maillard and caramelization reactions that were responsible for golden brownish coloration and variety of colored compounds. While, lower L* value in bread with substitution of RB could be due to phenolic compounds in RB to exhibit a gray colour to bread (Pauline *et al*., 2020). However, the appearance of bread would depend on the nature of the flour and the particle size substituted flour (Kurek *et al*., 2017).

No significant differences were observed in hardness, adhesiveness and gumminess among the AR substitutions of breads ($p<0.05$) except for the 20% SS (Table 8). The adhesiveness, gumminess, and chewiness increased significantly different for the SS substitution, but no different for RB substitution. Porcel *et al.* (2017) indicated the enriched bread with polysaccharides and proteins in bread formulations increased the hardness of the samples. Amylose and amylopectin matrix interactions with gluten and fiber could be attributed to the hardness parameter (Martins *et al*., 2017). The increment value of hardness would lead to increment value of gumminess and chewiness, but decrease the value of cohesiveness. Furthermore, as reported by Martins *et al.* (2017), the substitution of AR in bread generally increased hardness and chewiness resulted in the decrease of cohesiveness. As shown in Table 8, cohesiveness and resilience of bread decreased significantly ($p<0.05$) by the substitution of AR. Springiness, cohesiveness, and chewiness were affected by interactions between gelatinized starch and gluten dough that created elastic dough and formed bread sponge structure after heating (Martins *et al*., 2017). However, no difference was observed in the texture profile of substitution of 10% RB bread.

Table 7. Colour properties of the bread with AR substitution.

Bread	L*	a*	b*	ΔE
0%	80.26 ± 0.18^{a}	1.65 ± 0.04^{d}	21.97 ± 0.12^{e}	0.00 ± 0.00^{e}
10% RB	71.83 ± 0.10^{d}	3.14 ± 0.01^{b}	24.17 ± 0.02^{b}	8.84 ± 0.10^{b}
20% RB	65.66 ± 0.22^{e}	4.27 ± 0.01^{a}	24.93 ± 0.05^{a}	15.13 ± 0.22^{a}
10% SS	78.84 ± 0.20^{b}	2.47 ± 0.03^{c}	22.70 ± 0.08^{d}	1.80 ± 0.19^{d}
20% SS	72.29 ± 0.14^{c}	4.26 ± 0.03^{a}	23.37 ± 0.09^{c}	8.50 ± 0.14^{c}

Values are presented as mean±SD (n = 3). Values with different superscripts within the same column are statistically significantly different ($p<0.05$). 0%: 100% wheat flour (control), RB: rice bran flour, SS: spent soymilk flour.

Table 8. Texture profile of bread with AR substitution.

AR substitution	Hardness (g)	Adhesiveness (g.s)	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
0%	313 ± 45^{b}	-0.83 ± 0.53^{a}	0.93 ± 0.00^{a}	0.69 ± 0.01^{a}	216 ± 29^{b}	201 ± 26^{c}	0.25 ± 0.01^{a}
10% RB	284 ± 29^{b}	-0.42 ± 0.33^{a}	0.94 ± 0.02^{a}	0.70 ± 0.01^{a}	200 ± 23^{b}	188 ± 24^{c}	0.25 ± 0.02^{a}
20% RB	354 ± 28^{b}	-1.23 ± 0.54^{a}	0.84 ± 0.04^{b}	0.62 ± 0.03^{b}	218 ± 7^{b}	184 ± 3^{c}	0.19 ± 0.01^{c}
10% SS	616 ± 60^{b}	-0.74 ± 0.08^{a}	0.88 ± 0.02^{ab}	0.65 ± 0.01^{b}	398 ± 45^{b}	351 ± 46^{b}	0.22 ± 0.01^{b}
20% SS	2755 ± 541^{a}	-7.97 ± 1.06^{b}	0.83 ± 0.07^{b}	0.53 ± 0.01^{c}	1452 ± 323^{a}	1195 ± 164^{a}	0.15 ± 0.01^{d}

Values are presented as mean±SD (n = 3). Values with different superscripts within the same column are statistically significantly different ($p<0.05$). 0%: 100% wheat flour (control), RB: rice bran flour, SS: spent soymilk flour.

https://doi.org/10.26656/fr.2017.7(S1).30

Shear force of bread is the interpretation of the force needed to chew the bread. Higher value of shear force indicated a harder and stickier texture profiles in the bread. The shear force increased significantly with the increase of SS substitution (p<0.05), but not found in the bread with RB substitution (Table 9).

Table 9. Shear force of bread with AR substitution.

AR substitution	Shear work (g.s)
0%	2957± 119[b]
10% RB	2904±202[b]
20% RB	3131±263[b]
10% SS	5223±398[a]
20% SS	5629±402[a]

Values are presented as mean±SD (*n* = 3). Values with different superscripts within the same column are statistically significantly different (p<0.05). 0%: 100% wheat flour (control), RB: rice bran flour, SS: spent soymilk flour.

3.4 Estimate glycemic index

The EGI value of bread significantly decreased with the increase of the proportion of AR substitution (Table 10). The lower GI in both substitution RB and SS could be due to the high content of fiber. The IDF is the primary component of fiber in RB and SS. Thus, the IDF might contribute to the low EGI of these foods. Encapsulation of nutrients inside plant cell walls in fiber could prevent starch digestion, for the further decrease of the GI (Zabidi and Aziz, 2009). Low GI in SS products could be due to the high galacturonic acid content of SS fiber (Kamble and Rani, 2020). Nevertheless, a high-protein diet might be beneficial for people with diabetes (Li *et al*., 2012). Low-GI diets might have implications in the prevention and management of chronic diseases like type 2 diabetes, coronary heart disease or some cancers (Li, Qiao and Lu *et al*., 2012). Moreover, compared to IDF, soluble dietary fiber (SDF) demonstrated more effect to decrease eGI value. SDF reduced the dietary carbohydrate absorption rate by forming a viscous gel in the small intestine, hence reducing postprandial blood glucose response (Lu *et al*., 2013). The SS samples showed higher SDF than the RB samples, which could lower EGI of bread by substitution of SS.

Table 10. Estimated glycemic index (eGI) of bread with AR substitution.

AR substitution	eGI
0%	94.61[a]
10% RB	87.65±0.35[b]
20% RB	62.92±1.73[d]
10% SS	73.53±0.63[c]
20% SS	64.73±2.57[d]

Values are presented as mean±SD (*n* = 3). Values with different superscripts within the same column are statistically significantly different (p<0.05). 0%: 100% wheat flour (control), RB: rice bran flour, SS: spent soymilk flour.

3.5 Sensory acceptance

The results of sensory evaluation of bread with AR substitution were presented in Table 11. The bread incorporated with RB significantly increased the golden-brown colour and stickiness. The bread with SS substitution decreased the tenderness but increased the stickiness with the increase of SS substitution proportion (0-20%). However, no difference was found in aroma among the different AR substitutions. The overall acceptability of test breads indicated the control set is significantly higher than both RB an SS substitution (p<0.05). Moreover, the similar acceptance to the bread with both 10% SS and RB was found that closed to control bread. The bread contained 20 % SS showed the lowest acceptability in the score of 2.92, where the score of 3 indicates a dislike moderately. Therefore, the bread with 20% SS substitution is unacceptable, which could be due to the weak aroma, less tenderness, and strong stickiness of baked goods.

4. Conclusion

The substitution of RB and SS significantly decreased the dough quality by decreasing dough stability and extensibility due to the lack of gluten content. However, the substitutions of AR showed increasing nutritional values of bread in both crude fiber and crude protein. The SS substitution decreased the appearance of bread, particularly in volume and height. The bread incorporated with 10% RB indicated indifference in all texture parameters as compared to the control set. The value of estimated glycemic index (EGI) significantly decreased in both RB and SS substituted

Table 11. Hedonic score of panelists on the bread with AR substitution.

AR substitution	Colour	Aroma	Tenderness	Stickiness	Overall acceptability
0%	4.92[b]	5.15[a]	4.85[a]	4.77[b]	7.69[a]
10% RB	6.77[a]	3.92[ab]	4.92[a]	5.31[b]	5.08[bc]
20% RB	7.23[a]	4.00[ab]	4.85[a]	5.69[b]	4.46[c]
10% SS	4.77[b]	4.38[ab]	3.54[b]	5.62[b]	5.69[b]
20% SS	4.08[b]	3.46[b]	1.92[c]	7.15[a]	2.92[d]

Values are presented as mean±SD (*n* = 3). Values with different superscripts within the same column are statistically significantly different (p<0.05). 0%: 100% wheat flour (control), RB: rice bran flour, SS: spent soymilk flour.

https://doi.org/10.26656/fr.2017.7(S1).30

breads. The substitution of RB and SS in bread decreased the overall acceptability as compared to the control sample. Nevertheless, from the viewpoint of the benefit of health, the substitution of RB and SS can be used to improve the nutritional quality as well as to enhance the valued foods from the agricultural residues. More investigation will be needed to prevent the decrease of physical quality of bread.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

This study was made possible through financial support provided by U-Start Co., Ltd., Taichung, Taiwan.

References

AACC. (2000). International. Approved methods of the AACC. St. Paul, Minnesota, USA: American Association of Cereal Chemists.

Altuna, L., Ribotta, P.D. and Tadini, C.C. (2015). Effect of a combination of enzymes on dough rheology and physical and sensory properties of bread enriched with resistant starch. *LWT - Food Science and Technology*, 64(2), 867–873. https://doi.org/10.1016/j.lwt.2015.06.024

American Association of Cereal Chemists. (2010a). Method 54-10.01. Physical dough test procedure. 11th ed. Minnesota, USA: AACC International.

American Association of Cereal Chemists. (2010b). Method 54-21.02. Constant weight flour procedure. 11th ed. Minnesota, USA: AACC International.

Ayala-Zavala, J.F., Vega-Vega, V., Rosas-Domínguez, C., Palafox-Carlos, H., Villa-Rodriguez, J.A., Siddiqui, M.W., Davila-Aviba, J.E. and González-Aguilar, G.A. (2011). Agro-industrial potential of exotic fruit byproducts as a source of food additives. *Food Research International*, 44(7), 1866–1874. https://doi.org/10.1016/j.foodres.2011.02.021

Bagheri, R. and Seyedein, S.M. (2011). The effect of adding rice bran fibre on wheat dough performance and bread quality. *World Applied Sciences Journal*, 14(Special Issue 3), 121–125.

Boukid, F., Zannini, E., Carini, E. and Vittadini, E. (2019). Pulses for bread fortification: A necessity or a choice? *Trends in Food Science and Technology*, 88, 416–428. https://doi.org/10.1016/j.tifs.2019.04.007

Carocho, M., Morales, P., Ciudad-Mulero, M., Fernández-Ruiz, V., Ferreira, E., Heleno, S., Rodrigues, P., Barros, L. and Ferreira, I.C.F.R. (2020). Comparison of different bread types: Chemical and physical parameters. *Food Chemistry*, 310, 125954. https://doi.org/10.1016/j.foodchem.2019.125954

Chikpah, S.K., Korese, J.K., Hensel, O., Sturm, B. and Pawelzik, E. (2021). Rheological properties of dough and bread quality characteristics as influenced by the proportion of wheat flour substitution with orange-fleshed sweet potato flour and baking conditions. *LWT*, 147, 111515. https://doi.org/10.1016/j.lwt.2021.111515

Chisenga, S.M., Workneh, T.S., Bultosa, G., Alimi, B.A. and Siwela, M. (2020). Dough rheology and loaf quality of wheat-cassava bread using different cassava varieties and wheat substitution levels. *Food Bioscience*, 34, 100529. https://doi.org/10.1016/j.fbio.2020.100529

Eerlingen, R.C. and Delcour, J.A. (1995). Formation, analysis, structure and properties of type III enzyme resistant starch. *Journal of Cereal Science*, 22(2), 129–138. https://doi.org/10.1016/0733-5210(95)90042-X

Fabian, C., Ayucitra, A., Ismadji, S. and Ju, Y.H. (2011). Isolation and characterization of starch from defatted rice bran. *Journal of the Taiwan Institute of Chemical Engineers*, 42(1), 86–91. https://doi.org/10.1016/j.jtice.2010.03.013

Goñi, I., Garcia-Alonso, A., Saura-Calixto, F., Garcia-Alonso, A. and Saura-Calixto, F. (1997). A starch hydrolysis procedure to estimate glycemic index. *Nutrition Research*, 17(3), 422–437. https://doi.org/10.1016/S0271-5317(97)00010-9

Grasso, S. (2020). Extruded snacks from industrial by-products: A review. *Trends in Food Science and Technology*, 99, 284–294. https://doi.org/10.1016/j.tifs.2020.03.012

Huang, Z., Wang, J.J., Chen, Y., Wei, N., Hou, Y., Bai, W. and Hu, S.Q. (2020). Effect of water-soluble dietary fiber resistant dextrin on flour and bread qualities. *Food Chemistry*, 317, 126452. https://doi.org/10.1016/j.foodchem.2020.126452

Ibidapo, O.P., Henshaw, F.O., Shittu, T.A. and Afolabi, W.A. (2020). Quality evaluation of functional bread developed from wheat, malted millet (*Pennisetum Glaucum*) and 'okara' flour blends. *Scientific African*, 2020, e00622. https://doi.org/10.1016/j.sciaf.2020.e00622

Kamble, D.B. and Rani, S. (2020). Bioactive components, in vitro digestibility, microstructure and application of soybean residue (okara): a review. *Legume Science*, 2(1), 2–10. https://doi.org/10.1002/

leg3.32

Khalid, K.H., Ohm, J.B. and Simsek, S. (2017). Whole wheat bread: Effect of bran fractions on dough and end-product quality. *Journal of Cereal Science*, 78, 48–56. https://doi.org/10.1016/j.jcs.2017.03.011

Ktenioudaki, A. and Gallagher, E. (2012). Recent advances in the development of high-fibre baked products. *Trends in Food Science and Technology*, 28(1), 4–14. https://doi.org/10.1016/j.tifs.2012.06.004

Kurek, M.A., Wyrwisz, J., Karp, S., Brzeska, M. and Wierzbicka, A. (2017). Comparative analysis of dough rheology and quality of bread baked from fortified and high-in-fiber flours. *Journal of Cereal Science*, 74, 210–217. https://doi.org/10.1016/j.jcs.2017.02.011

Lee, D., Kim, M.J., Kwak, H.S. and Kim, S.S. (2020). Characteristics of bread made of various substitution ratios of bran pulverized by hammer mill or jet mill. *Foods*, 9(1), 9010048. https://doi.org/10.3390/foods9010048

Li, B., Lu, F., Nan, H. and Liu, Y. (2012). Isolation and structural characterisation of okara polysaccharides. *Molecules*, 17(1), 753–761. https://doi.org/10.3390/molecules17010753

Li, B., Qiao, M. and Lu, F. (2012). Composition, nutrition and utilization of okara (soybean residue). *Food Reviews International*, 28(3), 231–252. https://doi.org/10.1080/87559129.2011.595023

Li, S., Zhu, D., Li, K., Yang, Y., Lei, Z. and Zhang, Z. (2013). Soybean curd residue: composition, utilization and related limiting factors. *ISRN Industrial Engineering*, 2013, 423590. https://doi.org/10.1155/2013/423590

Lu, F., Liu, Y. and Li, B. (2013). Okara dietary fiber and hypoglycemic effect of okara foods. *Bioactive Carbohydrates and Dietary Fibre*, 2(2), 126–132. https://doi.org/10.1016/j.bcdf.2013.10.002

Martins, Z.E., Pinho, O. and Ferreira, I.M.P.L.V.O. (2017). Food industry by-products used as functional ingredients of bakery products. *Trends in Food Science and Technology*, 67, 106–128. https://doi.org/10.1016/j.tifs.2017.07.003

Millar, K.A., Barry-Ryan, C., Burke, R., McCarthy, S. and Gallagher, E. (2019). Dough properties and baking characteristics of white bread, as affected by addition of raw, germinated and toasted pea flour. *Innovative Food Science and Emerging Technologies*, 56, 102189. https://doi.org/10.1016/j.ifset.2019.102189

Mohammed, I., Ahmed, A.R. and Senge, B. (2012). Dough rheology and bread quality of wheat-chickpea flour blends. *Industrial Crops and Products*, 36(1), 196–202. https://doi.org/10.1016/j.indcrop.2011.09.006

Pauline, M., Roger, P., Sophie Natacha Nina, N.E., Arielle, T., Eugene, E.E. and Robert, N. (2020). Physico-chemical and nutritional characterization of cereals brans enriched breads. *Scientific African*, 7, e00251. https://doi.org/10.1016/j.sciaf.2019.e00251

Porcel, M.V.O., Campderrós, M.E. and Instituto, A.N.R. (2017). Effect of Okara Flour Addition on the Physical and Sensory Quality of Wheat Bread. *MOJ Food Processing and Technology*, 4(6), 184–190. https://doi.org/10.15406/mojfpt.2017.04.00111

Redondo-Cuenca, A., Villanueva-Suárez, M.J. and Mateos-Aparicio, I. (2008). Soybean seeds and its by-product okara as sources of dietary fibre. Measurement by AOAC and Englyst methods. *Food Chemistry*, 108(3), 1099–1105. https://doi.org/10.1016/j.foodchem.2007.11.061

Roman, L. and Martinez, M.M. (2019). Structural basis of resistant starch (RS) in bread: Natural and Commercial Alternatives. *Foods*, 8(7), 267. https://doi.org/10.3390/foods8070267

Rubel, I.A., Pérez, E.E., Manrique, G.D. and Genovese, D.B. (2015). Fibre enrichment of wheat bread with Jerusalem artichoke inulin: Effect on dough rheology and bread quality. *Food Structure*, 3, 21–29. https://doi.org/10.1016/j.foostr.2014.11.001

Sharif, K. and Butt, M.S. (2006). Preparation of fiber and mineral enriched pan bread by using defatted rice bran. *International Journal of Food Properties*, 9(4), 623–636. https://doi.org/10.1080/10942910600580625

Shumoy, H., Van Bockstaele, F., Devecioglu, D. and Raes, K. (2018). Effect of sourdough addition and storage time on *in vitro* starch digestibility and estimated glycemic index of tef bread. *Food Chemistry*, 264, 34–40. https://doi.org/10.1016/j.foodchem.2018.05.019

Sudha, M.L., Vetrimani, R. and Leelavathi, K. (2007). Influence of fibre from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. *Food Chemistry*, 100(4), 1365–1370. https://doi.org/10.1016/j.foodchem.2005.12.013

Taghinia, P., Ataye-Salehi, E. and Sheikholeslami, Z. (2016). Impact of pretreated rice bran on wheat dough performance and barbari bread quality. *Journal of Agricultural Science and Technology*, 18 (1), 135–144.

Torbica, A., Škrobot, D., Janić Hajnal, E., Belović, M. and Zhang, N. (2019). Sensory and physico-chemical properties of wholegrain wheat bread prepared with selected food by-products. *LWT*, 114, 108414. https://doi.org/10.1016/j.lwt.2019.108414

Wirkijowska, A., Zarzycki, P., Sobota, A., Nawrocka, A., Blicharz-Kania, A. and Andrejko, D. (2020). The possibility of using by-products from the flaxseed industry for functional bread production. *LWT*, 118, 108860. https://doi.org/10.1016/j.lwt.2019.108860

Xing, Q., Kyriakopoulou, K., Zhang, L., Boom, R.M. and Schutyser, M.A.I. (2021). Protein fortification of wheat bread using dry fractionated chickpea protein-enriched fraction or its sourdough. *LWT*, 142, 110931. https://doi.org/10.1016/j.lwt.2021.110931

Yaseen, A.A., Shouk, A.A. and Abousalem, F. (2009). Effect of okara addition on bread quality. *Journal of Food and Dairy Sciences*, 34(12), 11147–11155. https://doi.org/10.21608/jfds.2009.115828

Zabidi, M.A. and Aziz, N.A.A. (2009). *In vitro* starch hydrolysis and estimated glycaemic index of bread substituted with different percentage of chempedak (*Artocarpus integer*) seed flour. *Food Chemistry*, 117(1), 64–68. https://doi.org/10.1016/j.foodchem.2009.03.077

Zhao, C.C., Lu, J.K. and Ameer, K. (2021). Effects of tofu whey powder on the quality attributes, isoflavones composition and antioxidant activity of wheat flour pan bread. *LWT*, 143, 111166 https://doi.org/10.1016/j.lwt.2021.111166