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Preparing Gluten-free Cookies for Children From Quinoa and Papaya Powder

***Amira, M.A. Abd El- Salam, Hanan, A. Hussien & Mohammad, F.M. Abdulla**

Bread and Pastry Research Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt

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ABSTRACT

The increasing interest in improving the nutritional value of gluten-free products has prompted extensive exploration of various ingredients to create functional and valuable options in this field. This paper aims to study the suitability of using quinoa and papaya powder for improving the nutritive value of gluten free cookies. To achieve this quality of cookies were studied on the basis of proximate analysis, physical properties and sensory evaluation. Quinoa flour had the highest protein and fat content, with 15 g/100g and 3.59 g/100g, respectively. Papaya powder had significantly higher fiber and ash content (12.92 and 4.59 g/100g, respectively) compared to both rice flour and quinoa flour. It also contained a significantly higher amount of carotene (9.05 mg/100g). Substituting quinoa flour for rice flour led to noticeable increases in moisture, protein, fat, fiber, and ash contents. Similarly, papaya powder in gluten-free cookies resulted in increased moisture, fiber, and β-carotene content in the cookies. Furthermore, the addition of quinoa flour significantly increased the levels of all examined minerals. In terms of physical properties, the weight of the cookies increased with the incorporation of papaya powder and further increased with the addition of quinoa. The volume, diameter, and thickness remained relatively unchanged with the addition of papaya powder, while volume and thickness decreased significantly when quinoa was used as a substitute. Additionally, the specific volume decreased when both quinoa and papaya were included, which is consistent with previous studies. The acceptance test results indicated that the panelists preferred samples S3 and S4. Furthermore, the supplemented cookies, containing quinoa and papaya flours, had a relatively high essential amino acid balance, suggesting that they can improve amino acid intake for children with celiac disease. Addition of both quinoa and papaya powder as a replacer for rice flour in gluten free cookies improves its nutritional value without effecting its physical properties or consumer acceptance.

1. Introduction

Children with celiac disease (CD) show symptoms of undernourishment, which impacts their ability to grow and develop normally. Psychophysical problems and behavioral abnormalities like melancholy, impatience, and poor focus can also be signs. (Fasano and Catassi 2012).
An inability to absorb gluten is the result of celiac disease (CD), a chronic autoimmune illness that has detrimental implications for one's health. People with CD should adhere to gluten-free diets (GFDs); however, adherence rates among adults with CD range from 42% to 91%, which is significantly below optimal. (Jana 2020 and Abu-Janb 2020). Gluten replacement in bakery products represents a major technological challenge due to its essential structural binding properties. Removal of gluten impairs dough structure's ability to develop properly during kneading and baking (Gallagher et al., 2004). The desire to enhance the nutritional value of gluten-free products, coupled with the growing interest in this area, has led to the exploration of diverse ingredients to develop functional and valuable gluten
-free

*Corresponding Author
Email: amiraomar127@yahoo.com

In the design of new products, parameters such as color, texture, and volume, which directly influence consumer acceptance, should be considered (Bassinello et al., 2011). Quinoa (Chenopodium quinoa Willd) is a gluten-free pseudo-cereal that contains a high amount of fiber, high biological-value proteins, essential fatty acids (ω-3 and ω-6), vitamins, and minerals (Stikic et al., 2012). Quinoa is considered a super food due to its higher protein content and more balanced amino acid composition with respect to cereal flours (Cannas et al., 2020). (Dhondiram et al., 2023 and Sharma et al. 2023) reported quinoa flour to be high in protein, fat, and ash. (Badia-Olmos et al. 2023) reported 8.7% fiber in quinoa flour. Also, quinoa flour has high amounts of minerals, especially iron (8.42 mg/100 g), (Coţovanu et al., 2023). Papaya (Carica papaya L.) belongs to the family Caricaceae. Papaya (C. papaya L.) is the fourth-most important tropical fruit around the globe (Scheldeman et al., 2007). Some of the active compounds in papaya are ascorbic acid (108 mg/100 g). β-carotene (13.04 mg/100 g), potassium (90.00-257.00 mg/100 g) and iron (0.23-0.66 mg/100 g) (Chuwa and Dhiman, 2022)

In this study, we attempted to assess the suitability of utilizing quinoa and papaya for improving the quality and nutritive value of gluten-free cookies.

Material and Methods

Preparation method for papaya powder

Raw papaya was washed in tap water, hand peeled, cut into thin slices, and then blanched in hot water containing 0.1% sodium meta-bisulphite for 3 minutes. The slices were then dried at 60°C 24 hours. The dried slices were grounded, then sieved through a 60-mesh sieve. The powder samples were packed in polyethylene bags and stored at ambient temperature prior to use according to methods described by (Ukwuru and Adama 2003).

Treatments and cookie preparation

A pretest experiment (unpublished data) was carried out to select the best mix ratio of raw materials chosen for this study. It was found that cookies resulting from 15 or more substitution levels of papaya flour were unacceptable with respect to their physical properties. Therefore, the best level of 10% was selected to carry out the complete study, as shown in the following Table 1.

Table 1. Formula of Cookies

Sample	Control	S1	S2	S3	S4	S5
Rice	100	90	77.5	65	52.5	40
Papaya	0	10	10	10	10	10
Quinoa	0	0	12.5	25	37.5	50
Butter	35	35	35	35	35	35
Sugar	30	30	30	30	30	30
Salt	1	1	1	1	1	1
Baking Powder	1	1	1	1	1	1
Water	As needed					

Proximate composition of raw materials and cookies

Moisture, ash, protein, crude fiber, and fat were determined according to the method of (AOAC 2010). Total carbohydrates were calculated by the difference. Total calories (Kcal) were calculated by the formula of (James 1995) as follows:

Total calories =[(Protein + carbohydrate)4+ (9×fat)].

Determination of β-Carotene

Beta-carotene was determined using the spectrophotometer (Spectronic 21D) method according to the method described by Amaya 2001.

Water Activity of Cookies

The water activity (aw) was measured using a rotronic Hygro Lab EA10-SCS (Switzerland) aw meter as described by (Gokmen et al., 2008).

Percentages of the Recommended Dietary Allowances (%RDA) Provided from Cookies

The percentages of the recommended dietary allowances (%RDA), as determined by the National Academies, the Food and Nutrition Board, and the

(Institute of Medicine 2004).

Sensory Evaluation of Biscuits

Biscuit samples were organoleptically evaluated for their sensory characteristics according to the method of (Larmond 1982). Samples were scored for color, flavor, crispiness, texture and overall acceptability by ten panelists form Food Technology Research Institute.

Determination of the Amino Acid Profile of Cookies

Amino acid content was determined using the amino acid analyzer Biochrom 30.
the instruction manual according to the method outlined in (AOAC, 2010). The chemical score of essential amino acids (EAA) was relatively calculated according to (FAO/WHO 2007) using the following equation:
Chemical score (%) = (EAA in crud protein sample ×100) / EAA of FAO/WHO

Statistical Analysis

The data were statistically analyzed using SPSS 16.0 software. Means and standard deviations were determined using descriptive statistics. Comparisons between samples were determined using one-way variance (ANOVA) and multiple range tests. Statistical significance was defined at $P \leq 0.05$. (Steel and Torrie, 1986).

Result and Discussion

Table 2. presents the fiber and ash content of papaya powder were significantly higher compared to both rice flour and quinoa flour, as supported by the findings of (Chuwa and Kamal 2022), who reported 4.05% protein, 0.72% fat, and 4.48% ash. Also, (Chuwa and Kamal 2022) reported a lower fiber content of 9.61% in oven-dried papaya powder, suggesting that the variance could be attributed to differences in papaya varieties, locations, and soil types, as mentioned by (Chuwa and Kamal 2022) in their study. Papaya powder also exhibited a significantly higher carotene content of 9.05 mg/100g, while (Chuwa and Dhiman 2022) reported a β-carotene content of 13.04 mg/100g. The mineral content, specifically potassium and iron, fell within the range reported by (Chuwa and Dhiman in 2022), with values ranging from 90.00–257.00 mg/100g for potassium and 0.23-0.66 mg/100g for iron.

Table 2. Physico-chemical Properties of Raw Materials

Sample	Papaya Powder	Quinoa Flour	Rice Flour
Moisture (%)	12.20±0.08^{a}	9.98±0.05^{b}	9.69±0.12^{b}
Protein (%)	4.37±0.03^{c}	15.00±0.13^{a}	7.68±0.17^{b}
Fat (%)	0.80±0.06^{b}	3.59±0.03^{a}	0.25±0.01^{b}
Fiber (%)	12.92±0.12^{a}	7.80±0.08^{b}	0.18±0.05^{c}
Ash (%)	4.59±0.10^{a}	1.90±0.04^{b}	0.60±0.06^{c}
Carbohydrate (%)	77.32±1.17^{b}	71.71±1.15^{c}	91.29±0.19^{a}
Carotene (mg/100gm)	9.05±0.05^{a}	1.45±0.11^{b}	ND
Ca (mg/100gm)	172.19±0.13^{a}	97.33±0.17^{b}	11.25±0.04^{c}
P (mg/100gm)	35.87±0.09^{b}	345.41±0.12^{a}	ND
Mg (mg/100gm)	71.75±0.17^{b}	178.00±0.10^{a}	ND
Fe (mg/100gm)	0.72±0.04^{b}	14.50±0.06^{a}	0.45±0.13^{b}
Zn (mg/100gm)	0.50±0.09^{c}	5.71±0.09^{a}	2.30±0.08^{b}
K (mg/100gm)	19.98±0.06^{c}	739.50±0.17^{a}	82.09 ±0.10^{b}
WHC* (g of water/g dry matter)	6.23±0.14^{a}	2.88±0.13^{b}	1.77±0.03^{c}

WHC*= water holding capacity
*Values are means of three replicates ±SD, on dry weight basis. ** Total carbohydrates were calculated by difference.

In the case of quinoa flour, the analysis showed that it had the highest protein and fat content, reaching 15 g/100g and 3.59 g/100g, respectively. These results align with the findings of (Dhondiram et al., 2023), who reported 11.32% protein and 3.91% fat in quinoa flour. The ash content of quinoa flour was 1.90 g/100g, which agrees with (Sharma et al., 2023) report of 1.99% ash. The fiber content of 7.80 g/100g aligns with the findings of (Badia-Olmos et al., 2023), who reported 8.7% fiber in quinoa flour.

The iron content of 14.50 mg/100g is consistent with the work of (Coţovanu et al., 2023), who reported 8.12 mg/100g of iron. The phosphorus and calcium content of 345.41 mg/100g and 97.33 mg/100g, respectively, are in agreement with (Wang et al., 2020) study, in which they reported 458 mg/100g of phosphorus and 824 mg/100g of calcium in quinoa flour. The high water holding capacity (WHC) of papaya powders is attributed to their hydrophilic constituents, such as carbohydrates and crude fiber, as reported by (Akubor and Eze 2012). Additionally, (Akubor 2016) stated that the water absorption capacity of flour depends on the quantity and nature of hydrophilic constituents, to some extent on pH, and the nature of protein. The WHC of papaya powder was higher than that of both rice flour and quinoa flour, which were 1.77 g of water/dry matter and 2.88 g of water/dry matter, respectively. This difference can be attributed to the higher fiber content in papaya powder compared to rice flour and quinoa flour. These results are consistent with the findings of (Varastegani et al., 2015), while (Rosell and Santos 2010) suggested that the hydroxyl groups in the fiber structure of papaya powder facilitate more water interactions through hydrogen bonding.

Chemical Composition for Gluten-Free Cookies

When papaya powder was substituted in gluten-free cookies in Table 3., there was an increase in moisture, fiber, and β-carotene content. The fiber content increased from 1.5% in rice cookies to 2.12% in cookies with papaya, which aligns with the findings of (Kulla and Kuraganti, 2021). They reported that a 35% addition of papaya pulp increased moisture, fiber, and ash content while slightly decreasing protein and carbohydrate content without a significant difference in fat content. The carotene content significantly increased to 24.28%, compared to 18.20% in rice cookies. This increase can be attributed to the high fiber and carotene content of papaya flour, as supported by (Zaki et al., 2018), who reported an increase in β-carotene ranging between 42.7% and 65.62% in papaya-substituted cakes.

Table 3. Chemical Composition for Gluten-Free Cookies

Sample	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Carbohydrate (%)	Carotene (mg/100gm)	Energy (Kcal)
Control	6.89±0.14^{e}	3.90±0.04^{f}	18.77±0.06^{e}	1.50±0.10^{f}	1.45±0.09^{f}	74.38±0.03^{a}	18.20±0.08^{e}	470.35±0.05^{a}
S1	7.25±0.08^{d}	3.84±0.03^{e}	18.80±0.11^{e}	2.12±0.05^{e}	1.91±0.14^{e}	73.33±0.06^{b}	24.28±0.05^{a}	477.88±0.10^{ab}
S2	7.29±0.04^{c}	4.58±0.06^{d}	18.90±0.08^{d}	2.55±0.08^{d}	2.03±0.03^{d}	71.94±0.11^{c}	24.21±0.10^{ab}	476.18±0.12^{bc}
S3	7.35±0.09^{c}	5.25±0.11^{c}	19.00±0.05^{c}	2.98±0.11^{c}	2.11±0.08^{c}	70.66±0.04^{d}	24.19±0.09^{b}	474.64±0.03^{c}
S4	7.43±0.03^{b}	5.95±0.14^{b}	19.20±0.10^{b}	3.41±0.09^{b}	2.20±0.11^{b}	69.24±0.05^{e}	24.11±0.03^{c}	473.56±0.06^{cd}
S5	7.49±0.10^{a}	6.60±0.09^{a}	19.33±0.03^{a}	3.82±0.04^{a}	2.36±0.05^{a}	67.89±0.08^{f}	24.04±0.06^{c}	471.66±0.08^{d}

Control =100% rice, **S1** = 90% rice + 10% papaya**,**
S2 = 77.5 rice + 10% papaya +12.5% quinoa **S3** = 65 rice + 10% papaya +25% quinoa,
S4 = 52.5 rice + 10% papaya +37.5% quinoa **S5** = 40 rice + 10% papaya +50% quinoa.
*Values are means of three replicates ±SD, on dry weight basis. Number in the same column followed by the same letter are not significantly different at 0.05 level. ** Total carbohydrates were calculated by difference.

In the same Table 3., the substitution of quinoa flour for rice flour resulted in a noticeable increase in the moisture, protein, fat, fiber, and ash contents of the cookies. This rise in moisture and fiber can be attributed to the high fiber content present in quinoa flour, which enhances its water absorption capacity compared to rice flour. These findings are consistent with previous studies conducted by (Demir and Kılınç, 2017 and Cannas et al., 2020), which also observed a significant increase in the protein, fat, and ash content of cookies when quinoa flour was added. As a consequence of the increased protein, fat, and ash contents, the carbohydrate content decreased as the proportion of quinoa substitution increased.

Table 4. Mineral Content for Gluten-Free Cookies

Sample	Ca	Fe	Zn	P	Mg	K
Control	30.32±0.10[f]	0.30±0.11[e]	0.52±0.05[e]	74.04±0.09[f]	22.61±0.06[f]	54.07±0.05[f]
S1	39.93±0.05[e]	0.33±0.14[e]	0.51±0.11[e]	70.36±0.05[e]	24.72±0.03[e]	157.41±0.02[e]
S2	46.72±0.06[d]	1.44±0.06[d]	0.89±0.08[d]	89.67±0.03[d]	35.94±0.08[d]	209.71±0.06[d]
S3	53.55±0.11[c]	2.56±0.08[c]	1.28±0.05[c]	109.10±0.11[c]	47.18±0.04[c]	262.14±0.08[c]
S4	60.26±0.14[b]	3.67±0.09[b]	1.66±0.10[b]	128.24±0.03[b]	58.29±0.14[b]	313.91±0.10[b]
S5	66.01±0.03[a]	4.76±0.05[a]	2.04±0.09[a]	147.18±0.04[a]	69.31±0.10[a]	365.18±0.05[a]

Control =100% rice, **S1** = 90% rice + 10% papaya,
S2 = 77.5 rice + 10% papaya +12.5% quinoa **S3** = 65 rice + 10% papaya +25% quinoa,
S4 = 52.5 rice + 10% papaya +37.5% quinoa **S5** = 40 rice + 10% papaya +50% quinoa.
*Values are means of three replicates ±SD, on dry weight basis. Number in the same column followed by the same letter are not significantly different at 0.05 level.

Mineral Content for Gluten-Free Cookies

Table 4. revealed that the utilization of papaya powder as a substitute resulted in an elevation in the calcium, iron, magnesium, and potassium contents. For instance, the calcium content increased from 30.32 mg/100g in rice cookies to 39.93 mg/100g in cookies containing 10% papaya powder. These findings are consistent with the research conducted by (Zaki et al., 2018), which demonstrated an increase in calcium content in cakes with papaya substitution. However, no significant difference was observed in the iron and zinc contents between the control and substituted cookies. This finding contradicts the results reported by (Kulla and Kuraganti in 2021), who observed a decrease in both iron and zinc contents in their study. On the other hand, the addition of quinoa flour resulted in a substantial increase in all examined minerals. This can be attributed to the naturally high mineral content present in quinoa, as indicated in Table 2. These findings align with the results of (Demir and Kılınç, 2017), where an increase in all minerals was observed with the incorporation of quinoa flour.

Percentages of the recommended dietary allowances provided by Cookies for Children (4–8 years).

The percentages of the recommended dietary allowances (RDA%), as determined by the National Academies, the Institute of Medicine, and the (Food and Nutrition Board 2004), provided from 100g of cookies for children 4–8.

Table 5. RDA for Children 4-8 Years

Sample	Protein (19 g/d)	Fiber (25 g/d)	Carotene (400 ug/d)	Calcium (800 mg/d)	Iron (10 mg/d)	Zinc (5 mg/d)	Phosphorous (500 mg/d)	Magnesium (130 mg/d)	Potassium (2,300 mg/day)
Control	20.70[e]	6.04[f]	54.65[d]	3.79[f]	3.17[e]	10.73[e]	14.81[e]	174.02[f]	2.35[f]
S1	20.30[f]	8.52[e]	72.81[a]	4.99[e]	3.47[e]	10.47[e]	14.07[f]	190.23[e]	6.84[e]
S2	24.06[d]	10.25[d]	72.67[ab]	5.84[d]	14.50[d]	18.07[d]	17.93[d]	276.59[d]	9.12[d]
S3	27.54[c]	12.01[c]	72.61[b]	6.69[c]	25.73[c]	25.80[c]	21.83[c]	363.02[c]	11.40[c]
S4	31.41[b]	13.72[b]	72.41[c]	7.53[b]	36.47[b]	32.80[b]	25.66[b]	448.48[b]	13.65[b]
S5	34.83[a]	15.37[a]	72.22[c]	8.25[a]	47.40[a]	41.47[a]	29.45[a]	533.36[a]	15.88[a]

Control =100% rice, S1 = 90% rice + 10% papaya,
S2 = 77.5 rice + 10% papaya +12.5% quinoa S3 = 65 rice + 10% papaya +25% quinoa,
S4 = 52.5 rice + 10% papaya +37.5% quinoa S5 = 40 rice + 10% papaya +50% quinoa.

Table 5 shows that for children aged 4–8 years, the Recommended Dietary Allowances (RDAs) for minerals are as follows: 800 mg of calcium, 10 mg of iron, 2300 mg of potassium, 130 mg of magnesium, and 5 mg of zinc. Consuming 100g of S4 cookies provided approximately 7.53% of the RDA for calcium, 36.47% of the RDA for iron, 32.8% of the RDA for zinc, 448.48% of the RDA for magnesium, and 13.65% of the RDA for potassium.

In other words, the consumption of 100 grams of S4 cookies contributed a significant portion of the RDAs for iron, zinc, and magnesium, surpassing the recommended amounts. However, the intake of calcium and potassium from the cookies was relatively lower, meeting only a small percentage of the RDAs. These ratios play a crucial role in addressing mineral deficiencies, particularly in relation to iron (Fe), magnesium (Mg), and zinc (Zn). By substituting rice with quinoa, a grain with higher mineral levels, the overall mineral content of the resulting cookies was enhanced, as anticipated. Quinoa is known for its elevated levels of calcium, magnesium, iron, and zinc compared to common cereals, with a particular emphasis on its high iron content (as indicated in Table 2.). Previous studies have demonstrated that the inclusion of quinoa flour in various food products, such as tarhana and bread, effectively increases their mineral content (Demir, 2014; Bilgicli and Ibanoglu, 2015).

Physical Properties of Gluten-Free Cookies

Table 6. displays the physical properties of the cookie samples, revealing noteworthy variations in weight, volume, specific volume, diameter, thickness, spread ratio, and water activity. Notably, the weight of the samples exhibited an increase as papaya powder was introduced as a substitute.

Table 6. Physical Properties of Gluten-Free Cookies

Sample	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Diameter D (cm)	Thickness T (cm)	Spread ratio (D/T)	a_w
Control	8.00±0.07[f]	20.00±0.02[a]	2.50±0.07[a]	5.15±0.04[e]	0.95±0.09[a]	5.42±0.07[f]	0.323±.002
S1	8.60±0.02[e]	19.80±0.05[a]	2.30±0.03[b]	5.17±0.06[e]	0.92±0.05[a]	5.62±0.02[e]	0.331±.001
S2	10.00±0.06[d]	19.00±0.09[b]	1.90±0.05[c]	5.60±0.03[d]	0.89±0.03[b]	6.29±0.06[d]	0.325±.003
S3	11.80±0.03[c]	18.50±0.04[c]	1.57±0.06[d]	5.80±0.06[c]	0.86±0.07[c]	6.70±0.03[c]	0.323±.001
S4	13.00±0.09[b]	18.10±0.07[d]	1.39±0.06[e]	6.00±0.03[b]	0.83±0.05[c]	7.23±0.09[b]	0.323±.002
S5	13.80±0.05[a]	17.90±0.03[e]	1.29±0.02[f]	6.14±0.07[a]	0.79±0.03[d]	7.77±0.05[a]	0.324±.003

Control =100% rice, **S1 =** 90% rice + 10% papaya**,**
S2 = 77.5 rice + 10% papaya +12.5% quinoa **S3** = 65 rice + 10% papaya +25% quinoa,
S4 = 52.5 rice + 10% papaya +37.5% quinoa **S5** = 40 rice + 10% papaya +50% quinoa.
*Values are means of three replicates ±SD. Number in the same column followed by the same letter are not significantly different at 0.05 level.

The weight of the cookie samples exhibited notable changes in response to the addition of different ingredients. In the control sample, the weight was measured at 8.00g, which increased to 8.60g when 10% papaya powder was incorporated. This weight increase can be attributed to the high water-holding capacity of papaya powder, which evaporated during the baking process. These findings align with a study conducted by (Kulla and Kuraganti 2021). Furthermore, the inclusion of quinoa in the cookie recipe led to a significant weight increase. In particular, cookies with 50% quinoa incorporation reached a weight of 13.80g. Similar results were reported by (Nisar et al., 2018), where the weight of cookies increased from 10.5g to 11.7g with higher levels of quinoa seed flour. This weight gain can be attributed to the water absorption and retention properties of quinoa flour. Regarding volume, the addition of papaya powder did not result in significant changes. However, the incorporation of quinoa led to a significant decrease in volume. For cookies with 50% quinoa incorporation, the volume decreased from 20 cm3 to 17.90cm^3. Similarly, the specific volume also decreased with the addition of both papaya and quinoa. These results align with the study carried out by (Wang et al., 2015). The diameter of the cookie samples did not exhibit significant changes with the addition of papaya powder. However, when quinoa flour was incorporated, the diameter increased from 5.15cm in the control sample to 6.14cm in cookies with 50% quinoa incorporation. On the other hand, the thickness of the cookies did not show significant changes with the addition of papaya powder. However, with the inclusion of quinoa flour, the thickness decreased from 0.95cm in the control sample to 0.79cm in cookies with

50% quinoa incorporation. The alterations in diameter and thickness were reflected in the spread ratio values, which consistently increased from 5.42 in the control sample to 7.77 in cookies with quinoa incorporation. This indicates that the cookies spread more during baking when quinoa was added. These results align with a study conducted by (Păucean et al., 2015).Water activity increased with the addition of papaya powder and quinoa flour. This agrees with work by (Cannas et al., 2020).

Texture Profile Analysis (TPA) for Gluten -Free Cookies

It is worth mentioning that the cookies produced in this study had a soft texture, which differs from the crunchy and crumbly texture described by (Demir and Kılınç, 2017). The texture characteristics of the control sample and the samples substituted with papaya flour and quinoa flour are summarized in the provided Table 7. A notable reduction in hardness was observed, decreasing from 43.90 N to 35.00 N. These findings align with the study conducted by (Cannas et al., 2020). Additionally, both adhesiveness and chewiness showed a decrease, with values decreasing from 18 N to 14 N and from 120 mj to 84 mj, respectively. These results are consistent with the work conducted by (Wang et al., 2015). This decrease in texture attributes can be attributed to the substitution of rice flour with papaya flour and quinoa flour, which are known to have higher fiber content. Regarding consistency, a slight increase in cohesiveness was observed, rising from 0.45 to 0.61. It is important to note that the texture of the cookies made in this study was soft, as opposed to (Demir and Kılınç 2017) description of the cookies' crispy and crumbly nature.

Table 7. Texture Profile Analysis (TPA) of Gluten-Free Cookies

Sample	Textural Characteristics			
	Hardness (N)	Adhesiveness (N)	Chewiness (mj)	Cohesiveness
C	43.90±0.03[a]	18.00±0.06[a]	120.00±0.01[a]	0.45±0.07[e]
S1	35.70±0.07[b]	17.50±0.09[b]	96.00±0.05[b]	0.50±0.02[d]
S2	32.90±0.03[d]	15.50±0.01[c]	90.00±0.02[c]	0.55±0.03[c]
S3	30.30±0.05[e]	14.70±0.03[d]	87.30±0.03[d]	0.57±0.05[c]
S4	30.80±0.02[e]	14.30±0.07[e]	85.00±0.03[e]	0.59±0.06[b]
S5	35.00±0.01[c]	14.00±0.04[f]	84.00±0.06[e]	0.61±0.01[a]

Control =100% rice, **S1** = 90% rice + 10% papaya,
S2 = 77.5 rice + 10% papaya +12.5% quinoa **S3** = 65 rice + 10% papaya +25% quinoa,
S4 = 52.5 rice + 10% papaya +37.5% quinoa **S5** = 40 rice + 10% papaya +50% quinoa.
*Values are means of three replicates ±SD. Number in the same column followed by the same letter are not significantly different at 0.05 level

Sensory Evaluation of Gluten-Free Cookies

Table 8. provides a summary of sensory evaluation results for the cookie samples are presented in the table provided. The scores obtained for each sample ranged from 74 for the control sample to 92, 94, 97, 97, and 87 for samples S1 to S5, respectively. Interestingly, sample S5, which contained both quinoa flour and papaya powder, received lower scores compared to the other samples. These findings indicate that the substitution of rice flour with quinoa flour and papaya powder had a negative impact on the sensory attributes of the cookies. Furthermore, the acceptance test results revealed that the panelists showed a preference for the light brown color observed in samples S3 and S4, which could be attributed to the Maillard reaction. On the other hand, the control sample received significantly lower scores for taste, texture, and appearance. However, no significant differences in acceptance ratings were observed among samples S1 to S4. In terms of texture, the panelists favored samples S1 to S4 due to their soft and elastic nature, as opposed to the hard and less elastic texture of the control sample. Therefore, it can be concluded that incorporating quinoa flour into cookies at a level of up to 37.5% does not adversely affect their sensory qualities.

Table 8. Sensory Evaluation of Gluten-Free Cookies

Sample	Color (20)	Taste (20)	Oder (20)	Texture (20)	Appearance (20)	Total score (100)	Acceptance
Control	15±0.03[d]	14±0.06[d]	15±0.03[d]	15±0.04[d]	15±0.05[e]	74±0.06[e]	S
S1	19±0.03[b]	18±0.09[b]	19±0.07[b]	18±0.03[b]	18±0.01[c]	92±0.02[c]	V
S2	19±0.07[b]	19±0.03[a]	19±0.03[b]	18±0.06[b]	19±0.08[b]	94±0.09[b]	V
S3	20±0.05[a]	19±0.02[a]	19±0.09[b]	19±0.05[a]	20±0.07[a]	97±0.03[a]	V
S4	20±0.03[a]	19±0.07[a]	20±0.05[a]	19±0.02[a]	19±0.03[b]	97±0.07[a]	V
S5	18±0.01[c]	17±0.05[c]	18±0.01[c]	17±0.07[c]	17±0.06[d]	87±0.04[d]	G

Control =100% rice, **S1** = 90% rice + 10% papaya,
S2 = 77.5 rice + 10% papaya +12.5% quinoa **S3** = 65 rice + 10% papaya +25% quinoa,
S4 = 52.5 rice + 10% papaya +37.5% quinoa **S5** = 40 rice + 10% papaya +50% quinoa.
*Values are means of ten replicates ±SD. Number in the same column followed by the same letter are not significantly different at 0.05 level. Acceptance 100-90 very good (V), 89-80 Good (G), 79-70 Satisfactory (S), Less than 70 Questionable (Q).

Amino Acid Composition for Gluten-Free Cookies

Data in Table 9. included the amino acid composition, chemical score, and biological value of the produced cookies in comparison with the control. Chemical scores reflect the amount required of essential amino acids, as reported by (FAO/WHO 2007). In Table 9., the amino acid profile analysis of the optimized quinoa cookies identified ten different amino acids. The essential amino acid valine was the highest, followed by leucine and lysine. Cookies with quinoa and papaya contained a higher level of total essential amino acids, reaching 37.99 and 41.53 g/100g in S3 and S4, respectively, compared with the control sample (33.42 g/100g).

Table 9. Amino Acid Composition (g/100g protein) of Cookie Samples

Amino acids	Control		S3		S4		FAO/WHO
	Amino acid g/100 protein	CS%	Amino acid g/100 protein	CS%	Amino acid g/100 protein	CS%	
Essential A.A.							
Isoleucine	3.82	136.36	4.20	150.14	4.58	163.57	3.0
Leucine	5.02	76.06	6.14	93.03	6.95	105.30	6.6
Lysine	5.01	86.38	5.75	99.05	6.14	105.86	5.8
Methionine	3.42	136.88	3.77	151.03	4.12	164.80	2.5
Phenylalanine	2.82	44.76	3.09	49.01	3.36	53.33	6.3
Threonine	4.61	135.59	5.35	157.25	5.79	170.29	3.4
Valine	5.68	162.29	6.43	183.61	7.08	202.29	4.0
Tyrosine	0.55	14.47	0.53	14.01	0.55	14.47	3.8
Total E. A. A.	33.42		37.99		41.53		30.9

Control =100% rice, **S1** = 90% rice + 10% papaya,
S3 = 65 rice + 10% papaya +25% quinoa,
S4 = 52.5 rice + 10% papaya +37.5% quinoa
*FAO/WHO (2007). CS% = % Chemical score, Total E.A. A = total essential amino acids

By replacing rice flour with quinoa flour to produce cookies, an increase in amino acid levels was observed. As the replacement ratio increased, the amino acids increased compared to the control. This leads to an improvement in the nutritional value of the product, as reflected by the chemical score of the cookies. This may be due to the fact that quinoa flour is rich in an abundant amount of amino acids in its composition. These results are consistent with (Watanabe et al., 2014), who said that using quinoa flour increased the percentage of amino acids.

Therefore, it can be concluded that the combination of quinoa and papaya flours provided a balanced concentration of essential amino acids and increased the biological value. What would not be possible if we used only rice flour as the main ingredient for the production of the product.

4. Conclusion

By substituting rice flour with quinoa flour and papaya powder, it is possible to enhance the nutritional value of cookies by increasing their protein, amino acid, fiber, and beta-carotene content. This substitution serves as a means to improve the nutritional profile of gluten-free cookies, aligning with the goal of creating more beneficial food options.

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