



# Evaluation of a Functional Bread Made with Wheat Flour (*Triticum* spp.), Tarwi Flour (*Lupinus mutabilis* Sweet) and Hydroxypropyl Methyl Cellulose <sup>†</sup>

Paola Sánchez-Guamba and Pedro Maldonado-Alvarado \* 

Department of Food Science and Biotechnology, Escuela Politécnica Nacional, Quito 17-01-2759, Ecuador; paola.sanchez02@epn.edu.ec

\* Correspondence: pedro.maldonado@epn.edu.ec

<sup>†</sup> Presented at the VI International Congress la ValSe-Food, Lima, Peru, 23–25 September 2024.

**Abstract:** Making bread from tarwi represents a scientific and technical challenge due to its poor breadmaking properties; however, strategies like partial substitution with other flours as well as the use of improvers could maximize these properties. This work aimed to evaluate a functional bread made with wheat flour (*Triticum* spp.), tarwi flour (*Lupinus mutabilis* Sweet) and Hydroxypropyl Methyl Cellulose (HPMC). The partial substitution levels evaluated were 0, 5, 10, 15, 20 and 25% with and without the addition of HPMC as a bread improver. The bread's volume, weight, height and specific volume were determined. Sensory tests of the bread were carried out to determine bakery aptitude and acceptability. The specific volumes of the bread were 3.90; 3.46; 3.27; 3.23; 2.98 and 2.62 cm<sup>3</sup>/g in samples without HPMC and 4.60; 4.28; 4.27; 3.26; 2.96 and 2.62 cm<sup>3</sup>/g in samples with HPMC, respectively. These values had reciprocity with the heights of the breads, which were between 8.90 and 6.00 cm in samples without HPMC and between 10.55 and 6.50 cm in samples with HPMC. The specific volume of bread decreased from 15% substitution. The sample with 0, 5 and 10% substitution with tarwi flour had both acceptability and bakery aptitude.

**Keywords:** bread; tarwi; wheat; HPMC; sensory properties



**Citation:** Sánchez-Guamba, P.; Maldonado-Alvarado, P. Evaluation of a Functional Bread Made with Wheat Flour (*Triticum* spp.), Tarwi Flour (*Lupinus mutabilis* Sweet) and Hydroxypropyl Methyl Cellulose. *Biol. Life Sci. Forum* **2024**, *37*, 12. <https://doi.org/10.3390/blsf2024037012>

Academic Editors: Laura Mereles and Ma Carolina Zúñiga

Published: 13 November 2024



**Copyright:** © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

The marginalization of Andean crops has occurred due to different problems: =, including a low social prestige of endemic crops, a preference for the use of other imported crops (e.g., wheat), and a lack of public food sovereignty policies in southern countries, among others [1]. In addition, the valorization of Andean crops has not been easy because of the overproduction of crops, which can be understood as the non-use of a certain part of the food production, as well as poor valorization of endemic foods, related to the low valorization of raw materials in finished products [2]. However, it is well known that Andean crops, e.g., quinoa, amaranth, cassava, banana and lupin, have higher nutritional and functional properties, and can provide important benefits to human health [1].

In the Andes region, few studies related to research and development of new foods from the local matrix with functional properties such as tarwi, but also with maximized structural and sensory characteristics, have been reported. This is due to the difficulty of combining all these properties in synergy to obtain a finished product and, crucially, a gluten-free food [3]. The expanding number of gluten-free goods, like bread and extruded foods, use food matrices that are different from those that contain gluten, using products like pseudocereals, tubers and pulses to mimic the viscoelastic characteristics of this protein. Improvers like hydrocolloids, enzymes and modified starch can be added to achieve the desired expanded gluten-free network, which represents a technological challenge. On the other hand, achieving improved sensory characteristics with a gluten-free matrix is even more complex. Many of the gluten-free products that are on the market have a poor

sensory perception and, on the other hand, people are accustomed to the taste of products that contain wheat, such as bread [4].

The aim of this contribution was to evaluate a functional bread made with wheat flour (*Triticum* spp.), tarwi flour (*Lupinus mutabilis* Sweet) and Hydroxypropyl Methyl Cellulose (HPMC).

## 2. Materials and Method

### 2.1. Materials

Dry seeds of tarwi (*Lupinus mutabilis* Sweet) from Latacunga, Ecuador, were used. The seeds were soaked in water for a period of 1 day, cooked at a temperature of 87 °C for 1 h and debittered in water for 7 days, with 3 water changes being carried out daily. A manual selection was carried out and the non-hydrated grains were discarded; the selected grains were dried in a Selecta model oven (Barcelona, Spain) at 45 °C for 48 h. The grinding was carried out in an Alpine model mill (Augsburg, Germany) for a time of 10 s and was sieved through a No. 11 mesh. YA brand (Quito, Ecuador) fortified wheat flour for baking was acquired from a local market. The additive used to improve the bread was Methocel E5LV, Hydroxypropylmethylcellulose (The Dow Chemical Company, Midland, MI, USA).

To make the bread, fortified wheat flour for baking, fresh yeast, multipurpose vegetable margarine, white sugar and iodized salt were used.

### 2.2. Breadmaking Test

Following the INEN 530-2013 Standard [5] (Ecuador), a baking test was carried out using the two-fermentation method and bread samples with different substitutions (substitutions of lupine flour with 0, 5, 10, 15, 20 and 25% of wheat flour were performed) with the addition or not of HPMC 2% (based on flour content). The amount of water that was added to the flour to form a dough of suitable consistency was based on the percentage of water absorption obtained from the Mixolab analysis and was replicated for all samples. The salt, sugar and yeast were dissolved in water at  $30 \pm 2$  °C. The flour, HPMC (if established in the recipe) and margarine were placed in a deep container, and the water, salt and yeast solution were added. They were homogenized in a KENWOOD mixer (Tokyo, Japan), at a low speed (60 rpm) for 3 min, the dough was placed on baking trays and left to rest in a UNOX brand fermentation chamber, model XLT 135 (Rome, Italy), for 15 min. at 30 °C and a relative humidity of 80%. The dough was then kneaded and divided into 135 g portions, before being laminated, rolled and placed in the previously greased molds. Fermentation was carried out for a second time with the same characteristics but for a period of 45 min; the samples were cooked in a UNOX model XFT 115 forced convection oven (Rome, Italy) with the following conditions: 180 °C for 5 min with 80% humidity; 220 °C for 5 min without humidity; and 150 °C for 20 min without humidity and cooled until reaching an internal temperature of 30 °C. The weights, heights and volumes of the obtained breads were determined with a scale, a ruler and a pycnometer using birdseed. Specific volume was calculated as the ratio between the bread volume and the bread weight (mL/g).

### 2.3. Sensory Analysis

#### 2.3.1. Baking Aptitude

A panel of 20 semi-trained judges was established, who evaluated the baking aptitude of the samples with the following parameters: crust color (15), appearance and symmetry of the bread (15), flavor (10), crumb color (10), crumb texture (30) and crumb grain (20) (maximum scores are indicated in parentheses). For analysis, 1 cm wide slices of bread from each substitution level were selected and placed in white containers with a 3-digit random code for each sample. The INEN standard 530-2013 was taken as a reference.

#### 2.3.2. Acceptability

To understand the panel's preference for bread samples with different levels of substitution, 20 semi-trained judges evaluated the bread samples with a hedonic scale with

values between 0 and 5, in which 0 meant “Very Bad”, 1 “Bad”, 2 “Fair”, 3 “Acceptable”, 4 “Good” and 5 “Very Good”. The parameters evaluated were color, aroma, crumb texture, crust texture, flavor and symmetry. The sample preparation was carried out in the same way as in the baking aptitude evaluation [5].

#### 2.4. Statistical Analysis

Results were expressed as mean  $\pm$  standard deviation, and all measurements were conducted in triplicate. The results obtained were evaluated with an analysis of variance (ANOVA) followed by an LSD test with a confidence level of 95% in the STATGRAPHICS® CENTURION XVI software.

### 3. Results and Discussion

#### 3.1. Breadmaking Properties

Table 1 shows the results obtained for the different samples made with 0, 5, 10, 15, 20 and 25% of partial substitution of wheat flour with tarwi flour. In treatments without adding HPMC, no significant differences were found between the specific volume values of the 5, 10 and 15% replacement samples. For the different levels, the specific volume decreased by 11.3; 16.2; 17.2; 23.6 and 32.8%, respectively, compared to the value of bread with 0% substitution. On the other hand, a decrease in bread height was observed as the level of substitution increased because the CO<sub>2</sub> produced in fermentation is not retained, although there were significantly no differences between the different levels.

**Table 1.** Physical characteristics of bread with 0, 5, 10, 15, 20 and 25% partial replacement of wheat flour with tarwi flour.

| Partial Substitution of Wheat Flour by Tarwi Flour | Weight (g)                     | Volume (cm <sup>3</sup> )     | Specific Volume (cm <sup>3</sup> /g) | Height (cm)                    |
|----------------------------------------------------|--------------------------------|-------------------------------|--------------------------------------|--------------------------------|
| 0%                                                 | 109.87 <sup>a</sup> $\pm$ 1.56 | 429 <sup>f</sup> $\pm$ 2.98   | 3.90 <sup>d</sup> $\pm$ 0.05         | 8.90 <sup>b</sup> $\pm$ 0.05   |
| 0% *                                               | 105.43 <sup>a</sup> $\pm$ 1.56 | 485 <sup>e</sup> $\pm$ 2.98   | 4.60 <sup>e</sup> $\pm$ 0.05         | 10.55 <sup>bc</sup> $\pm$ 0.05 |
| 5%                                                 | 110.15 <sup>a</sup> $\pm$ 1.02 | 381 <sup>d</sup> $\pm$ 3.98   | 3.46 <sup>c</sup> $\pm$ 0.23         | 7.90 <sup>a</sup> $\pm$ 0.84   |
| 5% *                                               | 109.80 <sup>b</sup> $\pm$ 1.02 | 469 <sup>d</sup> $\pm$ 3.98   | 4.28 <sup>d</sup> $\pm$ 0.23         | 10.00 <sup>bc</sup> $\pm$ 0.84 |
| 10%                                                | 116.08 <sup>c</sup> $\pm$ 1.83 | 379.5 <sup>d</sup> $\pm$ 3.87 | 3.27 <sup>c</sup> $\pm$ 0.03         | 7.75 <sup>a</sup> $\pm$ 1.03   |
| 10% *                                              | 109.33 <sup>b</sup> $\pm$ 1.83 | 467 <sup>d</sup> $\pm$ 3.87   | 4.27 <sup>d</sup> $\pm$ 0.03         | 9.90 <sup>b</sup> $\pm$ 1.03   |
| 15%                                                | 114.12 <sup>b</sup> $\pm$ 1.63 | 369 <sup>c</sup> $\pm$ 1.35   | 3.23 <sup>c</sup> $\pm$ 0.07         | 7.35 <sup>a</sup> $\pm$ 1.47   |
| 15% *                                              | 113.47 <sup>c</sup> $\pm$ 1.63 | 371 <sup>c</sup> $\pm$ 1.35   | 3.26 <sup>c</sup> $\pm$ 0.07         | 8.10 <sup>ab</sup> $\pm$ 1.47  |
| 20%                                                | 113.62 <sup>b</sup> $\pm$ 1.17 | 339 <sup>b</sup> $\pm$ 5.72   | 2.98 <sup>b</sup> $\pm$ 0.09         | 7.05 <sup>a</sup> $\pm$ 2.09   |
| 20% *                                              | 115.37 <sup>c</sup> $\pm$ 1.17 | 342 <sup>b</sup> $\pm$ 5.72   | 2.96 <sup>b</sup> $\pm$ 0.09         | 7.30 <sup>a</sup> $\pm$ 2.09   |
| 25%                                                | 112.42 <sup>b</sup> $\pm$ 2.31 | 294 <sup>a</sup> $\pm$ 3.67   | 2.62 <sup>a</sup> $\pm$ 0.03         | 6.00 <sup>a</sup> $\pm$ 2.73   |
| 25% *                                              | 115.52 <sup>c</sup> $\pm$ 2.31 | 299 <sup>a</sup> $\pm$ 3.67   | 2.62 <sup>a</sup> $\pm$ 0.03         | 6.50 <sup>a</sup> $\pm$ 2.73   |

$\bar{x} \pm \sigma$  (n = 4). Different letters within the column indicate significant differences at  $p < 0.05$  (LSD). \* Samples with the addition of 2% HPMC based on flour content.

In treatments with the addition of HPMC, a significant increase in the specific volume was observed in the samples with 0, 5 and 10% replacement with lupine flour. The percentage increases were, respectively, 17.95; 23.21 and 30.58%. However, for the 15, 20 and 25% samples, no changes were observed in the specific volume, and the samples' original values were maintained.

Alasino et al. (2011) [6] showed that the average specific volume of bread made from wheat flour ranges around 3.98 cm<sup>3</sup>/g and that lower values occur in flours considered weak. According to Mongi et al. [7] in their study of making breads with soy flour, as the substitution percentage increases, the specific volume of the bread decreases. With a substitution level of 20%, a specific volume of 3 cm<sup>3</sup>/g is obtained, this is because there is no adequate protein source, and it does not allow for the appropriate retention of CO<sub>2</sub> to increase the volume of the bread. Rosell et al. [8] reported a specific volume of about 3 cm<sup>3</sup>/g for partial substitutions of wheat flour with 0 and 12.5% of tarwi flour, but the

specific volume of bread decreased to 2, 1.2 and 1 cm<sup>3</sup>/g for 25, 50 and 100% of substitution with tarwi.

### 3.2. Sensory Analysis

Table 2 shows the results obtained for the different samples made with 0, 5, 10, 15, 20 and 25% of partial substitution of wheat flour with tarwi flour. In treatments without the addition of HPMC, it was determined that samples with up to 10% substitution obtained scores greater than 80. Samples with a higher percentage of substitution obtained scores less than 70. The evaluated parameters did not present statistically significant differences between the samples with 5, 10, 15, 20 and 25% of substitution. The results of the evaluated parameters showed a relationship directly proportional to the percentage of bread substitution. However, in the flavor parameter, the values decreased drastically, due mainly to the fact that the bread took on a strange flavor as the substitution percentage increased.

**Table 2.** Baking ability for breads made with 0, 5, 10, 15, 20 and 25% partial replacement of wheat flour with lupine flour.

| Partial Substitution of Wheat Flour by Tarwi Flour | Sensory Parameters for Baking Aptitude |                               |                           |                           |                            |                           |                             |
|----------------------------------------------------|----------------------------------------|-------------------------------|---------------------------|---------------------------|----------------------------|---------------------------|-----------------------------|
|                                                    | Crust Color (/15)                      | Appearance and Symmetry (/15) | Flavor (/10)              | Crumb Color (/10)         | Crumb Texture (/30)        | Crumb Grain (/20)         | Sum (/100)                  |
| 0%                                                 | 14.50 <sup>a</sup> ± 1.41              | 14.20 <sup>b</sup> ± 1.45     | 8.70 <sup>c</sup> ± 1.55  | 9.40 <sup>b</sup> ± 1.78  | 27.50 <sup>b</sup> ± 3.69  | 18.40 <sup>a</sup> ± 2.73 | 92.70 <sup>b</sup> ± 8.65   |
| 0% *                                               | 14.20 <sup>a</sup> ± 1.41              | 14.50 <sup>b</sup> ± 1.45     | 8.30 <sup>b</sup> ± 1.55  | 9.50 <sup>b</sup> ± 1.78  | 28.50 <sup>b</sup> ± 3.69  | 18.30 <sup>a</sup> ± 2.73 | 93.30 <sup>b</sup> ± 8.65   |
| 5%                                                 | 14.30 <sup>a</sup> ± 1.58              | 14.00 <sup>ab</sup> ± 2.53    | 8.10 <sup>bc</sup> ± 2.40 | 9.10 <sup>b</sup> ± 2.11  | 26.30 <sup>b</sup> ± 2.72  | 17.20 <sup>a</sup> ± 2.11 | 89.00 <sup>ab</sup> ± 9.12  |
| 5% *                                               | 14.10 <sup>a</sup> ± 1.58              | 14.10 <sup>b</sup> ± 2.53     | 8.10 <sup>b</sup> ± 2.40  | 9.20 <sup>b</sup> ± 2.11  | 27.30 <sup>b</sup> ± 2.72  | 17.10 <sup>a</sup> ± 2.11 | 89.90 <sup>ab</sup> ± 9.12  |
| 10%                                                | 13.90 <sup>a</sup> ± 3.79              | 13.80 <sup>ab</sup> ± 2.78    | 7.90 <sup>ab</sup> ± 2.73 | 7.60 <sup>ab</sup> ± 2.10 | 25.50 <sup>b</sup> ± 2.96  | 16.40 <sup>a</sup> ± 1.26 | 85.10 <sup>ab</sup> ± 11.71 |
| 10% *                                              | 13.80 <sup>a</sup> ± 3.79              | 13.70 <sup>b</sup> ± 2.78     | 7.90 <sup>b</sup> ± 2.73  | 8.60 <sup>ab</sup> ± 2.10 | 26.50 <sup>b</sup> ± 2.96  | 16.20 <sup>a</sup> ± 1.26 | 86.70 <sup>ab</sup> ± 11.71 |
| 15%                                                | 10.70 <sup>a</sup> ± 4.56              | 10.90 <sup>ab</sup> ± 3.38    | 3.50 <sup>ab</sup> ± 2.85 | 7.20 <sup>ab</sup> ± 1.45 | 20.40 <sup>ab</sup> ± 3.69 | 16.10 <sup>a</sup> ± 3.41 | 68.80 <sup>a</sup> ± 13.33  |
| 15% *                                              | 10.50 <sup>a</sup> ± 4.56              | 10.40 <sup>ab</sup> ± 3.38    | 3.30 <sup>a</sup> ± 2.85  | 7.10 <sup>a</sup> ± 1.45  | 19.40 <sup>a</sup> ± 3.69  | 15.90 <sup>a</sup> ± 3.41 | 66.60 <sup>a</sup> ± 13.33  |
| 20%                                                | 10.30 <sup>a</sup> ± 6.34              | 9.70 <sup>a</sup> ± 3.53      | 3.10 <sup>a</sup> ± 2.03  | 6.30 <sup>a</sup> ± 0.98  | 20.10 <sup>a</sup> ± 6.46  | 15.90 <sup>a</sup> ± 5.76 | 65.40 <sup>a</sup> ± 15.15  |
| 20% *                                              | 10.10 <sup>a</sup> ± 6.34              | 9.60 <sup>a</sup> ± 3.53      | 3.10 <sup>a</sup> ± 2.03  | 6.10 <sup>a</sup> ± 0.98  | 19.10 <sup>a</sup> ± 6.46  | 15.70 <sup>a</sup> ± 5.76 | 63.70 <sup>a</sup> ± 15.15  |
| 25%                                                | 9.80 <sup>a</sup> ± 6.45               | 8.60 <sup>a</sup> ± 3.62      | 3.00 <sup>a</sup> ± 3.11  | 6.00 <sup>a</sup> ± 2.06  | 18.90 <sup>a</sup> ± 4.08  | 14.80 <sup>a</sup> ± 6.36 | 61.10 <sup>a</sup> ± 17.16  |
| 25% *                                              | 9.50 <sup>a</sup> ± 6.45               | 8.50 <sup>a</sup> ± 3.62      | 3.00 <sup>a</sup> ± 3.11  | 6.00 <sup>a</sup> ± 2.06  | 18.90 <sup>a</sup> ± 4.08  | 14.50 <sup>a</sup> ± 6.36 | 60.40 <sup>a</sup> ± 17.16  |

$\bar{x} \pm \sigma$  (n = 4). Different letters within the column indicate significant differences at  $p < 0.05$  (LSD). \* Samples with the addition of 2% HPMC based on flour content.

According to Zuleta et al. [9], breads with a partial substitution of soy flour obtained similar results; it was observed that the breads with 0, 5 and 10% of substitution had the best baking aptitude.

In treatments with the addition of HPMC, it was determined that samples with up to 10% substitution obtained scores greater than 80. The evaluated parameters did not present a statistically significant difference between the samples with 5, 10, 15 and 20% of substitution. The results of the evaluated parameters indicated that the breads with the best characteristics were those with 0, 5 and 10% substitution with lupine flour. The addition of HPMC improved the evaluated parameters since it provided the breads with superior sensory characteristics [10].

## 4. Conclusions

Andean farinaceous like tarwi can be used to obtain new functional foods, e.g., bread with maximized breadmaking and sensory properties. The addition of HPMC 2% to the doughs with partial substitution of wheat with tarwi can increase the specific volume of the bread for up to 15% of substitution.

**Author Contributions:** Conceptualization, P.M.-A.; methodology, P.M.-A. and P.S.-G.; validation, P.M.-A.; formal analysis, P.S.-G.; investigation, P.S.-G.; writing—original draft preparation, P.M.-A.; writing—review and editing, P.M.-A.; funding acquisition, P.M.-A. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by PIS-21-04 project of EPN from Quito-Ecuador.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data analyzed in this study are available from the authors upon reasonable request.

**Acknowledgments:** This work was supported by grant Ia ValSe Food-CYTED (Ref. 119RT0567), Universidad de Lima—Peru and EPN from Quito-Ecuador for financing support.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Haros, C.M.; Reguera, M.; Sammán, N.; Paredes-López, O. *Latin-American Seeds: Agronomic, Processing and Health Aspects*; CRC Press: Boca Raton, FL, USA, 2023; pp. 1–442. [[CrossRef](#)]
2. Walsh-Dilley, M. Resilience Compromised: Producing Vulnerability to Climate and Market among Quinoa Producers in South-western Bolivia. *Glob. Environ. Chang.* **2020**, *65*, 102165. [[CrossRef](#)]
3. Gallagher, E. *Gluten-Free Food Science and Technology*; Wiley: Hoboken, NJ, USA, 2009; pp. 1–246. [[CrossRef](#)]
4. Capriles, V.; Areas, A. Novel Approaches in Gluten-Free Breadmaking: Interface between Food Science, Nutrition, and Health. *Compr. Rev. Food Sci. Food Saf.* **2014**, *13*, 871–890. [[CrossRef](#)]
5. NTE INEN 530:2013; I.N.E.N. Instituto Ecuatoriano de Normalización. Harina de Trigo. Ensayo de Panificación: Quito, Ecuador, 2013.
6. Alasino, N.M.; Aringoli, E.E.; Sánchez, H.D. Optimización de Los Niveles de Los Agentes Oxidante/Reductor En La Panificación de Harina de Trigo. *Inf. Tecnológica* **2011**, *22*, 75–86. [[CrossRef](#)]
7. Mongi, R.; Ndabikunze, B.; Chove, B.; Mamiro, P.; Ruhembe, C.C.; Ntwenya, J. Proximate Composition, Bread Characteristics and Sensory Evaluation of Cocoyam-Wheat Composite Breads. *Afr. J. Food, Agric. Nutr. Dev.* **2011**, *11*, 5586–5599. [[CrossRef](#)]
8. Rosell, C.M.; Cortez, G.; Repo-Carrasco, R. Breadmaking Use of Andean Crops Quinoa, Kañiwa, Kiwicha, and Tarwi. *Cereal Chem. J.* **2009**, *86*, 386–392. [[CrossRef](#)]
9. Zuleta, A.; Binaghi, M.; Greco, C.; Aguirre, C.; De la Casa, L.; Tadini, C.; Ronayne, P. Diseño de Panes Funcionales a Base de Harinas No Tradicionales. *Rev. Chile Nutr.* **2012**, *39*, 58–64. [[CrossRef](#)]
10. San Miguel Fermoso, M.Á. Influencia de La Hidroxipropilmetilcelulosa, El Psyllium y Su Combinación En Las Propiedades Morfogeométricas y Texturales de Panes Sin Gluten Elaborados Con Harina de Arroz. Master's Thesis, Universidad de Valladolid, Valladolid, Spain, 2013.

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.