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Effect of dry shredded *Moringa oleifera* leaves and vitamin C on the physicochemical properties of the dough and bread

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Abstract
The effect of vitamin C addition on wheat-*Moringa* leaf bread was investigated. Bread prepared from wheat-*Moringa* leaf flour in ratios 100:0, 99:1, 98:2, 97:3, 96:4 and 95:5 designated as samples A, B, C, D, E and F were incorporated with 0g, 0.1g, 0.2g, 0.3g, 0.4g and 0.5g vitamin C respectively. Rheological (alveograph) properties of dough, physical properties of loaf, sensory attributes, and chemical composition of bread were determined using standard methods. The results showed significant (p<0.05) reduction/increment in maximum pressure, P (92.24 to 69.76 mm), extensibility, L (72.44 to 89.94 mm), swelling index, G (19.21 to 27.77 mm), deformation energy, W (265.60 to 220.10 J), P/L-ratio (1.27 to 0.78) and elasticity index, I.e. (50.88 to 55.22%) with increasing *Moringa* leaf flour and vitamin C. *Moringa* leaf significantly (p<0.05) increased crude protein (9.25 to 10.71%), ash (0.86 to 1.49%) and fat (3.44 to 4.85%), while decreasing total carbohydrate (86.45 to 82.97%) and moisture ranged from 21.89 to 26.64%) with significant difference (p<0.05). Incorporation of *Moringa* leaf significantly (p<0.05) decreased loaf volume, loaf height and specific loaf volume from 662.50 to 441.50cm^3, 6.05 to 4.95cm and 3.78 to 2.50cm^3/g respectively, while the loaf weight ranged from 175.20 to 179.50g. Sensory evaluation showed that the overall acceptability of bread samples decreased with increasing level of *Moringa* leaf and vitamin C. Hence, this research accepts supplementation of 2% *Moringa* leaf and 0.2g vitamin C in bread for quality loaf volume increase and good bread baking performance.

Keywords: wheat flour, vitamin C, alveograph, dough, bread

Introduction

Bread constitutes one of the staple foods in many households in Nigeria. Though wheat is the main flour component used in bread making, composite flour technology has also introduced other flour-like materials from grains, fruits and leafy vegetables due to their nutritional advantages [Sengev *et al.*, 2013, Sudipta and Soumitra, 2015, Rania *et al*., 2016 and Odunlade *et al*. 2017] [1, 2, 3, 4]. The incorporation of *Moringa oleifera* powder and soybean in wheat composites for bread making has been documented by other researchers [Kakde *et al*., 2018, Obichili and Ofediba, 2019, Urigacha, 2020 and Leone *et al*., 2015] [5, 6, 7, 8]. According to Leone *et al.* (2015) [8], the most used parts of *Moringa oleifera* are the leaves, owing to their richness in vitamins, carotenoids, polyphenols, phenolic acids, flavonoids, alkaloids, glucosinolates, isothiocyanates, tannins and saponins. Popoola and Obembe [9] also reported the medicinal and nutritional benefits of *Moringa oleifera* leaves and their potential improvement in the status of individuals in many undeveloped countries.
Aside the raw materials (wheat or composite flours) used in bread making, dough improvers (oxidizing agents) have also been known to influence the handling characteristics, specific volume and the texture of the finished product. These oxidizing agents increase the elasticity and reduce the extensibility of the dough [10]. Some of these oxidizing agents include potassium bromate, ascorbic acid and azodicarbonamide. They maintain the integrity of the dough mixture by preventing the reaction between glutathiones and gluten molecules. Oznur and Sukru [11] reported that vitamin C (ascorbic acid) is added during production of bread as an industrial oxidizing agent in order to maintain rheological property of bread during baking. Influence of enzymes and ascorbic acid on dough rheology and wheat bread quality has been investigated [12]. Vitamin C remains the most widely accepted improver owing to its positive impact on health. This study was aimed at evaluating the physicochemical and sensory quality of bread from wheat flour, *Moringa oleifera* leaves and vitamin C.

Materials and Methods

Sources of materials

Moringa oleifera leaves were obtained from the College of Food Technology and Human Ecology Complex, Federal University of Agriculture, Makurdi while Vitamin C was obtained from a Pharmacy Store in North Bank, Makurdi. Wheat flour and other ingredients for baking such as sugar, salt, yeast and margarine were purchased from Wurukum Market, Benue State.

Sample preparation

Dry shredded *Moringa oleifera* leaves

Fresh *Moringa* (Drumstick) leaves were harvested, destalked, shade dried and shredded by squeezing in a clean muslin cloth to obtain the shreds as shown in Figure I.

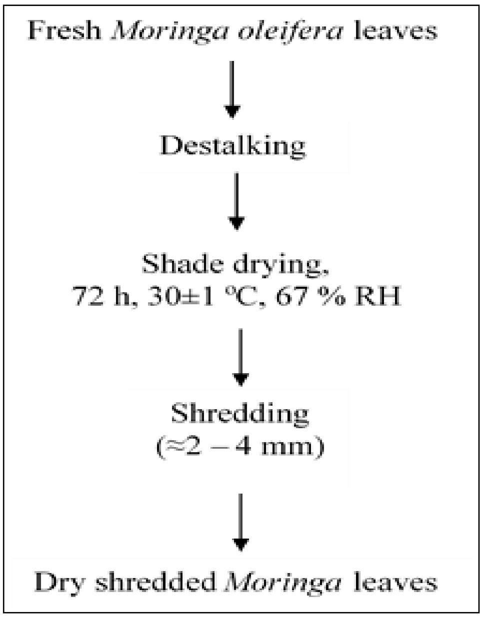

Fig I: Flow chart for the production of dry shredded *Moringa oleifera* leaves

Product formulation

The ingredient mix for bread production was carried out as reported by Sengev *et al.* [1] and shown in Table 1.

Table 1: Ingredient Mix for Bread Production

Ingredient	Sample					
	A	B	C	D	E	F
Wheat flour (g)	500	495	490	485	480	475
DSML (g)	0	5	10	15	20	25
Vitamin C (g)	0	0.5	1.0	1.5	2.0	2.5
Water (mL)	280	280	280	280	280	280
Sucrose (g)	13	13	13	13	13	13
Salt (g)	5	5	5	5	5	5
Margarine (g)	10	10	10	10	10	10
Yeast (g)	9	9	9	9	9	9

Source: Sengev *et al.* [1]
Key: DSML = Dry Shredded *Moringa* Leaves

Bread baking process

Doughs from the flour blends were baked using the straight-dough method described by Sengev *et al.* [1]. The baking formula was 500g of flour blend, 9g of compressed baker's yeast, 5g of salt (NaCl), 13g of sugar, 10g of fat (margarine) and approximately 280 mL of water. All ingredients were mixed in a Kenwood mixer (Model A 907 D, Finland) for 3.5 min. The doughs were fermented for 90 min at 28 °C ± 1 °C then punched and scaled to 100 g dough pieces, proofed for 90 min at 30 °C and baked at 250 °C for 30 min.

Chemical analysis

Moisture, crude protein, crude fat and ash content were determined using standard analytical methods as outlined by AOAC [13], while total carbohydrate was determined by difference as described by Sengev *et al.* [1].

Determination of Physical Characteristics

Weights of bread loaves were measured with a Mettler Toledo (PL203) digital weighing scale. Volume of was measured by millet seed displacement method [14]. Height was measured using a meter rule.

Weight loss

The weight loss of the bread was determined as described by Kim *et al.* [15]. The dough was weighed before baking while the loaves of bread were weighed after baking. Percent weight loss of the bread samples was calculated as:

$$\%\ Weight\ loss = \frac{Weight\ of\ dough - weight\ of\ baked\ bread}{Weight\ of\ dough} x100$$

Determination of rheological properties

The alveograph properties of dough were determined as described by AACC [14] using a Chopin alveograph (Model: MA 82, S/n: 2800, Finland). A 250g sample of known moisture content was placed into the mixer, sodium chloride solution (2.5%) was added through a burette and mixed for 7 min. The dough was forced through the extrusion gate in the form of a thin strip on to a small oiled steel plate. The extruded dough pieces of designated length were cut off, rolled with an oiled rolling pin to a uniform thinness, cut into a circular disk, transferred to an oiled steel plate, and subjected to a brief rest period in a tempered compartment of the alveograph for 15 min. Each circular dough test pieces were removed from the compartment and inserted between two metal plates that held it securely in position. The air valve was opened to supply air pressure to the held dough through an orifice. The electrically driven recording manometer was simultaneously activated to record the air pressure inside the dough bubble against time. The parameters obtained were: tenacity of the dough (P)-the maximum over pressure, extensibility of the dough (L)-the average abscissa at rupture and strength of the dough and (W)-the deformation energy of 1 g of dough.

Sensory evaluation

A 15-member panel of judges consisting of staff and students of the Department of Food Science and Technology, Federal University of Agriculture, Makurdi were used for this study. Sensory evaluation was performed 24 h after baking to evaluate crust appearance, crumb appearance, crumb texture, flavour and overall acceptability of the bread samples using a 9-point Hedonic scale [16].

Statistical analyses

The data were generated in duplicate and subjected to analysis of variance. Means were tested for significant difference using Duncan's Multiple Range Test (DMRT) [17]. Significance was accepted at $p<0.05$.

Results

Proximate composition of bread samples

The results of the effect of dry *Moringa* leaves and vitamin C on the proximate composition (%) of bread samples are presented in Table 1. The results of ash, protein and fat contents increased significantly ($p<0.05$) from 0.86 to 1.49%, 9.25 to 10.71% and 3.44 to 4.85% respectively while moisture and carbohydrates decreased.

Table 2: Effect of Dry Shredded *Moringa* Leaves and Vitamin C on the Proximate Composition (% Dry Matter) of Bread

Sample	Moisture	Ash	Protein	Fat	Total Carbohydrate
A	26.23^b	0.86^f	9.25^f	3.44^e	86.45^a
B	25.78^c	0.97^e	9.91^e	3.83^d	85.31^c
C	21.89^e	1.00^d	9.75^d	3.83^d	85.43^b
D	24.86^d	1.18^c	10.37^c	4.14^c	84.32^d
E	26.64^a	1.45^b	10.62^b	4.42^b	83.51^e
F	24.70^d	1.49^a	10.71^a	4.85^a	82.97^f

Values are means of two determinations. Means in the same column with the same superscript are not significantly different at $p \geq 0.05$

Key

A = 100% Wheat Flour.
B = 99% Wheat Flour, 1% *Moringa* leaves, 0.1 g vitamin C.
C = 98% Wheat Flour, 2% *Moringa* leaves, 0.2 g vitamin C.
D = 97% Wheat Flour, 3% *Moringa* leaves, 0.3 g vitamin C.
E = 96% Wheat Flour, 4% *Moringa* leaves, 0.4 g vitamin C.
F = 95% Wheat Flour, 5% *Moringa* leaves, 0.5 g vitamin C.

Rheological properties of the dough samples

The results of the effect of dry *Moringa leaves* and vitamin C are presented in Table 3. The results showed that tenacity (P), extensibility (L) and swelling index (G) ranged from 69.76 to 92.24 mm, 72.44 to 89.94 mm and 19.21 to 27.77 mm respectively while the deformation energy (W), configuration ratio and elastic index (Le) ranged from 220.10 x 10^4 to 265.60 x 10^4 J, 0.78 to 1.27 and 50.88 to 55.22% respectively, with significant differences between the samples.

Table 3: Effect of Dry Shredded *Moringa* Leaves and Vitamin C on the Rheological Properties of the Dough

Sample	P (mm)	L (mm)	G (mm)	W (x 10^{-4} J)	P/L	I.e. (%)
A	91.32^b	74.44^e	19.45^e	265.60^a	1.23^b	51.12^e
B	90.55^c	76.32^d	20.16^d	262.40^b	1.19^c	52.55^d
C	92.24^a	72.44^f	19.21^f	260.80^c	1.27^a	50.88^f
D	72.44^d	83.44^c	24.45^c	230.30^d	0.87^d	54.33^b
E	70.56^e	85.54^b	25.66^b	225.60^e	0.83^e	53.45^c
F	69.76^f	89.94^a	27.77^a	220.10^f	0.78^f	55.22^a

Values are means of two determinations. Means in the same column with the same superscript are not significantly different at $p \geq 0.05$.

Key: P = Tenacity (maximum overpressure), L = Extensibility, P/L = Configuration ratio, W = Deformation energy, G = Swelling index, I.e. = Elastic index.

Physical properties of bread samples

The results of the effect of *Moringa oleifera* (Drumstick) leaves and vitamin C on the physical properties of bread are presented in Table 4. The loaf height (cm), loaf volume (cm^3) and specific loaf volume (cm^3/g) decreased significantly ($p<0.05$) from 6.05 to 4.95, 662.50 to 441.50 and 3.78 to 2.50 respectively. The loaf weight (g) ranged from 175.20 to 179.50 and loss weight (g) ranged from 20.50 to 24.75 with significant differences ($p<0.05$) existing between the samples.

Table 4: Effect of Dry Shredded *Moringa* Leaves and Vitamin C on the Physical Properties of Bread

Sample	Loaf weight (g)	Loaf height (cm)	Weight loss (%)	Loaf volume (cm^3)	Specific loaf volume (cm^3/g)
A	175.20^c	6.05^a	24.75^a	662.50^a	3.78^a
B	175.20^c	5.65^b	24.75^a	582.50^b	3.32^b
C	179.50^a	5.70^b	24.75^a	527.50^c	2.94^c
D	175.20^c	5.75^b	20.50^c	455.00^d	2.60^d
E	178.00^{ab}	5.50^c	22.00^b	450.00^{de}	2.53^e
F	177.00^{bc}	4.95^d	23.00^b	441.50^e	2.50^e

Values are means of two determinations. Means in the same column with the same superscript are not significantly different at $p \geq 0.05$.

Organoleptic properties of bread samples

The results of the sensory attributes of the bread samples as affected by the addition of *Moringa oleifera* leaves and vitamin C are presented in Table 5. The results for crust appearance (5.07 to 8.40), crumb appearance (5.07 to 8.33), crumb texture (5.53 to 7.93), Flavour (5.33 to 7.80) and overall acceptability (5.40 to 8.00). The sensory scores for all the attributes decreased significantly ($p<0.05$) as the concentration of *Moringa oleifera* leaves and vitamin C increased.

Table 5: Effect of Dry Shredded *Moringa* Leaves and Vitamin C on the Sensory Attributes of Bread

Sample	Crust appearance	Crumb appearance	Crumb texture	Flavour	Overall acceptability
A	8.40^a	8.33^a	7.93^a	7.80^a	8.00^a
B	7.33^b	7.40^b	7.20^b	7.20^{ab}	7.33^{ab}
C	6.80^b	7.07^{bc}	7.00^b	7.07^{ab}	7.13^b
D	6.67^b	6.33^{cd}	6.93^b	6.73^{bc}	6.60^{bc}
E	5.80^c	5.87^{de}	6.80^b	6.00^{cd}	6.27^c
F	5.07^f	5.07^e	5.53^c	5.33^d	5.40^d

Means in the same column with the same superscript are not significantly different at $p \geq 0.05$.

Discussion

Proximate composition

The significant ($p<0.05$) increase in ash, protein and fat content of the bread samples with increase in dry shredded *Moringa oleifera* leaves (Table 2) is an indication that *Moringa* is a better source of these nutrients that wheat [9]. Several studies [1, 3, 18] also reported similar increment when *Moringa* leaf powder was used in bread. The moisture content of the bread samples compared favourably with the findings (21.90 to 26.85%) of other researchers [4, 19]. This may have an effect on the texture and stability of other nutrient materials in the food. Addition of *Moringa* and vitamin C did not adversely affect carbohydrate content, and consequently energy value of the bread. Values in the present study were in conformity with those reported by Odunlade *et al*. [4] for wheat-vegetable composite bread.

Rheological (Alveograph) properties of the dough samples

The tenacity (P) of the samples decreased steadily with increasing levels of *Moringa* and vitamin C, except for

sample C which displayed highest tenacity value (92.24 mm) and lowest extensibility (L) value (72.44 mm). This indicates the optimum level of wheat-*Moringa*-vitamin C combination that the dough would give maximum resistance to deformation and it relates to the stability the dough exhibited during proofing stage as well as its improved elasticity [20] According to Abdelaleem and Al-Azab [21], tenacity value of 92.24 mm is an indication of good wheat quality. The authors further linked lower extensibility value with good wheat quality.
The largest values of extensibility (L) and swelling index (G) and the smallest values of configuration ratio (P/L) imply that the flours were more extensible and stretchable, which may affect their suitability in bread making. Thus, as the concentration of *Moringa oleifera* leaves and vitamin C increased, the baking quality of the flours decreased. Zhygunov *et al*. (2020) [22] reported that flours with deformation energy (W) greater than 200.10 x 10^{-4} J and configuration ratio (P/L) ranging between 0.8 to 1.2 have good baking properties. The elastic index of the samples indicates suitability for bread making [22].

Physical properties of bread samples
Addition of *Moringa* increased the weight of the loaves despite increase in vitamin C, resulting in decrease in height and volume of the bread. The increase in bulk and closure of air spaces necessary for rising may have occurred as *Moringa* was introduced into the composite [23]. The decrease in height and volume may also be due to the antimicrobial action of *Moringa oleifera* leaves on the leavening activities of yeast during fermentation of the dough. Aida *et al*. [24] reported that addition of dry *Moringa oleifera* leaves in *Labneh* (a dairy product) suppressed the growth of yeast and mold. Fatma *et al*. [24] also recorded no yeast and mold growth in cream cheese containing *Moringa oleifera* leaves extract after four (4) weeks of storage.
The addition of dry *Moringa oleifera* leaves to wheat flour for bread making resulted in decreased loaf height, loaf volume and specific loaf volume, despite the corresponding increment in vitamin C content of the dough. This may again be linked to the antimicrobial properties of *Moringa oleifera* leaves. Other researchers [1, 4] reported similar results with wheat-vegetable flour composite bread.

Organoleptic properties of bread samples
Sensory evaluation results of the loaves depicted (Plate I and II) showed a general decrease in likeness of the products as the substitution level of dry *Moringa oleifera* leaves increased. The control sample (without *Moringa*) was most preferred in all the attributes. However, in terms of flavor, samples A, B and C were not significantly ($p \geq 0.05$) different. Samples A and B were statistical the same in terms of overall acceptability. The green coloration of the bread as well as suppression of leavening activities of yeast occasioned by *Moringa* may have resulted in the low ranking of the samples. This general observation is consistent with the findings of Sengev *et al*. [1].
The addition of vitamin C prevented the bread from collapsing, which was the case in the author's previous study. The results showed that *Moringa oleifera* leaves and vitamin C had no significant ($p \geq 0.05$) effect on samples A, B and C in terms of crust, crumb appearances and texture. Other researchers [3, 4] have reported decline in sensory acceptance with addition of leafy vegetables in bread.

Effect of dry shredded Moringa oleifera leaves and vitamin C on the physichochemical properties of dough and bread

Plate 1: Crust appearance of the bread samples

Plate 2: Crumb appearance of the bread samples

Conclusion
Addition of *Moringa oleifera* leaves to wheat flour improved the ash, protein and fat contents as well as weight of bread. Addition of 0.2 g vitamin C (sample C) produced dough with best alveograph properties suitable for bread making. The control sample was the most preferred in terms of sensory attributes.

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