Food Research 7 (4) : 281 - 288 (August 2023)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

The characteristic of whole wheat bread supplemented with roselle (*Hibiscus sabdariffa*) powder

[1]Nor Qhairul Izzreen, M.N., [1]Noor Syafiqah, A., [1]Hasmadi, M.,[2]Nurul Hanisah, J., [1]Pindi, W. and [1]Siti Faridah, M.A.

[1]*Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia*
[2]*Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*

Article history:
Received: 1 August 2022
Received in revised form: 2 September 2022
Accepted: 7 October 2022
Available Online: 28 August 2023

Keywords:
Roselle powder,
Bread performance,
Dough rheology,
Sensory evaluation

DOI:
https://doi.org/10.26656/fr.2017.7(4).340

Abstract

Roselle (*Hibiscus sabdariffa*) has many health benefits and all parts of the roselle, including calyx, seeds, leaves, fruits and roots. Over the years, high demand for whole-grain products has been observed worldwide due to their high nutritional values and protective effects against several chronic diseases. Whole wheat bread is one of the most consumed whole-grain products. However, products of whole wheat flour had lower consumer acceptability than refined flour. The objective of this study was to investigate the effects of the addition of roselle powder (1, 2, or 3%) on the characteristics and composition of whole wheat dough and whole wheat bread. Bread quality is determined by sensory evaluation, bulk density, texture profile analysis (TPA), colour and moisture content, ash, protein, fat, crude fibre, and carbohydrates. The sensory analysis showed the 2% roselle powder was the best bread formulation with 6.65±1.00 of panel acceptance compared to the other formulations. By incorporating roselle powder, the height of the dough was similar to any commercial bread (10 cm) and could shorten the fermentation time from 60 to 45 mins. Sensory-wise, the bread colour was lighter and reddish, which was appealing with the values of 53.92±0.02 for ΔE*. The firmness of roselle bread was reduced from 4.60±o.42 to 2.55±0.46 with a decreasing amount of roselle powder from 3% to 1% but increased to 5.19±0.15 during 4 days of storage. Interestingly, roselle bread has the potential to reduce staling of bread during storage with a value of 6.29±0.35 in control bread to 5.19±0.15 in F2 roselle bread after certain days of storage.

1. Introduction

Nowadays, there has been a growing interest in natural foods as consumers become more aware of the importance of diet and health. This demand is practically due to the advertising and scientific investigations showing the benefits that these foods may contribute to health. This trend leads to increasing demand for natural ingredients such as food supplements and preservatives specifically of plant origin and is known as functional food (Gul *et al.*, 2016). Therefore, plant-derived extracts that have biological activities such as antimicrobial, antioxidant and anticancer, and are high in nutrients, mainly vitamins, polyphenolic acids, flavonoids, and anthocyanin, served as an alternative to fulfil the need for natural food ingredients and might provide specific health benefits to humans (Daramola and Asunni, 2006; Yang *et al.,* 2012; Jung *et al.*, 2013; Cid-Ortega and Guerrero-Beltrán, 2015; Wu *et al.*, 2018).

Roselle contains a high number of proteins, crude fibre, and almost all amino acids except tryptophan and minerals. The content of bioactive compounds in roselle calyces can function as antioxidants and anticancer, contributing to its beneficial effects against main cardiovascular and chronic diseases such as diabetes mellitus, dyslipidaemia, and hypertension (Shruthi and Ramachandra, 2019). Therefore, roselle calyces and their extracts are currently of interest for use as ingredients in functional food production. In some countries, roselle calyces are traditionally used as drinks, jams, jellies, liquors, flour for biscuits, and other products (Cid-Ortega and Guerrero-Beltrán, 2015).

Roselle can improve the nutritional value and overall quality of some foods. Roselle can be used for food products such as baked foods, gelled foods, and drinks. Roselle calyces have been reported to have natural antioxidant ingredients, and the most prominent was anthocyanin (Yang *et al.,* 2012; Jung *et al.,* 2013; Wu *et*

*Corresponding author.
Email: *qhairul@ums.edu.my*

al., 2018). Abdel-Moemin (2016) evaluated the content of ascorbic acid and anthocyanin in cupcakes incorporated with roselle powder and found that 77% of anthocyanin was retained in the sample and was highly accepted by panellists specifically for colour and aroma. In meat products, Bozkurt and Belibali (2009) examined the antioxidant capacity of roselle calyces, rosemary leaves, and the synthetic antioxidant BHT (butylated hydroxytoluene) as a control. They discovered that meat treated with roselle calyces and BHT had comparable quantities of thiobarbituric acid TBARS, indicating oxidation reaction (0.47±0.03 and 0.41±0.01 mg/kg, respectively), however, meat added with rosemary had the lowest values of reactive substances of (TBARS) (0.23±0.02 mg/kg). Their findings suggested the addition of natural antioxidants could reduce the oxidation of fat in meat during cooking. In addition, the flavour, colour, and cutting smoothness improved in the meat supplemented with roselle calyces. Nevertheless, Daramola and Asunni (2006) found that pizza added with roselle calyces extract improved the taste and texture of and pizzas added with roselle extract had a lower peroxide index and higher content iron in pizzas 1.97 mg/g in the pizza added with roselle powder compared to 1.05 mg/g in control pizza.

Over the years, high demand for whole-grain products has been observed worldwide due to their high nutritional values and protective effects against several chronic diseases (Slavin *et al.,* 2013). Whole wheat bread is one of the most consumed whole-grain products; however, products of whole wheat flour had lower consumer acceptability than refined flour. Moreover, health benefits from roselle make it important for us to diversify products from roselle as a functional ingredient. Therefore, it is our interest to improve the quality of whole wheat products, especially bread. In the present study, whole wheat flour was substituted with a different percentage of roselle powder for bread production. The bread was chosen in this study because of its popularity worldwide and could serve as a ready-to-go food product. This study evaluated the effects of roselle composite flour on dough rheological properties and bread quality using different analysis techniques.

2. Materials and methods

2.1 Materials

Roselle was purchased from the street market in Kota Kinabalu, Sabah with the composition of 17% protein, 6.5% ash and 8.5% fibre. Whole wheat flour with high protein content (14.0% protein content, 14.0% moisture content and 1.55% ash content; Gunung Mas brand, Malaysia), sugar (Prai brand, Malaysia), dry instant yeast (Bunga Raya, Malaysia) and salt (Bake with Me, Malaysia) were purchased from a local market.

2.2 Roselle powder preparation

Fresh roselle was properly rinsed with tap water to eliminate contaminants and then frozen (-20°C) for a maximum of seven days before the analysis. The roselle was dried for 24 hrs at 60°C in a cabinet dryer (Thermoline, Australia) and then crushed to a fine powder with a Waring miller. Following that, the roselle was sieved (US standard testing sieve, A.S.T.M.E-11, W.S Tyler, Mentor, OH, USA) and kept in an airtight container (particle size < 250 m). To make bread, dried and powdered roselle samples (1, 2, and 3%) were combined with whole wheat flour. Before the examination, the roselle powder was kept at room temperature (25°C) in sealed plastic containers. A pre-test was undertaken to establish an acceptable level of roselle powder in the formulations.

2.3 Dough rheological characteristics

The characteristics of the farinograph were determined according to AACC method 54–21 (AACC, 2000) using a 300 g mixing bowl at 30°C for rotation of 63 rpm. Water is added to the flour and mixed into a dough. Water absorption (BU), dough development time (DT), dough stability time (ST min) and mixing tolerance index (MTI FU) were evaluated in a farinograph (Brabender, Germany) All determinations were made on a 14% moisture basis.

2.4 Bread-making process

The whole wheat bread was made according to Nor Qhairul Izzreen *et al*. (2015). Approximately 250 g of the whole wheat flour (adjusted to 14% moisture content), 162 mL water (30°C), 4.0 g saccharose, 4.0 g NaCl and 6 g yeast, respectively were mixed in a dough kneading machine (Tefal OW 300101, UK) and set to knead for 20 mins (Table 1). After kneading, 200 g of dough from each batch was transferred to a baking tin and then placed in a fermentation chamber at 30°C with 85% humidity, for fermentation. Fermentations were terminated before the dough collapsed and fermentation time was recorded (Table 3). Preliminary tests were carried out following the method by Nor Qhairul Izzreen *et al*. (2015). The dough was baked at 200°C for 25 mins to a centre temperature of 99°C in a convection oven (Binder, German). After baking, the loaves were cooled at room temperature for 15 mins, then removed from the baking tin, and further cooled on a grate at the same temperature for another hour before being stored at -18°C for further analysis. For storage studies, bread was stored in an airtight plastic bag for not more than 4 days at 25°C.

https://doi.org/10.26656/fr.2017.7(4).340

Table 1. Bread formulation.

Formulation	Whole wheat flour (g)	Roselle powder* (g)	Instant yeast (g)	Sugar (g)	Salt (g)	Water (mL)
F0	250.0	0.0	6	4	4	162.5
F1	247.5	2.5				
F2	245.0	5.0				
F3	242.5	7.5				

*The quantity of roselle powder was according to 250 g of whole wheat flour.
The percentage of water (65%) was based on 250 g of whole wheat flour and adjusted to reach 14% moisture content.
F1: 1% of roselle powder was added to the formulation, F2: 2% of roselle powder was added to the formulation, F3: 3% of roselle powder was added to the formulation.

2.5 Analysis of physical properties of bread

2.5.1 Bread colour

After baking, bread samples were cooled and stored at room temperature for colour measurement on the same day. The colour of the bread crumb was determined by measuring lightness (L*), redness (a*), and yellowness (b*) utilizing a Minolta Chroma Meter (CR-310, Konica Minolta Sensing, Inc., Osaka, Japan) in triplicate.

2.5.2 Bread weight, volume and specific volume

The weight of bread samples was determined using a digital balance (Precisa, Switzerland) and the bread volume was determined using the rapeseed displacement method Mamat *et al*. (2021) and the specific loaf volume (mL/g) was calculated, based on the average of 3 slices of bread. The specific volume of each bread was calculated as follows:

$$\text{Specific volume (mL)} = \frac{\text{Loaf volume (mL)}}{\text{Loaf weight (g)}}$$

2.5.3 Bread texture

Bread samples were measured using a texture analyser TA-XT2PLUS (Stable Microsystem) (method AACC 74–09 AACC, 1986). Before analysis, the bread crumb was cut into small pieces (15 × 15 × 15 mm). A cylindrical aluminium probe with a 21 mm diameter is used in the TPA model with twice compression which penetrates 40% of the crumb depth. A pre-test speed of 2 mm/s, a test speed of 1.7 mm/s, and a post-test speed of 10 mm/s were used. The delay between the first and second compression was set as 5 s. The testing was performed in triplicate for each bread sample, and the force was recorded in N.

2.6 Sensory evaluation

The sensory properties of the bread were examined in a sensory laboratory at the Faculty of Food Science and Nutrition, University Malaysia Sabah (UMS), Malaysia. Panellists were chosen from the Faculty of Food Science and Nutrition at UMS. All panellists provided informed consent to participate in this study. Bread samples were cut into slices (2 × 2 cm), coded with three-digit numbers, and rearranged before being served on a tray at random to panellists. Only a slice of bread was given to each panellist for each formulation. The hedonic tests featured a total of forty untrained panellists to rate bread samples based on colour, aroma, taste, texture, and general acceptability on a seven-point hedonic scale ranging from 1 (extremely disliked) to 7 (extremely like) (Mamat *et al.,* 2021). The Friedman test was used to examine data that was collected manually.

2.7 Shelf-life studies

2.7.1 Bread quality

The shelf-life studies were measured after 24 (day 1), 48 (day 2), 72 (day 3) and 96 h (day 4) of storage since the preliminary studies found that this bread could only last for four days at 25°C before the mould was detected. The moisture content analysis was carried out according to Section 2.5, and the sensory analysis was carried out according to Section 2.7. Water activity was measured using a water activity meter (Rotronic Hygrometer, Rotronic, New York, NY, USA)

2.8 Statistical analysis

All studies were done in triplicate. One-way ANOVA was used to analyse the data. The Tukey HSD test was used to estimate the statistical significance at $p < 0.05$ for the least significant differences. Version 16 of SPSS for Windows was used for the analysis.

3. Results and discussion

3.1 Dough characteristics

3.1.1 Dough development

The time it takes for the dough to leaven completely, and the maximum height of the dough are shown in Table 2. The fermentation time and the height of the whole wheat dough added with roselle powder decreased with an increasing percentage of roselle composite. The highest height of 12 cm was observed in the whole wheat dough, and a 60 min fermentation time was observed for the dough to be fully developed (Table 2). A similar result was found in bread added with Linseed fibre composite flour as the amount of composite flour

https://doi.org/10.26656/fr.2017.7(4).340

increased, and the fermentation time decreased compared to whole wheat bread (Švec and Hrušková, 2018). This may be due to the lower gluten content in all formulations F1, F2, and F3 than in control. Consequently, the formation of the network in the dough is not strong enough to trap CO_2 and therefore limits the height of the dough (Cauvain *et al.,* 2007). The roselle powder probably stiffened the dough during fermentation, preventing the expansion of the dough. Furthermore, the acidity in roselle powder is high as fruits are normally acidic. It could affect dough development, as acid strongly interacts with protein, which explains why the higher percentage of roselle powder decreased dough height. Commercial bread practically uses a height of 6 cm, and similar studies by Birch *et al*. (2013) and Nor Qhairul Izzreen *et al*. (2015) also obtained the same height for white bread and whole wheat bread. In this present work, all formulations were able to obtain the minimum height as commercial bread.

Table 2. Maximum height of dough development (cm) and optimal fermentation time (min) to reach the height.

Formulation	Dough height (cm)	Fermentation time (min)
F0	12	60
F1	11	50
F2	10	45
F3	9	30

F1: 1% of roselle powder was added to the formulation, F2: 2% of roselle powder was added to the formulation, F3: 3% of roselle powder was added to the formulation.

3.1.2 Farinograph parameters

Dough properties are important because they influence the quality of the final product (Arufe *et al.,* 2018). The rheological properties of the dough samples were studied using a farinograph. The results of the farinograph analysis are summarized in Table 3. Adding 1 to 3% roselle powder to dough formulations significantly decreased the amount of water required to achieve more than 500 BU. The water absorption of the dough ranged between 61.43 and 63.30%, with the control (without roselle powder) showing the highest water absorption. However, a different percentage of roselle powder has no significant effects on the water absorption of the dough. This might be due to a small difference in the amount of roselle powder used in every formulation. The control bread made with 100% whole wheat flour is also expected to have the highest water absorption since whole wheat has high fibre compared to roselle powder, and therefore more water is needed to hold high amounts of water through hydrogen bonding in the polysaccharide system.

A slightly similar trend was observed in the development and stability time of the dough, as the highest amount of roselle powder showed the lowest dough development and low stability time compared to the others. This result was common in composite flour, as they lack gluten which provides a strong network in the dough. Unless the composite powder contains any substrate similar to the action of gluten. The dough development and stability time would be lower compared to the control bread. These parameter values increased with decreasing amount of roselle powder; however, no significant differences were observed between samples F3 and F2, but significantly different from F1 and F0. F0 showed the longest time required for dough development, which could be due to the bran content in whole wheat dough. The time required for dough development or to achieve consistency in the dough would increase due to fibre addition (Mamat *et al.,* 2021).

Although roselle has a high fibre content (12 g/100 g), the 2% and 3% addition of roselle powder only need 8.80 and 8,72 min to develop into a dough compared to 10.10 min and 10.80 min for 1% addition of roselle powder and control bread, respectively. A similar result was obtained by Hallén *et al*. (2004) who found low stability time when Cowpea flour was added to produce bread. Furthermore, Ajila *et al*. (2008) reported that a 10% addition of mango flour reduced the stability time of the dough.

The mixing tolerance index of sample F0 (control) indicated a maximum value of 630.33 BU, while sample F1 (1% roselle powder) showed a minimum tolerance index of 534.67 BU. The tolerance index is used by bakers to determine the extent the dough will soften over a period of mixing. The tolerance index showed an increasing trend with an increased percentage of roselle powder, regardless of the control dough. However, the

Table 3. Dough characteristics prepared from roselle composite flour.

Formulation	Water absorption (%)	Development time (min)	Stability (min)	Tolerance index (BU)	Stickiness (g)
F0	63.30±0.06^a	10.80±0.10^a	8.80±0.10^a	630.33±1.15^a	25.87±3.47^a
F1	61.13±0.06^b	10.10±0.10b	5.91±0.02^b	534.67±6.66^c	22.91±2.50^c
F2	61.20±0.20^b	8.80±0.10^c	5.82±0.03^b	543.33±1.53^{bc}	24.82±4.08^b
F3	61.43±0.11^b	8.72±0.21^c	4.67±1.52^c	558.00±1.00^b	17.01±1.46^d

Values are presented as mean±SD, n = 9. Values with different superscripts within the same column are statistically significantly different ($p<0.05$). F1: 1% of roselle powder was added to the formulation, F2: 2% of roselle powder was added to the formulation, F3: 3% of roselle powder was added to the formulation.

https://doi.org/10.26656/fr.2017.7(4).340

values of F2 were not significant with F1 and F3. Blending whole wheat flour with roselle somewhat reduced the tolerance index showing dough stability increased with roselle powder addition. However, as the roselle powder blending increased, the tolerance index increased. This might be due to the absence of gluten protein contents in roselle powder which contributes to the elasticity of the dough, but too much roselle powder decreased the dough breakdown due to over-mixing.

The stickiness results obtained showed that the addition of roselle powder influenced the stickiness properties of the dough produced. Stickiness values ranged between 17.01 and 25.87 g. F3 showed the least stickiness value 17.01 was significantly different from F0, in which the sample without roselle powder showed the highest adhesion. The values of stickiness in all bread F0 to F3 were significantly different from each other.

3.2 Bread characteristics

3.2.1 Physical properties

Bread-specific volume is one of the most essential visual qualities of bread, and it has a significant impact on customer preferences. As a result, it is an important factor to consider when assessing bread quality. Table 4 shows the specific volume and density of the bread infused with roselle powder. The specific volume of the bread fell noticeably as the amount of roselle powder increased, although the bulk density rose. These findings were comparable to those reported by Mamat *et al.* (2021) in soft rolls using seaweed powder. The decrease in bread volume caused by the addition of roselle powder might be attributed to the combination of gluten dilution affecting and disrupting the structure of the gluten network. The specific volume and volume of a bakery product are modified when flour is replaced with fibre in the formulation because the fibre disrupts the starch–gluten matrix, so restricting or pushing gas cells to expand in just one dimension (Huang *et al.,* 2016). The firmness, springiness, cohesiveness, and chewiness of the bread are shown in Table 4. The firmness of the bread was in the range of 2.55±0.46 to 6.29±0.35 N. The firmness of bread increased when a higher percentage of roselle powder was added. However, control bread showed the highest firmness value. This was due to the formation of a gluten network in whole wheat flour. In addition, roselle powder contributes to the thickening of the crumb walls surrounding the air spaces, resulting in F3 showing the lowest firmness value compared to control bread. This shows that the effect on firmness could be reduced with the increase in the level of roselle powder and the ability of roselle powder to retain moisture and inhibited retrogradation. Mamat *et al.* (2021) and Arufe *et al.* (2018) obtained a similar result when both works incorporated seaweed powder in soft rolls and wheat bread, respectively. The values of bread springiness did not show significant differences in all bread formulations. Cohesiveness is the strength of the internal bonds of the breadcrumb. The cohesiveness of bread was in the range of 0.47±0.15 to 0.80±0.12. Control bread obtained the highest value of cohesiveness. Meanwhile, the cohesiveness of the bread added with roselle powder decreased with an increase in the percentage of roselle powder. This was expected since control bread has the highest gluten network and therefore, the matrix integrity of control bread was not affected compared to other formulations. In contrast to chewiness, the values increased with an increase in roselle powder. Chewiness follows the same behaviour as firmness, which is normal. Since this parameter is a function dependent on firmness, cohesiveness, and springiness. The chewiness of the products, therefore, becomes higher due to the increase in the crumb firmness.

The effects of roselle powder addition on bread colour are summarized in Table 5. Lightness (L*, 48.62–71.50), greenness/redness (a*, 3.76–9.48), and yellowness (b*, 5.94– 16.54) were remarkably affected by the incorporation of roselle powder. The highest L* and b* values were obtained from the bread baked without roselle powder, and these properties decreased as the level of roselle powder added was increased. Based on colour differences concerning the control colour as a reference, roselle additions affected the colour of the bread. The incorporation of roselle powder produced bread with an increase in greenness/redness. According to Martínez *et al.* (2001), the human eyes can perceive the colour differences for values greater than 3. In general, the bread colour lightened to reddish as the

Table 4. Effect of substituting whole wheat flour for roselle powder on the physical characteristics of bread

Formulation	Specific volume (mL /g)	Firmness (N)	Springiness	Cohesiveness	Chewiness
F0	1.87±0.03^{a}	6.29±0.35^{a}	0.92±0.07^{a}	0.80±0.12^{a}	1.61±0.95^{b}
F1	1.76±0.03^{b}	2.55±0.46^{b}	0.91±0.07^{a}	0.63±0.22^{b}	1.44±0.22^{c}
F2	1.47±0.00^{c}	3.19±0.22^{b}	0.92±0.51^{a}	0.53±0.04^{c}	1.38±0.07^{c}
F3	1.33±0.00^{c}	4.60±o.42^{c}	0.92±0.05^{a}	0.47±0.15^{d}	2.06±0.87^{a}

Values are presented as mean±SD, n = 9. Values with different superscripts within the same column are statistically significantly different (p<0.05). F1: 1% of roselle powder was added to the formulation, F2: 2% of roselle powder was added to the formulation, F3: 3% of roselle powder was added to the formulation.

https://doi.org/10.26656/fr.2017.7(4).340

amount of roselle powder increased. The colour of the bread is contributed to Maillard and caramelization processes during baking. With a higher percentage of roselle powder, the values of L *, b * and ΔE* of bread decreased, meanwhile the value of a * increased.

3.3 Sensory evaluation

The hedonic test was conducted to find the best formulation selected by the panellists. The sensorial attributes and overall acceptability of the whole wheat bread incorporated with roselle composite flours are shown in Table 6. Overall bread with 2% roselle powder (F2) shows the highest panellists' acceptance of attributes of aroma (6.00±1.20), taste (6.35±1.21), texture (6.03±1.51), sourness (6.38±0.95) and overall acceptance (6.65±1.00). Bread with the highest percentage of roselle powder (F3) shows the highest score, 6.23±1.54, for colour attribute. In general, the panellists preferred bread with moderate amounts of roselle powder. In most of the research concerning composite flour, it was found that the acceptance score decreased with the increased addition of composite flour. As expected, panellists usually prefer bread without the addition of composite flours such as seaweed composite, breadfruit composite, and apricot kernel composite, to name a few as they are familiar with the taste of common wheat bread in the market (Bakare *et al.,* 2016; Dhen *et al.,* 2018; Mamat *et al.,* 2021).

3.4 Effect of storage on bread properties

3.4.1 Physical properties during storage

The ageing of the bread was evaluated from the textural parameters (TPA) of the bread crumb, moisture content, and water activity measured after 24 hrs (day 1), 48 hrs (day 2), 72 hrs (day 3) and 96 hrs (day 4) of storage. The ageing of F1 and F3 formulations is not included in the study. The F2 sample was compared with the control sample. After 24 hrs of storage, the firmness of both control and F2 increases (Table 7). Roselle powder appears to not affect ageing. However, the increment in firmness values in F2 is more pronounced and almost double the values in control bread. Interestingly, on day 4, the firmness value of the F2 sample was lower than that of the control sample indicating the possibility of roselle delaying staling processes on certain days onwards. These results are partly similar to Mata-Ramírez *et al*. (2018) as they found a high firmness value in wheat bread supplemented with roselle powder. But they did not measure the effect of storage on the firmness of roselle

Table 5. Colour characteristics of roselle composite flour bread crumb.

Formulation	L*	a*	b*	ΔE*
F0	71.50±0.01^{a}	3.76±0.03^{d}	16.54±0.03^{a}	74.09±0.00^{a}
F1	59.63±0.02^{b}	5.36±0.03^{c}	10.38±0.03^{b}	61.03±0.00^{b}
F2	52.59±0.03^{bc}	7.46±0.06^{b}	7.10±0.01^{c}	53.92±0.02^{c}
F3	48.62±0.03^{c}	9.48±0.06^{a}	5.94±0.08^{d}	50.18±0.05^{c}

Values are presented as mean±SD, n = 9. Values with different superscripts within the same column are statistically significantly different (p<0.05). F1: 1% of roselle powder was added to the formulation, F2: 2% of roselle powder was added to the formulation, F3: 3% of roselle powder was added to the formulation.

Table 6. Sensorial attributes of roselle composite flour bread.

Formulation/ percentage of roselle (%)	Colour	Aroma	Taste	Texture	Sourness	Overall acceptance
F1 (1%)	5.60±1.52^{b}	5.75±1.52^{b}	5.38±1.53^{b}	5.00±1.59^{b}	5.83±1.34^{b}	5.75±1.58^{b}
F2 (2%)	5.45±1.20^{c}	6.00±1.20^{a}	6.35±1.21^{a}	6.03±1.51^{a}	6.38±0.95^{a}	6.65±1.00^{a}
F3 (3%)	6.23±1.54^{a}	5.55±1.28^{c}	5.03±1.63^{c}	4.55±1.50^{c}	4.63±1.71^{c}	5.08±1.54^{c}

Values are presented as mean±SD, n = 9. Values with different superscripts within the same column are statistically significantly different (p<0.05). F1: 1% of roselle powder was added to the formulation, F2: 2% of roselle powder was added to the formulation, F3: 3% of roselle powder was added to the formulation.

Table 7. Changes in firmness, moisture content, and water activity of control bread and bread after 4 days of storage at 25°C.

Storage day (s)	Firmness, N		Moisture Content		Water activity, a_w	
	Control	F2	Control	F2	Control	F2
0	0.89±0.02^{c}	0.88±0.05^{d}	44.21±0.11^{a}	42.29±0.27^{a}	0.69±0.03^{a}	0.67±0.01^{a}
1	1.25±0.03^{c}	2.50±0.15^{c}	43.06±0.09^{a}	41.19±0.49^{ab}	0.69±0.10^{a}	0.68±0.00^{a}
2	1.62±0.31^{bc}	3.19±0.05^{bc}	41.13±0.09^{b}	40.25±0.13^{b}	0.68±0.02^{a}	0.67±0.00^{a}
3	2.09±0.11^{b}	4.63±0.06^{b}	40.51±0.47^{c}	39.29±0.45^{b}	0.64±0.01^{ab}	0.67±0.00^{a}
4	6.29±0.23^{a}	5.19±0.15^{a}	40.14±0.16^{c}	34.28±0.16^{c}	0.61±0.06^{c}	0.67±0.00^{a}

Values are presented as mean±SD, n = 9. Values with different superscripts within the same column are statistically significantly different (p<0.05). F1: 1% of roselle powder was added to the formulation, F2: 2% of roselle powder was added to the formulation, F3: 3% of roselle powder was added to the formulation.

https://doi.org/10.26656/fr.2017.7(4).340

bread. This might be due to starch gelatinization and retrogradation that happened inside the breadcrumb of control bread. Relatively, bread added with roselle powder contains less starch than control bread; therefore, at 96 hrs the firmness value was low. Moreover, the addition of roselle powder minimizes the retrogradation susceptibility of the starch, however, the presence of free sugar may have favoured crystallization, ending in an increase in firmness during storage as a whole. The increase in firmness was in contrast to the moisture content results in both the F2 and the control samples. In general, moisture content decreases during storage from day 0 to day 4, however, the values were not so significantly different for the first 3 days but more significant at the end of day 4 (Table 7). This condition is expected as firmness is a result of moisture moving from the centre of the crumb to the crust and from the product to the atmosphere due to the water vapour permeability of the packaging material (Cauvain, 2003) causing the bread to be stale. A similar result was found in bread using micronized whole wheat flour (Protonotariou *et al.,* 2020). In contrast, Baik and Chinachoti (2003) found that high-moisture crumbs presented a softer texture, particularly during their refined wheat bread storage. Furthermore, the values for water activity were not significantly different in F2 (0.67 -0.68) and slightly decreased in control bread (0.61-0.69) after freshly baking and during 4 days of storage, the values were not significantly different between control and F2 samples. It is noted that moisture loss and water activity did not affect the firmness during storage but in total contributes to the bread staling.

4. Conclusion

This study provides the possibility of the utilization of roselle as an important ingredient in food production. Commonly, the addition of fruits in bread is a fruit compote, and it would not affect the whole process of bread, especially when using whole wheat flour. Therefore, this research creates an option for bakers to use composite powder as part of the ingredients in baking. Whole wheat bread with the addition of 2% roselle powder was the best bread formulation with sensory acceptance of 6.65±1.00 compared to other formulations. The addition of roselle composite flour to produce bread influenced the physicochemical properties of the final products. This addition, although decreased some of the bread's physical characteristics, provided a positive attribute of natural red colour with panel acceptance of 5.45±1.20 and the most acceptable sourness of 6.38±0.95 to the bread which was appealing. In addition, bread added with roselle powder might delay the staling process compared to normal whole wheat bread after a certain storage day, which might lead to an extension in the shelf-life of baked goods. In general, this bread provides an option for those that do not like the taste of whole-wheat bread. Further studies should be done to improve the formulation and analyse the antioxidant activity since roselle is rich in anthocyanin, and the physicochemical properties of the bread to gain consumer acceptance.

References

AACC. (2000). Approved Methods of the American Associations of Cereal Chemists, American Association of Cereal Chemists (Method 54-21). St. Paul, USA: AACC.

Abdel-Moemin, A.R. (2016). Effect of Roselle calyces extracts on the chemical and sensory properties of functional cupcakes. Food Science and Human Wellness, 5(4), 230–237. https://doi.org/https://doi.org/10.1016/j.fshw.2016.07.003

Ajila, C.M., Leelavathi, K. and Prasada Rao, U.J.S. (2008). Improvement of dietary fibre content and antioxidant properties in soft dough biscuits with the incorporation of mango peel powder. *Journal of Cereal Science*, 48(2), 319-326. https://doi.org/10.1016/j.jcs.2007.10.001

Arufe, S., Della Valle, G., Chiron, H., Chenlo, F., Sineiro, J. and Moreira, R. (2018). Effect of brown seaweed powder on physical and textural properties of wheat bread. *European Food Research and Technology*, 244, 1–10. https://doi.org/10.1007/s00217-017-2929-8

Baik, M.Y. and Chinachoti, P. (2003). Water Self-Diffusion Coefficient and Staling of White Bread as Affected by Glycerol. *Cereal Chemistry*, 80(6), 740-744. https://doi.org/10.1094/CCHEM.2003.80.6.740

Bakare, A.H., Osundahunsi, O.F. and Olusanya, J.O. (2015). Rheological, baking, and sensory properties of composite bread dough with breadfruit (*Artocarpus communis Forst*) and wheat flours. *Food Science and Nutrition*, 4(4), 573–587. https://doi.org/10.1002/fsn3.321

Birch, A.N., Petersen, M.A. and Hansen, Å.S. (2013). The aroma profile of wheat bread crumbs is influenced by yeast concentration and fermentation temperature. *LWT - Food Science and Technology*, 50(2), 480–488. https://doi.org/10.1016/j.lwt.2012.08.019

Bozkurt, H. and Belibağlı, K.B. (2009). Use of rosemary and *Hibiscus sabdariffa* in the production of kavurma, a cooked meat product. *Journal of the Science of Food and Agriculture*, 89(7), 1168–1173. https://doi.org/https://doi.org/10.1002/jsfa.3570

Cauvain, S.P. (2003). Bread making: Improving quality.

Bread Making: Improving Quality. https://doi.org/10.1533/9781855737129

Cid-Ortega, S. and Guerrero-Beltrán, J.A. (2015). Roselle calyces (*Hibiscus sabdariffa*), an alternative to the food and beverages industries: A review. *Journal of Food Science and Technology*, 52(11), 6859–6869. https://doi.org/10.1007/s13197-015-1800-9

Daramola, B. and Asunni, O.A. (2006). Nutrient composition and storage studies on roselle extract enriched deep-fat-fried snack food. *African Journal of Biotechnology*, 5(19), 1803-1807. https://doi.org/10.5897/AJB06.345

Dhen, N., Ben Rejeb, I., Boukhris, H., Damergi, C. and Gargouri, M. (2018). Physicochemical and sensory properties of wheat- Apricot kernels composite bread. *LWT-Food Science and Technology* 95, 262–267. https://doi.org/https://doi.org/10.1016/j.lwt.2018.04.068

Hallén, E., Ibanoğlu, Ş., and Ainsworth, P. (2004). Effect of fermented/germinated cowpea flour addition on the rheological and baking properties of wheat flour. *Journal of Food Engineering*, 63(2), 177-184. https://doi.org/10.1016/S0260-8774(03)00298-X

Huang, G., Guo, Q., Wang, C., Ding, H.H. and Cui, S.W. (2016). Fenugreek fibre in bread: Effects on dough development and bread quality. *LWT-Food Science and Technology*, 71, 274–280. https://doi.org/10.1016/j.lwt.2016.03.040

Jung, E., Kim, Y. and Joo, N. (2013). Physicochemical properties and antimicrobial activity of Roselle (*Hibiscus sabdariffa* L.). *Journal of the Science of Food and Agriculture*, 93(15), 3769–3776. https://doi.org/https://doi.org/10.1002/jsfa.6256

Gul, K., Singh, A.K. and Jabeen, R. (2016). Nutraceuticals and Functional Foods: The Foods for the Future World. *Critical Reviews in Food Science and Nutrition*, 56(16), 2617-2627. https://doi.org/10.1080/10408398.2014.903384

Mamat, H. Bin, Wan Chen, Y., Abdul Hamid, M., Md Haque Akanda, J., Pusiran, A.K. and Zainol, M.K. (2021). Assessment of dough rheological characteristics and soft bread roll quality of wheat flour incorporated with seaweed powder. *British Food Journal*, 123(12), 3888-3901.https://doi.org/10.1108/BFJ-08-2020-0676

Martínez, J.A., Melgosa, M., Pérez, M.M., Hita, E. and Negueruela, A.I. (2001). Note. Visual and Instrumental colour Evaluation in Red Wines. *Food Science and Technology International*, 7(5), 439-444. https://doi.org/10.1106/VFAT-5REN-1WK2-5JGQ

Mata-Ramírez, D., Serna-Saldívar, S.O., Villela-Castrejón, J., Villaseñor-Durán, M.C. and Buitimea-Cantúa, N.E. (2018). Phytochemical profiles, dietary fibre and baking performance of wheat bread formulations supplemented with Roselle *(Hibiscus sabdariffa*). *Journal of Food Measurement and Characterization*, 12(4), 2657–2665. https://doi.org/10.1007/s11694-018-9883-4

Nor Qhairul Izzreen., M.N, Petersen, M.A. and Hansen, A. (2015). Volatile compounds in the crumb of whole-meal wheat bread fermented with different yeast levels and fermentation temperatures. *Cereal Chemistry*, 93(*2)*, 209–216. https://doi.org/10.1094/CCHEM-09-14-0196-R

Protonotariou, S., Stergiou, P., Christaki, M. and Mandala, I.G. (2020). Physical properties and sensory evaluation of bread containing micronized whole wheat flour. *Food Chemistry*, 318, 126497. https://doi.org/10.1016/j.foodchem.2020.126497

Shruthi, V.H. and Ramachandra, C.T. (Eds.) (2019). Roselle (*Hibiscus sabdariffa L.*) calyces: a potential source of natural colour and its health benefits. In Food Bioactives. 1st ed., p. 169-190. London, United Kingdom: Apple Academic Press. https://doi.org/10.1201/9780429242793-8

Slavin, J., Tucker, M., Harriman, C. and Jonnalagadda, S.S. (2013). Whole grains: Definition, dietary recommendations, and health benefits. *Cereal Foods World*, 58(4), 191–198. https://doi.org/10.1094/CFW-58-4-0191

Švec, I. and Hrušková, M. (2018). Effect of golden and brown linseed fibre on wheat flour pasting, dough properties and bread quality. *Cereal Research Communications*, 46(1), 114-123. https://doi.org/10.1556/0806.45.2017.063

Wu, H.Y., Yang, K.M. and Chiang, P.Y. (2018). Roselle anthocyanins: Antioxidant properties and stability to heat and pH. *Molecules*, 23(6), 1357. https://doi.org/10.3390/molecules23061357

Yang, L., Gou, Y., Zhao, T., Zhao, J., Li, F., Zhang, B. and Wu, X. (2012). Antioxidant capacity of extracts from calyx fruits of roselle (*Hibiscus sabdariffa L.*). *African Journal of Biotechnology*, 11(17), 4063–4068.

