

Development of Gluten-Free Cookies Produced from Blends of Chickpea Flour and Soybean Flour with Rice Flour

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Abstract: The incorporation of chickpea and soybean flours may improve the nutritional quality of gluten-free cookies, particularly their protein and resistant starch contents. This study investigated the effects of various levels of chickpea or soybean flour (10%, 30%, and 50% w/w) substituted to rice flour on the physicochemical and pasting properties of composite flours, and cookie quality, resistant starch, and sensory properties of gluten-free cookies were evaluated. Proximate analysis revealed that fortification increased the protein from 6.8% to 22.36% in the composite flours. The composite flours showed lower swelling index and higher water absorption capacity than rice flour and both peak and final viscosities decreased when compared to rice flour. The increased substitution levels led to cookies of smaller diameter and spread ratio, while the thickness of the cookies was increased when compared with cookies prepared with rice flour alone. The higher the level of chickpea or soybean flour, the darker the color of the cookies (lower L* values), but the higher the redness (a*) and yellowness (b*) values. The resistant starch content increased as well, being the highest in cookies produced with 50% of chickpea or soybean flour (18 or 14.98%, respectively). Sensory evaluation showed no significant differences in color, shape, and aroma, while significant differences were observed in crispiness, taste, and overall acceptability. Overall, the use of chickpea and soybean flours as partial substitutes for rice flour is a promising approach for improving the nutritional quality of gluten-free cookies, particularly their protein and resistant starch contents, while maintaining acceptable sensory properties.

Keywords: chickpea flour, gluten-free cookies, resistant starch, rice flour, soybean flour

Abstrak: Penambahan tepung kacang arab dan tepung kedelai berpotensi meningkatkan kualitas gizi kukis bebas gluten, khususnya kandungan protein dan pati resisten. Penelitian ini bertujuan untuk mengevaluasi pengaruh substitusi tepung beras dengan tepung kacang arab atau tepung kedelai pada berbagai tingkat konsentrasi, yaitu 10%, 30%, dan 50% (b/b), terhadap sifat fisikokimia dan sifat pasting tepung komposit, serta mutu kukis, kandungan pati resisten, dan sifat sensoris kukis bebas gluten. Analisis proksimat menunjukkan bahwa fortifikasi meningkatkan kandungan protein tepung komposit dari 6,8% menjadi 22,36%. Tepung komposit memiliki indeks pengembangan yang lebih rendah dan kapasitas penyerapan air yang lebih tinggi dibandingkan tepung beras. Selain itu, viskositas puncak dan viskositas akhir tepung komposit menurun dibandingkan dengan tepung beras. Peningkatan tingkat substitusi menghasilkan kukis dengan diameter dan rasio pengembangan yang lebih kecil, sedangkan ketebalan kukis meningkat dibandingkan kukis yang dibuat hanya dari tepung beras. Semakin tinggi tingkat substitusi tepung kacang arab atau tepung kedelai, warna kukis semakin gelap, yang ditunjukkan oleh penurunan nilai L*, serta peningkatan nilai kemerahan (a*) dan kekuningan (b*). Kandungan pati resisten juga meningkat, dengan nilai tertinggi diperoleh pada kukis yang dibuat menggunakan substitusi 50% tepung kacang arab atau tepung kedelai, masing-masing sebesar 18% dan 14,98%. Evaluasi sensoris menunjukkan bahwa tidak terdapat perbedaan nyata pada atribut warna, bentuk, dan aroma, sedangkan perbedaan nyata ditemukan pada kerenyahan, rasa, dan penerimaan keseluruhan. Secara keseluruhan, penggunaan tepung kacang arab dan tepung kedelai sebagai substituen parsial tepung

beras merupakan pendekatan yang menjanjikan untuk meningkatkan kualitas gizi kukis bebas gluten, terutama kandungan protein dan pati resisten, dengan tetap mempertahankan sifat sensoris yang dapat diterima.

Kata kunci: kukis bebas gluten; pati resisten; tepung beras; tepung kacang arab; tepung kedelai

INTRODUCTION

Cookies have emerged as highly popular snack options across all age groups, appealing to consumers worldwide. This widespread popularity can be attributed to various factors, including their relatively low production costs, convenient portability, and extended shelf life. The global cookie market has continued to expand in recent years, reflecting shifts in consumer preferences and growing interest in convenient snack products that combine indulgence with affordability. Factors such as the rising popularity of on-the-go snacking, the growing health-conscious consumer segment, and the diversification of cookie flavors and formulations have all contributed to the expansion of this market (Shen 2024).

Chickpea (*Cicer arietinum*) and soybean are nutritionally valuable legumes that can be incorporated into cookie and other baked-food formulations to enhance their nutritional profile. Their substantial contents of protein, carbohydrates, B-group vitamins, and essential minerals make them promising ingredients for improving the nutritional value of conventional cookies (Hajas *et al.* 2026). Chickpea flour is particularly attractive because of its relatively high protein content and favorable nutritional composition (Kumar *et al.* 2025). Studies have shown that incorporating chickpea flour into cookie recipes can substantially increase the protein content of the final product. Rababah *et al.* (2006) reported that fortifying biscuits with 3-12% chickpea flour increased the protein content from 16.93% to 19.64%. This suggests that even a modest addition of chickpea flour can enhance the nutritional profile of cookies without significantly altering the overall sensory characteristics. Moreover, Yamsaengsung *et al.* (2012) reported that incorporating chickpea flour at 20–40% into wheat-based cookies and at 60–80% into amaranth- and buckwheat-based formulations improved overall acceptability, with a more pronounced effect observed in gluten-free cookies. These findings indicate that chickpea flour can be incorporated into cookie formulations while maintaining favorable sensory acceptance, particularly those catering to individuals with gluten sensitivities.

Soybeans, with their exceptionally high protein content of approximately 40%, can also be an effective ingredient for improving the nutritional quality of cookies (Adeyeye 2020). This protein content surpasses that of other legumes (20-30%) and cereals (8-15%), making soybean flour a valuable addition to cookie recipes. Adeyeye (2020) also demonstrated that cookies made with blends of riceflour and soybean flour at 0-20% substitution had

protein contents ranging from 8.94% to 17.51%. Among the formulations evaluated, the cookie containing 85% rice flour and 15% soybean flour received the highest overall acceptability score (7.6), accompanied by favorable sensory ratings for crispiness, texture, flavor, taste, and color. These findings suggest that the strategic incorporation of soybean flour can not only boost the protein content of cookies but also maintain favorable sensory characteristics, making them more appealing to consumers.

Resistant starch (RS) escapes enzymatic digestion in the small intestine and reaches the colon, where it is fermented by the resident microbiota. Owing to its fiber-like physiological behavior, RS can exert prebiotic effects by providing a fermentable substrate that supports the proliferation of beneficial bacteria, including *Bifidobacterium* and *Lactobacillus* spp. This unique property makes RS particularly important for dietary health (Gutiérrez & Tovar 2021). Colonic fermentation of RS generates short-chain fatty acids, particularly butyrate, which serves as a major energy substrate for colonocytes. Beyond its role in colonic energy metabolism, butyrate has been associated with anti-inflammatory effects and may contribute to a lower risk of colorectal cancer. Previous studies have highlighted the potential of pulse consumption in supporting metabolic health, particularly in the prevention and management of conditions such as diabetes mellitus and coronary heart disease. In gluten-free cookie formulations, the incorporation of pulse flours may also slow gastric emptying, thereby promoting earlier satiation during consumption and greater postprandial satiety. Several (Giuntini *et al.* 2022). Several studies have highlighted the potential health benefits associated with dietary RS, particularly when included in gluten-free formulations. Van Hung *et al.* (2021) explored the effects of adding RS to gluten-free cookies and found that it significantly increased the RS levels while maintaining desirable sensory attributes. Another study by Roman & Martinez (2019) demonstrated that incorporating novel RS ingredients in bread improved their dietary fiber content and was well-received by consumers who perceived the products as healthier alternatives. For gluten-free products, incorporation of legume flours may provide an opportunity to improve nutritional quality, including protein and resistant starch content. Dietary RS has been associated with improved insulin sensitivity and better glycemic regulation, suggesting its potential as a beneficial dietary component for individuals with impaired glucose control or an elevated risk of diabetes (Wang *et al.* 2019).

However, the effects of incorporating chickpea and soybean flours at different substitution levels into rice-based gluten-free cookies, particularly with respect to their physicochemical characteristics, resistant starch content, and sensory acceptance, remain insufficiently understood. Thus, the present study investigated the effects of incorporating chickpea flour (CPF) or soybean flour (SBF) at different substitution levels (10%, 30%, and 50%) into rice flour (RF) on the physicochemical, nutritional, starch digestibility, and sensory properties of gluten-free cookies. Changes in the proximate composition, functional and pasting properties of the composite flours, as well as the physical characteristics, color, resistant starch content, and sensory attributes of the resulting cookies, were evaluated.

MATERIALS AND METHODS

Materials

Dried chickpeas and soybeans were purchased from Bien Hoa Market, Vietnam. Rice (4900 long-grain Vietnamese white rice) was obtained from Vien Dong Rice Processing Joint Stock Company, Vietnam. Wheat flour (Bakers' Choice, Vietnam), baking powder (Tan Nhat Huong, Vietnam), diet sugar (Vikybomi, Vietnam), unsalted butter (TH true MILK, Vietnam), chicken eggs (Ba Huan, Vietnam), and salt were purchased from WinMart, Vietnam. All chemicals used were of analytical grade and obtained from Sigma-Aldrich Co. (St. Louis, MO, USA).

Preparation of chickpea flour and soybean flour

Chickpeas and soybeans were cleaned and sorted before soaking in water for 24 h. The chickpeas were subsequently dehulled, and both chickpeas and soybeans were oven-dried at 50 °C for 24 h. The dried samples were milled and passed through a 212- μ m sieve to obtain fine flours. The resulting chickpea flour (CPF) and soybean flour (SBF) were stored in airtight containers until further use.

Preparation of composite flours

Composite flours were prepared by replacing rice flour (RF) with chickpea flour (CPF) or soybean flour (SBF) at 10%, 30%, and 50% (w/w), corresponding to RF or RF ratios of 90:10, 70:30, and

50:50, respectively. Rice flour alone (100% RF) was used as the control (RC). Cookies prepared from 100% wheat flour (WC) were included as a reference formulation.

Preparation of cookies

The cookie-making process followed a formulation based on the protocol reported by (Yen *et al.* 2023), with slight adjustments to the ingredient proportions. The ingredients included flour (300 g), unsalted butter (100g), sugar (83.33 g), sodium chloride (3 g), sodium bicarbonate (3 g), and eggs (50). The initial step involved blending of sugar and butter in a mixer for a duration of 3 min. Subsequently, beaten whole eggs were gradually incorporated into the mixture and whisked until a smooth and foamy texture was achieved. Following this, the mixture was subsequently combined with salt, baking powder, and flour and beaten until a slightly firm dough was obtained. The dough was rolled into a 4-mm-thick sheet and cut into circular pieces using a 45-mm-diameter mold. The pieces were transferred to a lightly oiled baking tray and baked at 170 °C for 12 min. After baking, the cookies were cooled at room temperature for 30 min, packed in polypropylene bags, and stored until further laboratory analyses.

Chemical compositions of composite flours

The moisture, protein, ash, total crude fiber, and lipid content of composite flour were determined by following the methods of (AACC 2000). The total carbohydrate content is calculated by subtracting the sum of the percentages of moisture, ash, protein, and lipid from 100%.

Determination of swelling index

The swelling index of the composite flour was assessed based on the procedure reported by Tien *et al.* (2025), with minor modifications. Briefly, composite flour (1 g) was dispersed in 20 mL of distilled water and vortex-mixed for 1 min. The suspension was subsequently maintained at 90 °C in a shaking water bath (200 rpm) for 30 min. Following heating, the sample was cooled under running tap water for 30 s and further cooled in an ice bath for 10

Table 1. Formula for substitution of SBF and CPF to RF

No	Sample	Rice flour	Wheat flour	Soybean	Chickpea
1	RF	100	—	—	—
2	WF	—	100	—	—
3	10SBF	90	—	10	—
4	30SBF	70	—	30	—
5	50SBF	50	—	50	—
6	10CPF	90	—	—	10
7	30CPF	70	—	—	30
8	50CPF	50	—	—	50

min. The cooled suspension was centrifuged at $5500 \times g$ for 10 min, after which the supernatant was removed. The recovered residue was allowed to equilibrate at room temperature for 5 min before weighing. The swelling index was expressed as the mass of the centrifuged residue relative to the initial flour mass (g/g).

Determination of water absorption capacity

Water absorption capacity (WAC) was determined following the procedure of Tien *et al.* (2025). Composite flour (2 g) was dispersed in 40 mL of distilled water and vortexed at ambient temperature for 10 min. The resulting suspension was centrifuged at $6500 \times g$ for 15 min, and the supernatant was subsequently removed. The hydrated flour residue was weighed, and WAC was expressed as the amount of water retained per gram of the initial flour sample (g/g).

Determination of pasting properties

Pasting behavior was characterized using a micro visco-amylograph according to the procedure described by Van Hung *et al.* (2021), with the composite flour dispersed in water at a concentration of 15% (w/v). The sample was heated from 30 to 93 °C at a programmed rate of 7.5 °C/min and held at 93 °C for 15 min. The paste was subsequently cooled to 30 °C at the same rate and maintained at this temperature for a further 15 min before the measurement was completed.

Determination of physical properties of cookies

Cookie diameter (D) and thickness (T) were measured using a digital caliper (model 500-151-30, Mitutoyo, Kanagawa, Japan) at three locations on randomly selected cookies, following the procedure reported by Cervini *et al.* (2021). The spread ratio (SR) was calculated as the quotient of cookie diameter and thickness (D/T). Measurements were performed in triplicate for each batch.

Color characteristics

Cookie color was measured using a Minolta CR-400 Chroma Meter (Konica Minolta, Japan) according to Cervini *et al.* (2021). The CIELAB parameters (L^* , a^* , and b^*) were recorded after calibration with a white standard tile. Three measurements were obtained from three randomly selected cookies per batch.

Starch digestibility

In vitro starch digestibility of cookies containing chickpea flour (CPF) and soybean flour (SBF) was evaluated following Van Hung *et al.* (2021). Briefly, 0.3 g of powdered cookie sample was mixed with 20 mL of acetate buffer (pH 5.2) and heated in a water bath at 95 °C for 30 min. After cooling, 5 mL of an enzyme mixture containing α -amylase (1400 U/mL) and amyloglucosidase (13 AGU/mL) was added. The

samples were incubated in a shaking incubator at 37 °C. After 20 and 120 min of hydrolysis, 0.5 mL of the hydrolysate was withdrawn and the enzymatic reaction was stopped by adding 20 mL of 66% ethanol. The released glucose was determined using the phenol-sulfuric acid method, and the glucose contents obtained after 20 and 120 min were designated as G20 and G120, respectively. After 120 min of enzymatic hydrolysis, the remaining suspension was heated in a water bath for 30 min, cooled for 15 min, and treated with 10 mL of 7 M KOH to solubilize the residual starch, including the resistant starch fraction, and facilitate its subsequent hydrolysis by amyloglucosidase (50 AGU/mL) for determination of total glucose (TG). The mixture was kept cold for 30 min and shaken every 10 min. Subsequently, 1 mL of the treated sample was mixed with 10 mL of 0.5 M acetic acid and 0.2 mL of amyloglucosidase (50 AGU/mL), followed by incubation at 70 °C for 20 min. The enzyme was then inactivated at 95 °C for 10 min. After cooling, the hydrolysate was centrifuged at $1500 \times g$ for 15 min, diluted, and the glucose concentration was determined using the phenol-sulfuric acid method. The resulting glucose content was designated as total glucose (TG). The contents of rapidly digestible starch (RDS), slowly digestible starch (SDS), and resistant starch (RS) were calculated from G20, G120, and TG.

Sensory evaluation

The sensory assessment of the cookies was conducted in accordance with the methodology outlined by Van Hung *et al.* (2021). Employing a descriptive analysis approach, a group of 60 untrained individuals served as panelists for the evaluation process. Each participant provided with a guided scorecard to assess various attributes of the cookies. To ensure unbiased evaluation, the samples were anonymized with random three-digit codes and presented to the panelists in a randomized sequence. Evaluation criteria encompassed the color, shape, flavor, crispiness and overall acceptability of the cookies. Ratings were assigned using a 9-point hedonic scale with nine discrete levels ranging from "like extremely" to "dislike extremely".

Statistical analysis

All analyses were performed in triplicate, and the results are reported as mean $\pm$ standard deviation. Differences in the physicochemical properties, and sensory attributes of gluten-free cookies formulated with different proportions of chickpea flour (CPF), soybean flour (SBF), and rice flour (RF) were assessed using one-way ANOVA, followed by Tukey's multiple comparison test at $p < 0.05$.

RESULTS AND DISCUSSION

Proximate composition of composite flours

The proximate composition of the rice flour (RF), wheat flour (WF), and composite flours containing different proportions of chickpea flour (CPF) or soybean flour (SBF) is presented in Table 2. The protein content of RF was 6.8%, which was significantly lower than that of WF (7.57%). Substitution of RF with CPF or SBF, the protein content of these flours increased. The increase was from 6.8% for the control to 8.97% to 22.36% for 10% to 50% of SBF, 8.07% to 15.40% for 10% to 50% of CPF. The analysis of ash, lipid, and fiber content in various flour samples revealed significant differences. Ash content increased with higher substitutions, with 50% chickpea flour (50CPF) having the highest ash content (1.29%) compared to RF of 0.34% and WF of 0.45%. Lipid content also rose notably with SBF and CPF substitutions, with 50SBF showing the highest lipid content 11.11%, while control samples ranged from 1.18% to 1.62%. Fiber content followed a similar trend, with the highest value in 50SBF (7.74%) compared to control samples RF (0.85%) and WF (0.92%). These results demonstrate that incorporation of SBF and CPF substantially modified the proximate composition of

the composite flours, particularly by increasing protein, lipid, ash, and fiber contents. RF contained significantly lower levels of protein, ash, total total carbohydrates, lipids, and dietary fiber than WF, whereas CPF and SBF provided higher concentrations of these components. Such differences in proximate composition reflect the distinct nutritional profiles of the flour sources and are consistent with the findings of Rababah *et al.* (2006).

Swelling index and water absorption capacity

Table 3 presents the swelling index and water absorption capacity of the rice flour (RF), wheat flour (WF), and composite flours containing different proportions of chickpea flour (CPF) or soybean flour (SBF). The swelling index was highest in 10SBF (7.55 g/g), although this value did not differ significantly from that of RF (7.52 g/g). Regarding water absorption capacity, the highest value was recorded for the 50CPF sample (2.40 g/g), and the lowest for the WF sample (1.72 g/g). The highest WAC was observed for 50CPF (2.40 g/g), whereas WF showed the lowest value (1.72 g/g). Overall, increasing the substitution level of CPF or SBF tended to decrease the swelling index while increasing WAC. The reduction in swelling index

Table 2. Proximate composition of composite flours with different ratios ²

No	Sample ¹	Ash (% dw)	Protein (% dw)	Lipid (% dw)	Fiber (% dw)	Carbohydrate (% dw)
1	RF	0.34 ± 0.01 ^d	6.80 ± 0.09 ^f	1.18 ± 0.02 ^f	0.85 ± 0.04 ^g	80.55 ± 0.08 ^a
2	WF	0.45 ± 0.04 ^c	7.57 ± 0.19 ^{ef}	1.62 ± 0.08 ^f	0.92 ± 0.02 ^{fg}	76.72 ± 0.13 ^c
3	10SBF	0.46 ± 0.01 ^c	8.97 ± 0.19 ^c	4.21 ± 0.08 ^d	2.42 ± 0.04 ^c	76.33 ± 0.37 ^c
4	30SBF	0.92 ± 0.02 ^b	12.78 ± 0.25 ^c	6.00 ± 0.20 ^c	4.53 ± 0.07 ^c	68.12 ± 0.43 ^e
5	50SBF	1.23 ± 0.03 ^a	22.36 ± 0.93 ^a	11.11 ± 0.46 ^a	7.74 ± 0.02 ^a	49.74 ± 0.49 ^g
6	10CPF	0.52 ± 0.01 ^c	8.07 ± 0.22 ^{ef}	2.63 ± 0.14 ^c	1.30 ± 0.07 ^f	79.18 ± 0.19 ^b
7	30CPF	1.01 ± 0.08 ^b	10.92 ± 0.15 ^d	5.45 ± 0.09 ^c	3.03 ± 0.04 ^d	71.22 ± 0.02 ^d
8	50CPF	1.29 ± 0.01 ^a	15.40 ± 0.68 ^b	9.01 ± 0.44 ^b	5.46 ± 0.29 ^b	60.40 ± 0.50 ^f

¹RF and WF are rice flour and wheat flour, respectively. 10SBF, 30SBF, and 50SBF are composite flours containing 10%, 30%, and 50% soybean flour substituted for rice flour, respectively, while 10CPF, 30CPF, and 50CPF are composite flours containing 10%, 30%, and 50% chickpea flour substituted for rice flour, respectively.

²Mean values within a column that do not share letter are significantly different ($p < 0.05$).

Table 3. Swelling index and water absorption capacity of the composite flours ²

No	Sample ¹	Swelling index (g/g)	Water absorption capacity (g/g)
1	RF	7.52 ± 0.07 ^a	2.27 ± 0.02 ^{abc}
2	WF	5.52 ± 0.02 ^d	1.72 ± 0.04 ^d
3	10SBF	7.55 ± 0.27 ^a	2.17 ± 0.03 ^{bc}
4	30SBF	6.64 ± 0.16 ^{bc}	2.24 ± 0.11 ^{abc}
5	50SBF	5.30 ± 0.02 ^d	2.34 ± 0.04 ^{ab}
6	10CPF	7.12 ± 0.12 ^{ab}	2.11 ± 0.03 ^{bc}
7	30CPF	6.59 ± 0.15 ^c	2.18 ± 0.03 ^{bc}
8	50CPF	4.27 ± 0.20 ^e	2.40 ± 0.03 ^a

¹RF and WF are rice flour and wheat flour, respectively. 10SBF, 30SBF, and 50SBF are composite flours containing 10%, 30%, and 50% soybean flour substituted for rice flour, respectively, while 10CPF, 30CPF, and 50CPF are composite flours containing 10%, 30%, and 50% chickpea flour substituted for rice flour, respectively.

²Mean values within a column that do not share letter are significantly different ($p < 0.05$).

with increasing legume flour incorporation may be associated with the lower starch proportion and the interference of non-starch components with starch swelling. In contrast, the increase in WAC may be related to the greater contribution of protein and dietary fiber, whose hydrophilic groups can interact with water through hydrogen bonding (Bellissent-Funel *et al.* 2016; Cornejo-Ramírez *et al.* 2018). These findings suggest that incorporation of chickpea or soybean flour can modify the hydration and swelling behavior of rice-based composite flours, which may subsequently influence dough handling and the textural characteristics of the resulting cookies.

Pasting properties

The pasting properties of composite flours are shown in Table 4. Increasing the proportion of CPF or SBF generally resulted in lower peak, trough, and final viscosities, particularly at higher substitution levels. A similar reduction in pasting viscosity with increasing incorporation of composite flour was reported by Tharise *et al.* (2014). The gelatinization temperature (GT) varied considerably among the composite flours, with SBF-containing samples showing lower values than RF, whereas CPF-containing samples exhibited a non-linear pattern. Because the measurements were performed on composite flour systems rather than isolated starches, the GT values obtained from the Micro Visco-Amylograph profiles represent the apparent onset of viscosity change of the flour system and should not be directly interpreted as the intrinsic gelatinization temperature of native starch. The lower GT values observed in some composite flours may be associated with changes in starch concentration and hydration behavior resulting from the incorporation of non-starch components, such as proteins, lipids, and dietary fiber.

In addition, RF showed the highest values for peak viscosity (PV) at 927 BU, followed by 10% of CPF addition, and 50% of substitution with SBF hold the lowest rate at 101 BU. The lower peak viscosity observed at higher CPF and SBF substitution levels may be associated with starch dilution and interactions between starch and non-starch components, particularly proteins and dietary fiber (Asaam *et al.* 2018). The reduction in final viscosity at higher SBF substitution levels may reflect reduced starch reassociation during cooling, resulting from the lower starch proportion and increased contribution of non-starch components. The marked reduction in breakdown and final viscosity with increasing composite flour incorporation suggests a diminished capacity of the starch system to develop viscosity during heating and subsequent cooling. (Tharise *et al.* 2014). Additionally, the lower setback viscosity observed in blends with higher protein contents may indicate reduced starch reassociation during cooling and, consequently, a potentially lower

tendency for starch retrogradation and staling. Notably, the GT of 30CPF was considerably lower than those of RF and WF, reflecting a lower apparent onset temperature of viscosity change in this composite flour system. This difference should therefore be interpreted in the context of the composite flour matrix rather than as evidence that the native starch gelatinizes at 38.9°C. Additionally, the TV of 30CPF (451 BU) was intermediate between those of RF (498 BU) and WF (414 BU). In addition, the stronger reduction in viscosity observed in SBF-containing flours may be related to their greater protein and lipid contents, together with the dilution of starch, which can collectively interfere with starch swelling and paste development.

Physical properties and color characteristics of cookies made from composite flours

Table 5 demonstrates physical and color characteristics of the cookies substituted with varying concentrations (10%, 30%, 50%) of CPF and SBF including diameter, thickness, and spread ratio. Cookies formulated with composite flours tended to be thicker than the rice flour control (RC), although the differences were not statistically significant. In contrast, the incorporation of CPF or SBF generally resulted in lower diameter and spread ratio values, although some formulations did not differ significantly from RC. A similar reduction in spread ratio has been reported for high-protein and low-calorie cookies in previous studies (Kulthe *et al.* 2014). The reduced spread ratio may be related to competition among dough ingredients for available water. The higher water absorption capacity of the composite flours (Table 3) could limit water availability during dough formation, thereby restricting cookie spread during baking (Moiraghi *et al.* 2019). Increasing the substitution level, particularly with SBF, generally reduced L values, although cookies containing 10% SBF or 10% CPF exhibited higher L values than RC. The reduction in L at higher substitution levels may be associated with the darker color of the legume flours and enhanced browning reactions during baking. Similar findings were reported by Yamsaengsung *et al.* (2012), who observed that adding chickpea flour to white flour reduced the lightness of the cookie surface. In addition, Zhang (2021) reported that incorporation of soy or pulse flours darkened the cookie surface and increased its redness and yellowness. Although b values tended to increase in cookies containing higher CPF levels, these differences were not statistically significant. In addition, the a values shifted toward red with increasing SBF substitution, changing from negative values at 10% substitution to positive values at 30% and 50% substitution. CPF-containing cookies also showed a shift in a, although the values remained negative at all substitution levels. The changes in a values may be associated with enhanced Maillard browning resulting from

Table 4. Pasting properties of composite flours ^{2,3}

No	Sample ¹	GT (°C)	PV (BU)	TV (BU)	FV (BU)	SB (BU)	BD (BU)
1	RF	72.0 ± 0.3 ^a	927 ± 3 ^a	498 ± 13 ^a	713 ± 7 ^{bc}	215 ± 17 ^c	428 ± 15 ^a
2	WF	57.7 ± 0.1 ^b	790 ± 11 ^b	414 ± 7 ^c	1210 ± 9 ^a	796 ± 13 ^a	377 ± 13 ^b
3	10SBF	34.4 ± 1.4 ^c	471 ± 2 ^c	435 ± 2 ^{bc}	741 ± 6 ^b	306 ± 4 ^b	36 ± 0 ^c
4	30SBF	40.1 ± 2.1 ^c	215 ± 1 ^f	193 ± 3 ^c	426 ± 9 ^c	234 ± 7 ^c	22 ± 2 ^{ef}
5	50SBF	49.3 ± 3.3 ^b	101 ± 1 ^g	98 ± 2 ^f	224 ± 4 ^f	127 ± 2 ^d	3 ± 3 ^f
6	10CPF	70.2 ± 1.4 ^a	801 ± 2 ^b	432 ± 6 ^{bc}	713 ± 1 ^{bc}	281 ± 6 ^b	369 ± 5 ^b
7	30CPF	38.9 ± 7.9 ^c	665 ± 21 ^c	451 ± 8 ^b	699 ± 1 ^{cd}	249 ± 6 ^b	214 ± 13 ^c
8	50CPF	71.9 ± 0.0 ^a	554 ± 5 ^d	386 ± 10 ^d	675 ± 16 ^d	289 ± 24 ^b	168 ± 6 ^d

¹RF and WF are rice flour and wheat flour, respectively. 10SBF, 30SBF, and 50SBF are composite flours containing 10%, 30%, and 50% soybean flour substituted for rice flour, respectively, while 10CPF, 30CPF, and 50CPF are composite flours containing 10%, 30%, and 50% chickpea flour substituted for rice flour, respectively.

²GT, gelatinization temperature; PV, peak viscosity; TV, trough viscosity; FV, final viscosity; SB, setback; BD, breakdown

³Mean values within a column that do not share letter are significantly different ($p < 0.05$).

Table 5. Physical and color characteristics of cookies made from the composite flours ²

No	Sample ¹	Diameter	Thickness	Spread ratio	L*	a*	b*
1	RC	46.0 ± 0.7 ^a	6.47 ± 0.26 ^a	7.12 ± 0.39 ^a	59.6 ± 3.8 ^{ab}	-2.51 ± 1.10 ^{bc}	34.43 ± 0.12 ^a
2	WC	44.8 ± 2.7 ^b	6.57 ± 0.06 ^a	6.82 ± 0.07 ^{ab}	56.9 ± 1.6 ^{ab}	-2.17 ± 1.09 ^{bc}	35.75 ± 2.34 ^a
3	10SBC	45.0 ± 0.6 ^{ab}	6.51 ± 0.06 ^a	6.92 ± 0.15 ^{ab}	61.4 ± 3.0 ^a	-15.21 ± 0.55 ^d	35.76 ± 0.45 ^a
4	30SBC	44.6 ± 0.2 ^{bc}	6.57 ± 0.10 ^a	6.79 ± 0.09 ^{ab}	57.2 ± 0.8 ^{ab}	1.92 ± 0.63 ^{ab}	35.82 ± 0.30 ^a
5	50SBC	43.5 ± 0.6 ^{cd}	6.60 ± 0.23 ^a	6.59 ± 0.23 ^b	55.3 ± 0.1 ^b	4.70 ± 2.04 ^a	36.00 ± 3.59 ^a
6	10CPC	45.0 ± 0.9 ^{ab}	6.50 ± 0.14 ^a	6.93 ± 0.09 ^{ab}	63.7 ± 2.3 ^a	-13.98 ± 1.49 ^d	33.56 ± 1.48 ^a
7	30CPC	44.4 ± 1.0 ^{bcd}	6.55 ± 0.10 ^a	6.77 ± 0.13 ^{ab}	60.9 ± 0.9 ^{ab}	-6.71 ± 1.14 ^c	39.63 ± 2.40 ^a
8	50CPC	43.2 ± 0.1 ^d	6.58 ± 0.04 ^a	6.61 ± 0.02 ^b	60.7 ± 0.6 ^{ab}	-6.44 ± 1.14 ^c	41.07 ± 2.96 ^a

¹10SBC, 30SBC, 50SBC, 10CPC, 30CPC and 50CPC are the cookies made from the composite flours with 10%, 30%, 50% of soybean and chickpea flour substituted for rice flour, respectively; RC and WC are the cookies made from rice flour and wheat flour.

¹RC and WC are the cookies made from rice flour and wheat flour, respectively. 10SBC, 30SBC, and 50SBC are the cookies made from composite flours containing 10%, 30%, and 50% soybean flour substituted for rice flour, respectively, while 10CPC, 30CPC, and 50CPC are the cookies made from composite flours containing 10%, 30%, and 50% chickpea flour substituted for rice flour, respectively.

²Mean values within a column that do not share letter are significantly different ($p < 0.05$).

interactions between amino groups and reducing sugars during baking. This increase in proteins can enhance the Maillard reaction between reducing sugars and amino acids. Similar changes in cookie color following incorporation of protein-rich ingredients have been reported by Pérez *et al.* (2013).

In vitro starch digestibility

Table 6 presents the starch fractions in cookies made from different flour substitutions. In general,

the higher levels of incorporation of CPF and SBF into rice flour-based cookies led to significant changes in the starch digestibility profile, with increased resistant starch (RS) and changes in slowly digestible starch (SDS) and decreased rapidly digestible starch (RDS) content. In particular, the RC and WC exhibited the highest levels of RDS, at 82.0% and 83.1%, respectively while its content was generally lower in the cookies containing CPF or SBF compared to RC and WC. A greater proportion

of starch was susceptible to rapid enzymatic hydrolysis, which can lead to rapid spikes in blood sugar levels. Substitution of rice flour with chickpea flour (CPF) resulted in an increase in SDS contents from 9.2% at 10% substitution to 11.0% at 30% substitution, followed by a decrease to 6.9% at 50% substitution. Thus, 30CPC had the highest SDS content (11.0%), followed by 10CPC (9.2%), whereas 50CPC showed a lower SDS content (6.9%). This indicates that the effect of CPF incorporation on the SDS fraction was not linear, with SDS increasing up to 30% substitution before decreasing at 50% substitution. The decrease at the highest substitution level may be related to changes in starch–protein and starch–fiber interactions and the altered distribution of starch and non-starch components within the cookie matrix. The RS content increased as the

substitution level of chickpea flour (CPF) and soybean flour (SBF) increased in cookie formulations. The highest RS content was observed in 50CPC (18.0%), followed by 50SBC (14.4%). These findings may be related to the presence of fiber and proteins, which can contribute to a more complex structure that limits starch accessibility to digestive enzymes (Van Hung *et al.* 2021). Overall, the incorporation of CPF and SBF into rice flour-based cookies increased the resistant starch fraction, while the effect on SDS depended on the type and level of legume flour substitution.

Sensory evaluation

Table 7 presents the sensory evaluation scores of the cookies. There were no significant differences among samples in terms of color, shape, aroma, and

Table 6. *In vitro* starch digestibility of cookies made from the composite flours ²

No	Sample ¹	Rapidly digestible starch (%)	Slowly digestible starch (%)	Resistant starch (%)
1	RC	82.0 ± 0.6 ^a	6.4 ± 0.6 ^c	11.6 ± 1.2 ^{bc}
2	WC	83.1 ± 3.1 ^a	7.0 ± 0.3 ^{bc}	9.9 ± 3.4 ^c
3	10SBC	82.5 ± 2.0 ^a	5.5 ± 2.9 ^c	12.0 ± 0.9 ^{bc}
4	30SBC	78.8 ± 2.4 ^{ab}	7.6 ± 1.1 ^b	13.6 ± 1.4 ^b
5	50SBC	77.5 ± 0.6 ^b	8.1 ± 2.6 ^b	14.4 ± 2.0 ^b
6	10CPC	78.8 ± 2.9 ^{ab}	9.2 ± 2.4 ^{ab}	12.0 ± 3.5 ^{bc}
7	30CPC	74.9 ± 3.5 ^{ab}	11.0 ± 0.3 ^a	14.1 ± 0.7 ^b
8	50CPC	75.1 ± 0.1 ^b	6.9 ± 0.8 ^c	18.0 ± 0.8 ^a

¹RC and WC are the cookies made from rice flour and wheat flour, respectively. 10SBC, 30SBC, and 50SBC are the cookies made from composite flours containing 10%, 30%, and 50% soybean flour substituted for rice flour, respectively, while 10CPC, 30CPC, and 50CPC are the cookies made from composite flours containing 10%, 30%, and 50% chickpea flour substituted for rice flour, respectively.

²Mean values within a column that do not share letter are significantly different ($p < 0.05$).

Table 7. Sensory score of cookies made from composite flours ²

No	Sample ¹	Color	Shape	Aroma	Crispiness	Taste	Overall acceptability
1	RC	7.43 ± 1.13 ^a	7.73 ± 1.02 ^a	6.95 ± 1.51 ^a	6.45 ± 1.45 ^{ab}	6.52 ± 1.58 ^{ab}	6.80 ± 1.30 ^{ab}
2	WC	7.45 ± 1.19 ^a	7.68 ± 1.02 ^a	7.10 ± 1.20 ^a	6.97 ± 1.25 ^a	7.20 ± 1.09 ^a	7.40 ± 1.01 ^a
3	10SBC	7.52 ± 1.08 ^a	7.38 ± 1.28 ^a	6.78 ± 1.43 ^a	6.62 ± 1.61 ^{ab}	6.53 ± 1.63 ^{ab}	6.58 ± 1.27 ^b
4	30SBC	7.30 ± 1.03 ^a	7.20 ± 1.35 ^a	6.45 ± 1.48 ^a	5.98 ± 1.87 ^b	6.32 ± 1.78 ^b	6.27 ± 1.51 ^b
5	50SBC	7.40 ± 1.01 ^a	7.47 ± 1.01 ^a	6.65 ± 1.33 ^a	6.55 ± 1.31 ^{ab}	6.85 ± 1.46 ^{ab}	6.80 ± 1.21 ^a
6	10CPC	7.23 ± 1.03 ^a	7.32 ± 1.12 ^a	6.37 ± 1.77 ^a	6.40 ± 1.89 ^{ab}	6.05 ± 2.02 ^b	6.32 ± 1.74 ^b
7	30CPC	7.35 ± 1.02 ^a	7.52 ± 0.89 ^a	6.58 ± 1.38 ^a	6.55 ± 1.43 ^{ab}	6.35 ± 1.69 ^{ab}	6.60 ± 1.50 ^b
8	50CPC	7.38 ± 1.03 ^a	7.57 ± 0.96 ^a	6.58 ± 1.50 ^a	6.50 ± 1.65 ^{ab}	6.63 ± 1.07 ^{ab}	6.75 ± 1.1a ^b

¹RC and WC are the cookies made from rice flour and wheat flour, respectively. 10SBC, 30SBC, and 50SBC are the cookies made from composite flours containing 10%, 30%, and 50% soybean flour substituted for rice flour, respectively, while 10CPC, 30CPC, and 50CPC are the cookies made from composite flours containing 10%, 30%, and 50% chickpea flour substituted for rice flour, respectively.

²Mean values within a column that do not share letter are significantly different ($p < 0.05$).

crispiness. The RF cookies received relatively favorable scores for crispiness, taste, and overall acceptability. In particular, crispiness scores tended to decrease with increasing SBF substitution. The other formulations showed relatively comparable crispiness scores, with 10SBC receiving a score close to that of RC. WC received the highest taste score (7.20), whereas cookies containing SBF generally received lower taste scores than RC, suggesting a less favorable taste. Cookies containing 50% SBF or 50% CPF received the highest overall acceptability scores among the composite-flour formulations. The relatively favorable sensory scores may be associated with the physicochemical characteristics of the composite flours, particularly their protein content and water absorption capacity, which can influence dough properties and the resulting cookie texture.

Overall, the findings demonstrate the potential of chickpea and soybean flours as functional ingredients for improving the nutritional quality of rice-based gluten-free cookies. The main advantage of their incorporation is the enhancement of protein and resistant starch contents, while also providing additional fiber and lipid components. From a technological perspective, the changes in hydration, pasting behavior, physical characteristics, and color indicate that the substitution level can be adjusted according to the desired product characteristics. These findings provide a useful basis for the formulation of nutritionally improved gluten-free bakery products using chickpea and soybean flours. However, further optimization of the formulation is needed to achieve a balance between nutritional benefits and sensory acceptability, particularly at higher substitution levels.

CONCLUSION

The effects of incorporating chickpea and soybean flours at 10%, 30%, and 50% substitution levels on the physiochemical properties of composite flours, physical properties and sensory attributes of cookies were studied. The incorporation of soybean and chickpea flours into formulations increased the protein, lipid, and fiber contents of the composite flours, particularly in terms of protein, fat, and fiber content. The incorporation of CPF and SBF also reduced the swelling index and increased water absorption capacity, while markedly altering the pasting properties of the composite flours. CPF and SBF substitution modified the physical characteristics and sensory attributes of the cookies. Higher substitution levels generally resulted in darker cookies and altered their redness while reduced the diameter and spread ratio of the gluten-free cookies. In addition, the RS content also tended to increase with increasing substitution level, particularly in CPF-containing cookies. The gluten-free cookies showed sensory scores generally comparable to the rice flour control, particularly for color, shape, aroma, and crispiness. Further studies should

investigate formulation strategies to improve sensory acceptance while retaining the enhanced protein and RS contents achieved at higher CPF and SBF substitution level. These findings suggest that CPF and SBF have potential as alternative ingredients for producing nutritionally improved gluten-free bakery products, although further formulation optimization is needed before practical application. Overall, incorporation of CPF and SBF improved the nutritional profile of rice-based gluten-free cookies while modifying their technological and physical characteristics without markedly compromising sensory acceptability.

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