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Consumer acceptance and nutritional potential of products made from quinoa, chocho, broad bean and maize flours: An age-segmented study in the hospitality sector

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Abstract: This study examines the nutritional properties and consumer acceptance of food products made from quinoa (Chenopodium quinoa), chocho (Lupinus mutabilis), broad bean (Vicia faba), and maize (Zea mays) flours within the hospitality sector. A total of 80 participants, segmented into four age groups (20–29, 30–39, 40–49, ≥50 years), evaluated prototype cookies to assess flavor, texture, aroma, and overall acceptance. In addition, physicochemical analyses were conducted to determine each flour's composition (proteins, lipids, fiber, ash, and carbohydrates). The results revealed that chocho and broad bean stood out in terms of protein, while quinoa and maize offered a balanced nutritional profile with competitive acceptability. The younger group showed greater openness to novel ingredients, whereas older participants tended to prefer more familiar flavors. Using a partial least squares structural equation modeling (PLS-SEM) approach, the influence of age on the preference for non-traditional flours was confirmed. These findings underscore the importance of implementing segmented strategies in the hospitality sector, highlighting healthier and culturally relevant alternatives.

Keywords: *Age-segmented study, Alternative flours, Consumer acceptance, Hospitality, Sensory evaluation.*

1. Introduction

The quest for more nutritious foods and the revaluation of traditional ingredients have fostered an expansion in the use of alternative flours within the hospitality industry [1, 2]. In recent years, consumer interest has grown toward products combining functionality and cultural roots [3-5]. Quinoa (Chenopodium quinoa), chocho (Lupinus mutabilis), broad bean (Vicia faba), and maize (Zea mays) flours offer attractive nutritional profiles and culinary possibilities that not only enhance gastronomic offerings but also address the demand for healthier menus [6, 7].

Hospitality is a space where diverse cultures and expectations converge, making it ideal for developing new food proposals [8-10]. Nevertheless, consumer acceptance depends not only on a product's nutritional quality but also on sensory perception and sociodemographic factors, such as age [11-13]. Previous studies indicate that younger consumers often demonstrate greater openness to novel ingredients, whereas older adults prefer traditional flavors [14-16]. Consequently, understanding how age influences preferences for alternative flours may guide more effective product positioning and marketing strategies [17, 18].

Despite abundant research on food innovation, there is a shortage of studies combining physicochemical analyses of Andean flours with advanced statistical models—such as PLS-SEM—to predict age-segmented sensory acceptance [19-21]. The present study addresses this gap by proposing an integral approach that, on the one hand, examines these flours' nutritional composition and, on the other, analyzes consumers' responses to products made from them [22-24]. As such, it

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aims to benefit both the academic community and the hospitality industry, providing insight for decision-making around formulation, menu development, and market segmentation [25].

1.1. Justification and Relevance

Transforming native flours presents an opportunity to diversify gastronomic offerings and stimulate local value chains [26-28]. Quinoa contains a high-quality protein including essential amino acids [29, 30] while chocho has protein levels comparable to or exceeding soy [31]. Broad bean, in turn, offers protein and dietary fiber, which fosters satiety and digestive health [32, 33]. Maize, as an ancestral cereal, is culturally significant and offers culinary versatility [34, 35].

These flours face potential sensory and cognitive barriers, particularly among older consumers who prioritize flavor familiarity [11, 36, 37]. Assessing consumer acceptance is essential to ascertain the commercial and social feasibility of incorporating these products into restaurant or hotel menus [38-40]. Thus, this study adopts a multidisciplinary stance, blending food science and service marketing within the hospitality domain [41-43].

1.2. Objectives

1. Analyze the nutritional composition (protein, fat, fiber, ash, and carbohydrates) of quinoa, chocho, broad bean, and maize flours, highlighting their potential for enriching offerings within the hospitality sector [44, 45].
2. Develop prototype cookies using each flour and evaluate their sensory properties (taste, texture, aroma, and overall acceptance) via hedonic scales [46-48].
3. Examine the role of age in consumer preference by segmenting participants into four age ranges and exploring differences in sensory perception [12, 49].
4. Apply PLS-SEM to comprehensively interpret how age, openness to alternative flours, and sensory acceptance are interrelated, thereby contributing to scholarly knowledge and industry practice [50-52].

2. Materials and Methods

2.1. Study Design

A mixed-method approach was chosen, combining physicochemical measurements with sensory evaluation and advanced statistical analysis [53-55]. Experimentally, prototype cookies were created using each of the four flours, and their acceptability was evaluated by 80 participants. Concurrently, an official [44, 56] nutritional composition analysis was performed. Subsequently, partial least squares structural equation modeling (PLS-SEM) was employed to assess the latent relationships [19].

2.2. Participants and Age Segmentation

The total sample comprised 80 individuals (45% men, 55% women), recruited via convenience sampling from the ESPOCH community [57, 58]. Inclusion criteria required participants to consume baked goods at least once weekly and have no allergies to the primary ingredients [59, 60]. They were categorized into:

- Group 1 (20–29 years): 25 participants
- Group 2 (30–39 years): 20 participants
- Group 3 (40–49 years): 20 participants
- Group 4 (≥50 years): 15 participants

This segmentation aligns with previous evidence of shifts in flavor and texture perception across life stages [61-63].

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2.3. Flour Procurement and Preparation

Quinoa, chocho, broad bean, and maize flours were sourced from certified local suppliers, ensuring traceability [64, 65]. To achieve a uniform particle size (200 μm), knife mills and standardized sieves were used [66, 67]. Certain flours (quinoa and chocho) underwent washing and drying processes to remove saponins and bitter alkaloids [68]. They were then hermetically sealed and stored at 20–22 °C until use [69, 70]

2.4. Physicochemical Analysis

Moisture, protein, fat, ash, and fiber were measured in triplicate following [44]. Carbohydrates were calculated by difference [71]. Specifically:

1. Moisture: Gravimetric method at 105 °C to constant weight [44, 72].
2. Protein: Kjeldahl method, conversion factor 6.25 [44, 73, 74].
3. Fat: Soxhlet extraction with petroleum ether [44, 75].
4. Ash: Incineration in a muffle furnace at 550 °C [44].
5. Crude Fiber: Enzymatic-gravimetric procedure [44, 76].

2.5. Prototype Cookie Development

Four formulations were prepared, each containing 100 g of the respective flour, 30 g of sugar, 20 g of vegetable oil, 1 g of salt, and sufficient water for kneading [77, 78]. The process consisted of:

1. Mixing dry ingredients (flour, sugar, salt).
2. Adding oil and blending.
3. Gradually incorporating water until a uniform dough was obtained.
4. Rolling the dough to 3 mm thickness and cutting into 4 cm diameter discs.
5. Baking at 180 °C for 15 minutes in a conventional oven [79, 80].
6. Cooling and storing cookies in airtight containers for 24 hours prior to evaluation [81, 82].

2.6. Sensory Evaluation

Sensory tests were performed in individual booths under white lighting [47, 48]. Each sample was labeled with a three-digit code and served in random order [12, 83]. Panelists scored taste, texture, aroma, and overall acceptance using a 9-point hedonic scale (1 = "extremely dislike," 9 = "extremely like") [46, 84]. Between samples, participants rinsed their mouths with water [85, 86].

3. Statistical Analysis

3.1. Descriptive Statistics and ANOVA

Means and standard deviations were calculated for each physicochemical parameter and sensory rating. One-way ANOVA determined significant differences ($p < 0.05$) [87, 88]. Tukey's test was used as a post-hoc procedure [89, 90].

3.2. Structural Equation Modeling (PLS-SEM)

To explore relationships among age, openness to alternative flours, and sensory acceptance, the partial least squares (PLS-SEM) approach was utilized [19, 52]. The following latent constructs were defined:

- Preference for Traditional Flours (PHT)
- Openness to Novel Flours (AHN)
- Overall Acceptance (sum of sensory scores)

"Age" was included as an observed variable, hypothesizing:

1. Age → (+) PHT
2. Age → (–) AHN
3. PHT, AHN → Overall Acceptance

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The measurement model was evaluated by reliability (Cronbach's alpha, CR) and convergent validity (AVE) [50, 51]. The structural model was analyzed using path coefficients (β), significance (t-values via 5000 bootstrap replications), and R2 [20, 91].

4. Results

4.1. Nutritional Composition of the Flours

Table 1.
Shows the moisture, protein, fat, fiber, ash, and carbohydrate content (by difference) for quinoa (QU), chocho (CH), broad bean (HA), and maize (MA) flours, with mean values from three replicates.

Parameter	Quinoa (QU)	Chocho (CH)	Broad Bean (HA)	Maize (MA)
Moisture (%)	10.8 ± 0.2	10.3 ± 0.3	11.2 ± 0.2	10.5 ± 0.2
Protein (%)	15.9 ± 0.4	36.5 ± 0.5	26.2 ± 0.4	9.4 ± 0.3
Fat (%)	5.7 ± 0.2	18.2 ± 0.4	2.1 ± 0.1	3.8 ± 0.2
Fiber (%)	7.5 ± 0.3	12.4 ± 0.4	9.1 ± 0.3	7.9 ± 0.3
Ash (%)	2.3 ± 0.06	3.0 ± 0.05	2.8 ± 0.05	1.3 ± 0.04
CHO (%)*	57.8 ± 0.6	19.6 ± 0.7	48.6 ± 0.5	67.1 ± 0.5

Note: * CHO: Carbohydrates by difference.

The results align with prior reports highlighting high protein content in chocho (36–40%) and broad bean (25–30%) [31, 32]. Maize showed the lowest protein fraction (9.4%) but the highest carbohydrate percentage (67.1%). Quinoa displayed balanced values consistent with its "superfood" designation [29]. Differences were statistically significant (ANOVA, $p < 0.05$) [87].

4.2. Sensory Evaluation of Cookies

4.2.1. Flavor

Scores (on a 1–9 scale) ranged as follows:

- Maize (MA): 7.4 ± 0.5
- Quinoa (QU): 7.1 ± 0.6
- Broad Bean (HA): 6.5 ± 0.6
- Chocho (CH): 6.3 ± 0.7

ANOVA identified differences ($p < 0.05$). Tukey's test revealed CH to be significantly lower in flavor compared to MA and QU, with comments on a residual bitterness [11, 16]. Maize was described as "familiar" and "naturally sweet."

4.2.2. Texture

Texture scores showed a similar trend:

- Maize: 7.3 ± 0.4
- Quinoa: 7.0 ± 0.5
- Chocho: 6.8 ± 0.5
- Broad Bean: 6.5 ± 0.5

Panelists considered maize to provide a crunchy, pleasant texture, whereas broad bean felt "somewhat dry" [9, 82].

4.2.3. Aroma

Aroma ratings were:

- Maize: 7.2 ± 0.4
- Quinoa: 7.0 ± 0.4
- Broad Bean: 6.7 ± 0.5
- Chocho: 6.5 ± 0.4

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Although differences were less pronounced than in flavor or texture, chocho received the lowest rating, associated with a "earthy" odor [40] Aroma ratings were:

- Maize: 7.2 ± 0.4
- Quinoa: 7.0 ± 0.4
- Broad Bean: 6.7 ± 0.5
- Chocho: 6.5 ± 0.4

Although differences were less pronounced than in flavor or texture, chocho received the lowest rating, associated with a "earthy" odor [40].

4.2.4. Overall Acceptance

Overall acceptance combined the average of the above attributes [47]. The following values were obtained:

- Maize: 7.5 ± 0.5
- Quinoa: 7.2 ± 0.6
- Broad Bean: 6.6 ± 0.5
- Chocho: 6.4 ± 0.6

Differences were significant ($p < 0.05$) when comparing maize and chocho. Quinoa's rating was close to that of maize, reinforcing its sensory potential [29]. Panelists' comments suggest that chocho and broad bean may require flour blending or further processing techniques to enhance acceptability [24, 92].

4.3. Age Segmentation

When results were grouped by age, distinct patterns emerged:

- Group 1 (20–29): a higher preference for quinoa (7.3) and maize (7.4), with openness to novel flavors [14].
- Group 2 (30–39): maize (7.5) still led, though quinoa (7.1) also received positive scores [37].
- Group 3 (40–49): a predilection for maize (7.6), with moderate chocho (6.2) and broad bean (6.5) ratings [12].
- Group 4 (≥50): a clear inclination toward maize (7.7), with lower acceptance for chocho (6.0) and broad bean (6.4), confirming a preference for traditional flavors [15, 36].

4.4. PLS-SEM Results

4.4.1. Measurement Model

The constructs "Preference for Traditional Flours (PHT)" and "Openness to Novel Flours (AHN)" met reliability (Cronbach's alpha between 0.72–0.85, CR>0.75) and convergent validity (AVE>0.50) standards [51, 52].

4.4.2. Structural Model

Path coefficients were estimated using 5000 bootstrap replications [50]:

- Age → PHT: $\beta = 0.47$ ($p < 0.01$). This implies that older individuals exhibit a stronger preference for traditional options (maize).
- Age → AHN: $\beta = -0.34$ ($p < 0.05$). Suggesting that openness to non-conventional flours decreases with age.
- PHT → Overall Acceptance: $\beta = 0.52$ ($p < 0.01$). Reflects that a preference for familiar flavors boosts overall evaluations.
- AHN → Overall Acceptance: $\beta = 0.48$ ($p < 0.01$). Indicates that willingness to try new ingredients raises acceptance, especially for quinoa.

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The R2 for "Overall Acceptance" was 0.46, indicating a moderate explanatory power [20, 91]. The model confirmed the strong correlation between age and sensory preference [17, 38].

5. Discussion

Findings suggest that incorporating quinoa, chocho, and broad bean flours can enrich menus in hospitality establishments, particularly if age segmentation strategies are used [1, 2, 93]. Despite their high protein content, chocho and broad bean face sensory limitations related to bitter flavors and less crunchy textures [34, 82]. Various studies indicate that partially blending these flours with milder cereals or pseudocereals can alleviate such issues [22, 77, 92].

Maize achieved the highest acceptance across all age brackets, confirming the relevance of cultural factors and flavor familiarity [35]. Quinoa ranked second overall and was particularly appealing to younger consumers, aligning with literature on superfoods and health-oriented trends [4, 29]. From a hospitality standpoint, these results validate the idea of dual menus, catering on one hand to traditional consumers (maize), and on the other to more adventurous segments (quinoa, chocho) [14, 49].

The PLS-SEM model supports the hypothesis that age influences openness to novel flours and preference for conventional flavors [11, 15]. Accordingly, the study contributes to consumer behavior theory in hospitality, revealing how the age dimension can moderate the adoption of new ingredients [9, 17]. For managerial practice, emphasizing nutritional benefits and cultural storytelling when offering chocho and broad bean products to younger consumers is advisable [4, 43]. Meanwhile, for older customers, moderate percentages of these flours combined with maize can maintain a more recognizable sensory profile [36].

6. Limitations and Future Research

While 80 participants provide clear indications of the role of age, expanding the sample size and cultural diversity could strengthen external validity [55, 63]. Testing other products (e.g., breads, pastas, snacks) would broaden the functional understanding of these flours [24, 25]. Moreover, flavor chemistry methodologies or volatile compound analysis could elucidate the causes of bitterness in chocho and broad bean [94]. From a sustainability perspective, a life-cycle assessment of each flour and its socioeconomic impact would be valuable [27, 28].

7. Conclusions

1. Andean Flours with Distinctive Value: Chocho and broad bean provide high protein levels, whereas quinoa offers a balanced profile. Even though maize has lower protein, it retains strong cultural roots and high sensory acceptance.
2. Influence of Age: Younger consumers (20–29) show notable openness to quinoa and, to a lesser extent, chocho and broad bean. In contrast, older adults (≥50) lean toward maize and rate bitter or unfamiliar flavors more negatively.
3. PLS-SEM Model: Confirms that age moderates acceptance of alternative flours, with an R2 of 0.46 for overall acceptance. PHT and AHN emerge as key constructs for segmenting strategies within the hospitality sector.
4. Practical Recommendations: Blend flours to improve sensory attributes, employ health- and tradition-based marketing strategies, and segment menus according to identified age-based preferences.

In summary, introducing quinoa, chocho, broad bean, and maize flours into hospitality gastronomy offers nutritional benefits and cultural diversity. However, market success depends on adequate sensory formulation and consideration of demographic factors, particularly age, which affects the adoption of novel foods. This research paves the way for further investigations and practical applications that strengthen the integration of native ingredients in the food industry.

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The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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