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Quinoa flour and *Malva neglecta* powder as functional components to improve the quality of gluten-free rice cake formulation

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ABSTRACT

Cake possesses high diversity as one of the flour-based products and receives considerable attention, particularly among the children and teenagers. The gluten protein in rice cakes can be harmful to celiac disease in patients due to its consumption with intestinal inflammation and swelling causes irritable bowel syndrome in exposed consumers. In the present research, the aim is to optimize the most suitable formulation of enriched gluten-free rice cake and improve the qualitative and sensory characteristics with the response surface methodology. For this purpose, effective factors including different percentages of potato (10, 20 and 30), quinoa flour (50, 60 and 70) and *Malva neglecta* powder (0, 2.5 and 5) were applied in 15 formulations of rice cake samples and then several assays such as moisture, ash, fiber, specific volume, texture, antioxidant attribute and sensory evaluation were conducted with three repetitions on treatments; finally, control and optimal samples were compared with Fourier transform infrared spectroscopy. The conducted assays for moisture 20.10 to 30.20 %, ash 0.50 to 2.51 %, fiber 0.21 to 0.58 %, specific volume 1.02 to 61.3 Cm^3/g, texture 90. 17 to 2.35 N, antioxidant potential 1 to 17.7 µmol Trolox g^{-1} dry matter and sensory assessment 2 to 5.7 were reported in rice cake samples. The optimum production conditions of gluten-free rice cake formulation with the highest moisture (27.07 %), ash (2.19 %), fiber (0.51 %), specific volume (3.09 Cm^3/g), antioxidant function (6.69 µmol Trolox g^{-1} dry matter) and sensory score (3.46) and also the lowest hardness (26.08 N) corresponded to 18.08 % potato, 65.15 % quinoa and 4.81 % *Malva neglecta* powder. The general results illustrated that replacement of quinoa flour and *Malva neglecta* powder significantly enhanced qualitative and quantitative traits of rice cake samples, which can be presented to industry as a novel formulation for functional production.

1- Introduction

Gluten is the main ingredient for maintaining the product quality made from grains, which reveals an important factor in creating cohesion and preserve carbon dioxide gas produced during fermentation [1]. Nowadays, attention to healthy dietary pattern and celiac prevalence have led to the consumption of more gluten-free products among consumers [2]. Celiac disease is an inflammation type of the small intestine caused by intolerance to wheat gluten and various researches performed on gluten-free products including inulin application [3], sponge cake produced by broccoli leaves [4], apple pomace, carrot and orange powders in rice cake [5], whey powder and grape skin made from corn flour in pasta [6], potato starch paste using quinoa and kiwicha [7], stevia leaves in lactose-free cake [8] and pumpkin [9].

Rice holds a specific position as one of the most consumed commodities all over the world with unique attributes such as pleasant flavor, white color, low gluten, sodium, protein, fat, fiber and high digestible carbohydrates [5]. On the other hand, potato is considered a staple crop with more quality in the market trend, which plays a crucial role for food chain security of developing countries and supplies 50 % required energy efficiency with rice, wheat and also corn [7]. Quinoa is an inherently beneficial crop with high nutritive value comparable to ancient grains owing to 10 to 18 % protein, a balanced amino acid composition (further lysine and methionine), gluten-free, 52.3 % linoleic and 3.9 % linolenic acids [10].

Malva neglecta plant contains vitamins A, B and C, tannin, leucoanthocyanidin, anthocyanin, malvin glycoside and flavonoids, which antioxidant traits and also chelating ability are chiefly due to the effect of these components [11]. Several researches had been conducted on the sedative, antifungal, antibacterial, antiviral, anti-inflammatory, antioxidant, immune system regulating and anti-mutagenic effects of flavonoids in this plant [11 and 12].

No research has been found on the desired composition so far and the purpose for in present study is to optimize the formulation of gluten-free rice cake enriched with different potato flour (10, 20 and 30 %), quinoa powder (50, 60 and 70 %) and *Malva neglecta* powder (0, 2.5 and 5 %) and investigating qualitative characteristics (moisture, ash, fiber, specific volume, texture, antioxidant features) and sensory evaluation.

2- Materials and methods

2-1- Materials

Raw materials including potato flour, rice, whole quinoa, sunflower oil, eggs and baking powder, vanilla and also sugar purchased from Bartar Food Product, Tarkhineh, Quinoa Aman Green Farm, Oila, Armaghan Chicken Companies and supermarkets in Tehran, respectively. *Malva neglecta* plant was obtained from the local market of Andimeshk city and powdered after washing and also drying.

2-2- Cake preparation

The formulation of 100 g prepared cake included eggs 65 g, sunflower oil 5 g, water 7.6 g, salt 0.3 g, baking powder 0.2 g and tartar cream 0.2 g. Briefly, eggs, corn oil, salt, baking powder and tartar cream were blended using a mixer (Bonito, HM 200 K) at low and medium speeds about 1 and 20 min. Afterwards, water, potato (10, 20 and 30 %) and quinoa (50, 60 and 70 %) flour were stirred at low speed for 5 min and rice flour was applied in each sample to reach 100 %. In the final stage, *Malva neglecta* powder (0, 2.5 and 5 %) was added at less speed during 3 min. Then, cake dough was placed in silicone molds and baked at 190 °C about 18 min in a preheated electric oven (Techno) [13].

2-3- Physicochemical aspects

The moisture and ash contents were measured using an oven (Memmert ULM500) and also electric furnace (Thermolab) at 105 °C about 4 h and 600 °C until the ash turned white to reach a constant weight, respectively. The crude fiber level was calculated through AACC standard method number 32-10; initially, sample was defatted by petroleum ether, then 3 g treatment with 200 mL of 0.255 N sulfuric acid were mixed into the porcelain crucible. Boiling was done for 30 min and after this step, the acid was discharged by the device vacuum. The 200 mL of 0.313 N NaOH solution was added to ingredients inside the porcelain crucible and boiled about 30 min and then resulting mixture was evacuated under device vacuum. Afterwards, the material inside porcelain crucible was washed several times using water and finally placed at 100 °C until reached to a constant weight. Then, porcelain crucible was placed in the oven at 550 °C and turned into ash; after cooling and weighing, fiber level was obtained using Eq. 1 [14]:

Eq. 1: $F = [(W_2 - W_1)/M] \times 100$

Where M, F, W_2 and W_1 are sample in g, total fiber, the weight of porcelain bush containing the sample and ash after baking and also furnace, respectively.

2-4- Texture profile assay

The specific volume for cakes was measured according to AACC 72-10 using the replacement method of millet seeds [14]. The texture analyzer (Hounsfield H5KS) was equipped with an aluminum cylindrical probe (36 mm diameter and 50 N load cell) to determine feature. Texture profile analysis double compression test was performed at 2 mm/s speed, which regulated to 50 % initial height with 30 S delay between the first and the second modes and also cake slices mm (15 thickness) were applied for analysis [10].

2-5- Trolox equivalent antioxidant capacity

The 7 mmol/L solution of 10 mL 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) and 51.4 mmol/L $K_2S_2O_4$ (0.5 mL) were mixed to obtain a radical cation at λ = 734 nm and 0.7 ± 0.05 absorbance. The obtained samples (20 L) was blended to solution of 1480 L 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) for measuring in cuvettes. The 10 L suitable diluted samples, standard and blanks were placed into microplate wells to evaluate. Afterwards, time and reaction were measured by adding 290 L of mentioned solution and a microplate reader with an injector. The reaction was performed at 30 °C in darkness about 6 min for microplates and cuvettes; then, absorbance was expressed. The 1.00 mmol/L stock solution was used to calibrate and achieved results were reported as mmol trolox equivalents per L for dry cake combination with *Malva neglecta* powder and gluten-free, as depicted in Eq. 2 [15]:

Eq. 2: $$\mathrm{ABTS_{PV}} = \left(\mathrm{ABTS}_C - \left(\mathrm{ABTS}_C \times \frac{N}{100\,\%}\right)\right) + \frac{\mathrm{ABTS_{BLP}} \times N}{100\,\%}$$

Where $\mathrm{ABTS_C}$ and $\mathrm{ABTS_{BLP}}$ are the antioxidant capacity of gluten-free rice cake and also *Malva neglecta* powder measured by 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) diammonium salt assay, respectively and N is the *Malva neglecta* percentage.

2-6- Sensory assessment

The obtained samples were chopped 3 h after manufacture and coded and after that they were investigated by 10 trained panelist for assaying several attributes such as color, aroma, smell and taste, texture and overall acceptance through a 5-point hedonic scale test. In this assessment, the numbers corresponded to 5, 4, 3, 2 and 1, which indicated excellent, good, average, weak and extremely bad [2].

2-7- Fourier transform infrared spectroscopy (FTIR) analysis of optimum cake and control

The chemical components of optimum (18.08 % potato, 65.15 % quinoa and 4.81 % *Malva neglecta* powder) and control (100 % potato without enrichment) cakes were studied using FTIR spectroscopy (Thermo Nicolet Corp., Madison, WI, USA) from 400 to 4000 cm^{-1} [16].

2-8- Statistical analysis

Box-benken design was employed including three independent variables of potato (10, 20 and 30 %), quinoa flour (50, 60 and 70 %) and *Malva neglecta* powder (0, 2.5 and 5 %), which these combinations were selected to study and optimize the variable effect. The levels were chosen based on preliminary assays for independent variables (without determining the data). The designed model was applied to predict the relationship between investigated response and selected experimental variables and statistical analysis was performed using SPSS 23.0.0 software.

3- Results and Discussion

3-1- Physicochemical attributes of gluten-free rice cake samples

The moisture absorption is corresponded to the microbial, chemical and physical functions in cake samples, which is particularly prominent for ensuring sufficient shelf life of grain and their products due to microbial spoilage, especially certain fungi types [8]. The obtained laboratory results and predicted responses for each experimental unit illustrated the moisture level in 20.10 to

30.20 % range (Table 1). After converting the t-test table results, all sentences with not statistically significant were removed and Eq. 3 changed as follows:

Eq. 3: $Y_1 = 11.2 + 0.565417\,X_1 - 0.04375\,X_2 - 0.0055\,X_1X_2$

Y_1 is moisture samples, which are coded responses of independent variables X_1 (potato %), X_2 (quinoa %) and X_3 (*Malva neglecta*). The influence of improvement percentage for potato and quinoa flour are demonstrated on moisture regimes in gluten-free rice cake samples by 2.5 % *Malva neglecta* presence at a central point, which elevated with both factors, as depicted in diagram 1(a). The maximum moisture belonged to a sample with 0 % *Malva neglecta*, 30 % potato and 60 % quinoa flour.

Figure 1

The results outlined that *Malva neglecta* powder had no impact on sample moisture owing to hydrogen bonds, which enhanced by quinoa flour addition and higher fiber content; on the other hand, absorption and retention of water molecules in product improved during cooking due to further hydroxyl groups in structure [7]. The moisture availability changed significantly from 27.99 to 29.91 % by replacing quinoa flour with rice and potato in cake samples [10]. Some researchers did not find out any significant difference between the moisture absorption of gluten-free and control cakes [6 and 17].

The 0.50 to 2.51 % range of ash response was distinguished in gluten-free rice cake samples (Table 1). According to t-test table results and examining the relationship between independent and also dependent variables, Eq. 4 was outlined as follows:

Eq. 4:

$$Y_2 = -4.55833 + 0.0208333\,X_1 + 0.137083\,X_2 + 0.521667\,X_3 - 0.001332\,X_1^2 - 0.011X_1X_3 - 0.004\,X_2X_3$$

The ash contents of gluten-free rice cake samples (Y_2) are coded responses and independent variables. The optimal ash for gluten-free rice cake samples illustrates that different effects of variable levels can be obtained and these results are depicted in Figure 1 (b and c) as response surface diagrams. The higher potato flour and *Malva neglecta* percentages enhances ash condition in Figure 1 (b), which quinoa is constant at central point (X_3: 50 %). Figure 1 (c) displays the percentage effect of quinoa flour and *Malva neglecta* powder on ash target and in this condition, potato flour is kept constant at central point (X_2: 20 %) that mentioned factor declines with potato flour addition, but further ash is in line with quinoa increment. The sample with 5 % *Malva neglecta* powder, 10 % potato and 60 % quinoa flour had the maximum ash.

The more *Malva neglecta* powder had led to an ash enhancement because of mineral compositions [7]. The ash level was elevated by adding marjoram plant extract to cake flour [18] and changed significantly from 1.13 to 1.58 % through replacing quinoa flour with potato, which was attributed to 2.45 and 0.24 % minerals and also bran, respectively [10].

Fiber is considered as one of the beneficial nutritional profiles for humans, which improves quality assurances and extends the product shelf life owing to hydrophilic nature and also further cellulose [5]. The amount of fiber in gluten-free rice cake samples was estimated from 0.21 to 0.58 % (Table 1). Eq. 5 was obtained using t-test table results and examining the relationship between independent and dependent variables:

Eq. 5: $Y_3 = -1.16625 + 0.0369167\,X_1 + 0.020375\,X_2 + 0.165833\,X_3 + 0.00128333\,X_1^2 - 6.25\,X_1X_2 - 0.0015\,X_1X_3 - 0.002\,X_2X_3$

The coded levels and independent variables are exhibited by Y_3 as the fiber of gluten-free rice cake samples. The effect of higher percentages for quinoa and potato flour in samples is observed on fiber, which *Malva neglecta* powder is kept constant at a central point (X_3: 2.5 %), as indicated in Figure 1 (d), which the mentioned factor is elevated and diminished using more quinoa and potato, respectively. Figure 1 (e) represents the influence of potato flour and *Malva neglecta* powder on target factor and quinoa is constant at central point (X_2: 60 %) and also fiber is aligned with both components. The highest fiber corresponded to a sample with 10 % potato, 70 % quinoa and 5 % *Malva neglecta* powder.

The ash content was enhanced using higher quinoa due to fiber compared to potato and wheat flour, which confirmed by previous research results [7, 10 and 19]. *Malva neglecta* plant is found to be a promising source of vitamins A, B, C, fiber, flavonoids, carotenoids, tocoferol, carbohydrates, unsaturated fatty acids, beta-carotene and lycopene [12]. Previous researchers had presented that apple pomace [5], mango pulp and skin [20], black seeds and also green tea [21] as enriched sources improved fiber factor in cake samples, which was in line with plant presence in this research.

3-2- Textural evidence of gluten-free rice cake samples

The specific volume is considered is one of the key parameters in baked product quality for customer evaluations [10]. The variance analysis results of specific volume data in Table 2 with different stability values are found to be between 1.02 and 3.61 (Cm^3/g). The satisfactory state with a high explanatory coefficient and non-significance of model mismatch test were represented (Table 2) and Eq. 6 was indicated as follows (Y_4: volume of gluten-free rice cake samples):

Eq. 6: $Y_4 = -139625 + 046125\,X_2 - 0003\,X_2^2 + 0004\,X_2X_3$

Figure 1 (f) demonstrates the impact of higher quinoa and *Malva neglecta* percentages on specific volume for cake samples in potato flour presence at a constant central point (X_3: 20) and this parameter is improved with elevation of both factors.

The further protein of quinoa flour provides a higher specific volume, which develops by enhancing dough viscoelasticity and duration before semi-solidification, which related to interaction and transfer of protein starch [22]. The previous results pointed out that cake volume was attributed to storage capacity during baking not initial air [22 and 23]. Similar result was found that replacement of rice and corn flour with quinoa significantly improved bread volume [19]. Manufactured cake samples including different levels of gum (xanthan and cress) had a higher specific volume than control (rice and corn) in another research [23].

The texture range of gluten-free rice cake samples was estimated from 17.90 to 2.35 N (Table 2), which was depicted in Eq. 7:

Eq. 7: $$Y_5 = -20.8375 - 0.437917\,X_1 + 1.07625\,X_2 + 0.00979167\,X_1^2 - 0.00720833\,X_2^2 - 0.151333\,X_3^2 + 0.00925\,X_1X_2 - 0.028\,X_1X_3$$

The resulted texture in Y_5 is coded responses and independent factor and also there are only significant relationships between different variables. The influence of more quinoa and potato flour is detected on textural features with concentration (X_3: 2.5 %) for *Malva neglecta* remaining constant, which hardness distribution is improved by further quinoa flour and potato powder in Figure 1 (g). Hardness is affected by adding potato flour and *Malva neglecta* powder, as clarified in Figure 1 (h) and corresponds to stable quinoa (X_2: 60 %), which enhancement in highlighted index are aligned to more both factors. A smooth texture was a chief goal in cake not hardness; therefore, the lowest hardness level belonged to a sample including 10 % potato, 50 % quinoa and 0 % *Malva neglecta* powder.

Carbonic gas, virtual chemicals that release them or aeration by heating oil, sugar and eggs applies to create porosity in cake texture, but maintaining the spongy state is due to gluten network [22]. No gluten was distinguished in cakes of present research, which related to hardness; however, *Malva neglecta* powder could play the role of an emulsifier owing to unsaturated fatty acids and reduce hardness [12]. The effect of replacing quinoa flour on textural attributes (hardness, elasticity, adhesion and flexibility) in gluten-free rice cakes exhibited that sample without quinoa indicated the maximum hardness value and adding this component caused a significant reduction in the highest force when broken, which was correlated with mentioned index [19]. The elasticity of cake crumbs was related to protein accumulation that indicated a fresh, aerated and elastic product [22].

3-3- Antioxidant status of gluten-free rice cake samples

The peroxide results represented the satisfactory condition of model with a high explanatory coefficient and the non-significance for mismatch test in the 1 to 7.17 range (μmol Trolox g^{-1} dry matter), as depicted in Eq. 8:

Eq. 8: $$Y_6 = -5.01 - 0.749833\,X_3 + 0.233667\,X_3^2 + 0.0127\,X_2X_3$$

Eq. 8 displayed that antioxidant traits in Y_6 represented coded responses and independent variables. As revealed in Figure 1 (i), the addition of *Malva neglecta* powder and quinoa flour has an influence antioxidant function, when potato flour is stable at central point (X_1: 20) and this feature is developed by further both factors.

The usefulness of plant components was based on stability and health benefits for bioactive substances after processing [12]. The effects of phenol-rich additives with high antioxidant activities had been illustrated in food products [5]. In present result, *Malva neglecta* had led to an improvement in antioxidant features of cake samples due to phenolic contents, which was consistent with previous researchers [11 and 12]. The broccoli leaf waste (0 to 2.7 %) was applied in sponge cake, which enhanced the antioxidant characteristics [4]. Thermal processing did not affect hydrophilic nature, especially total phenolics or antioxidant potential of gluten-free rice cake [24].

3-4- Sensory evaluation of gluten-free rice cake samples

The satisfactory status with a high explanatory coefficient and non-significance of model mismatch test were demonstrated and the range was 2.7 to 5 (Table 2). Eq. 9 was obtained using the t-test table results and examining the relationship between independent and also dependent variables:

Eq. 9: $Y_7 = -17.0875 + 0.0820833\,X_1 + 0.708750\,X_2 + 0.626667\,X_3 - 0.00370833\,X_1^2 - 0.00620833\,X_2^2 - 0.103334\,X_3^2 + 0.00125\,X_1X_2 + 0.01\,X_1X_3 - 0.008\,X_1X_3$

Y_7 included the coded responses and independent variables and also there are only significant relationships between different variables. Sensory attributes are influenced by increasing potato and quinoa powders while maintaining a constant percentage of *Malva neglecta* (X_1: 2.5 %), as appeared in Figure 1 (j), which improves with enhancement in both factors to a point and then declines. Figure 1 (k) reveals the impact of higher quinoa and *Malva neglecta* powder on target factor in condition that potato flour is kept constant at a central point (X_2: 20 %) and this index enhances and diminishes by adding components, respectively. The effect of more potato and *Malva neglecta* powder is detected on sensory evaluation with stable quinoa flour (X_1: 60 %), which enhancement until to a point and reduction in this assessment are observed using further substances in Figure 2 (g). The formulation of 23.53 % potato, 58.28 % quinoa and 1.91 % *Malva neglecta* powder was corresponded to the maximum sensory integration.

Some researchers stated that hydrocolloids in production of gluten-free products improved the sensory characteristics [5 and 8]. Overall acceptance scores determined from 7.7 and 7.1 for gluten-free rice cakes prepared with rice flour, corn and adding 0.3 and also 0.4 % xanthan gum, respectively [25]. The previous research reported sensory acceptance evaluation ranging from 0.7 to 4.8 in gluten and egg-free cookies produced by rice flour and also different jambolan fruit pulps with or without xanthan gum [26 and 27]. The color, moisture, softness and water activity indicators were improved in gluten-free rice cake owing to presence of roasted quinoa compared to normal form with less sensory acceptance [17]. The results confirmed that quinoa flour significantly elevated the sensory characteristics of gluten-free rice cakes [10]; however, excessive quinoa had a negative effect on overall acceptance scores due to bitterness and inadequate flavor [19].

Table 2

3-5- Formulation optimization of gluten-free rice cake samples

Optimum production conditions for gluten-free rice cake formulation with the highest moisture (27.07), ash (2.19), fiber (0.51), specific volume (3.09 Cm^3/g), antioxidant feature (6.69 µmol Trolox g^{-1} dry matter) and sensory evaluation (3.46) and also the lowest hardness (26.08 N) were correlated to 18.08 % potato, 65.15 % quinoa and 4.81 % *Malva neglecta* powder. The results obtained by the confirmation assays were performed with two repetitions and no significant difference was not revealed between the predicted and actual values.

3-6- FTIR spectroscopic assay

This spectrum was evaluated in order to determine the structural functions of cake treatments (Figure 2). The peak in an area of polysaccharides attributed to stretching or bending C-O, C-C and C-O-H (600-1150 cm^{-1}) vibrations was more intense in optimal sample due to potato and high starch in flour than control [16 and 28]. The amide I, II and III vibrations were correspond to different protein components in all spectra. The amide I (1600-1700 cm^{-1}) indicated the presence of β-turn structure and α-helix elements, amide II (1480-1575 cm^{-1}) and amide III (1200-1400 cm^{-1}) from potato and also rice protein [16 and 29]. The examination of amide III region (1200-1350 cm^{-1}) in optimal sample preparation illustrated that mucilage related to quinoa had caused cell and protein hydration; therefore, low beta structures and random compounds changed [28]. The finding suggested that after adding quinoa and *Malva neglecta* powder, glycoprotein content of optimal sample was potentially significant [29]. It seemed that absorbance values in the range of 1500-1800 cm^{-1} were consistently associated with functional groups in organic acids and proteins and also intensity enhancement of peaks for optimum samples could be attributed to quinoa including proteins, glucuronic acid and also essential oil that possessed organic acids with carboxyl groups [16]. The peaks around 3000 cm^{-1} demonstrated CH groups belonging to alkane group and asymmetric stretching vibrations of carboxylic acids owing to free sugar in samples [29]. The peak in the range of 3500-3000 cm^{-1} was observed, which related to stretching vibration for O-H groups in all samples, which could be related to sugars (rhamnose and xylose), phenolic compounds, water and secondary N-H groups that overlapped [28]. The intensity of peak in control was lower than optimal sample, which was due to quinoa absence as a water absorbing agent.

Figure 2

4- Conclusion

The obtained results exhibited that substitution of quinoa flour significantly elevated the physicochemical and quality indicators for cakes in present research. Textural analysis proved that dough stability, homogeneity and mechanical strength improved using quinoa flour. Furthermore, nutritional, technological and sensory attributes were enhanced by adding quinoa flour and optimal formulation of target cake had 18.08 % potato, 65.15 % quinoa and also 4.81 % *Malva neglecta* powder. The present research concluded that 65 % quinoa flour could be successfully in formulation of gluten-free rice cake without causing any negative effects and *Malva neglecta* powder had an impact on improving nutritional value.

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6- References

[1] Mirab, B., Gavlighi, H.A., Sarteshnizi, R.A., Azizi, M.H. and Udenigwe, C.C. 2020. Production of low glycemic potential sponge cake by pomegranate peel extract (PPE) as natural enriched polyphenol extract: Textural, color and

consumer acceptability. LWT, 134, 109973. DOI: 10.1016/j.lwt.2020.109973

[2] Karami, M. and Salehi, F. 2023. Investigation on replacing egg with soy flour and Psyllium seed gum in gluten-free rice cake. Journal of Food Science and Technology (Iran), 20(143), 62-77. DOI: 10.22034/FSCT.20.143.62

[3] Kalani, P., Jafarian, S., Azizi, M.H., Asadi, G.H. and Roozbeh Nasiraie, L. 2022. Evaluation of physicochemical characteristics of gluten-free cupcake containing inulin. Journal of Food Science and Technology (Iran), 19(130), 111-120. DOI: 10.22034/FSCT.19.130.111

[4] Drabińska, N., Ciska, E., Szmatowicz, B. and Krupa-Kozak, U. 2018. Broccoli by-products improve the nutraceutical potential of gluten-free mini sponge cakes. Food Chemistry, 267, 170-177. DOI: 10.1016/j.foodchem.2017.08.119

[5] Kırbaş, Z., Kumcuoglu, S. and Tavman, S. 2019. Effects of apple, orange and carrot pomace powders on gluten-free batter rheology and cake properties. Journal of Food Science and Technology, 56, 914-926. DOI: 10.1007/s13197-018-03554-z

[6] Ungureanu-Iuga, M., Dimian, M. and Mironeasa, S. 2020. Development and quality evaluation of gluten-free pasta with grape peels and whey powders. LWT, 130, 109714. 1 DOI: 0.1016/j.lwt.2020.109714

[7] Vidaurre-Ruiz, J., Salas-Valerio, F., Schoenlechner, R. and Repo-Carrasco-Valencia, R. 2021. Rheological and textural properties of gluten-free doughs made from Andean grains. International Journal of Food Science & Technology, 56(1), 468-479. DOI: 10.1111/ijfs.14662

[8] De Souza Nespeca, L., Cardoso, F.A.R., Droval, A.A., Marques, L.L.M., Beneti, S.C., Heck, S.C. and Fuchs, R.H.B. 2023. Impact of replacing sugar with Stevia rebaudiana Bertoni leaves on the physical–chemical and sensory characteristics of gluten-free and lactose-free cake. International Journal of Food Science & Technology, 58(10), 5097-5113. DOI: 10.1111/ijfs.16609

[9] Samie, M.M., Emamifar, A. and Salehi, F. 2023. Rheological batter and textural characteristics of gluten-free sponge cake containing pumpkin powder. Journal of Food Science & Technology, 142(20), 68. DOI: 10.22034/FSCT.20.142.68

[10] Bozdogan, N., Kumcuoglu, S. and Tavman, S. 2019. Investigation of the effects of using quinoa flour on gluten-free cake batters and cake properties. Journal of Food Science and Technology, 56, 683-694. DOI: 10.1007/s13197-018-3523-1

[11] Jourabian, F. and Nouri, M. 2023. Optimization of formulated kefiran/malva neglecta film with rice bran oil to maintain cauliflower quality in storage. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 93(3), 697-703. DOI: 10.1007/s40011-023-01463-6

[12] Seyyednejad, S.M., Koochak, H., Darabpour, E. and Motamedi, H. 2010. A survey on Hibiscus rosa—sinensis, Alcea rosea L. and Malva neglecta Wallr as antibacterial agents. Asian Pacific Journal of Tropical Medicine, 3(5), 351-355. DOI: 10.1016/S1995-7645(10)60085-5

[13] Li, M., Sun, H.N., Mu, T.H., Tian, S.L., Ji, L.L., Zhang, D.Q., Li, S.Q., Ge, X., Cheng, J.X. and Tian, J.C. 2020. Preparation and quality characteristics of gluten‐free potato cake. Journal of Food Processing and Preservation, 44(11), 14828. DOI: 10.1111/jfpp.14828

[14] AACC Method. Resistant starch in starch samples and plant materials. In: Approved methods of the American Association of Cereal Chemists. 10th ed. St Paul: American Association of Cereal Chemists, 2011.

[15] Horszwald, A. and Andlauer, W. 2011. Characterisation of bioactive compounds in berry juices by traditional photometric and modern microplate methods. Journal of Berry Research, 1, 189-199. DOI: 10.3233/JBR-2011-020

[16] Cao, Y., Zhao, J., Jin, Z., Tian, Y., Zhou, X. and Long, J. 2021. Improvement of rice bran modified by extrusion combined with ball milling on the quality of steamed brown rice cake. Journal of Cereal Science, 99, 103229. DOI: 10.1016/j.jcs.2021.103229

[17] Rothschild, J., Rosentrater, K.A., Onwulata, C., Singh, M., Menutti, L., Jambazian, P. and Omary, M.B. 2015. Influence of quinoa roasting on sensory and physicochemical properties of allergen‐free, gluten‐free cakes. International Journal of Food Science & Technology, 50(8), 1873-1881. DOI: 10.1111/ijfs.12837

[18] Hafez, A.A. 2012. Physico-chemical and sensory properties of cakes supplemented with different concentration of marjoram. Australian Journal of Basic and Applied Sciences, 6(13), 463-470. DOI: 10.4236/fns.2013.47097

[19] Foste, M., Nordlohne, S.D., Elgeti, D., Linden, M.H., Heinz, V., Jekle, M. and Becker, T. 2014. Impact of quinoa bran on gluten-free dough and bread characteristics. European Food Research and Technology, 239(5), 767-775. DOI: 10.1007/s00217-014-2269-x

[20] Noor Aziah, A.A., Lee Min, W. and Bhat, R. 2011. Nutritional and sensory quality evaluation of sponge cake prepared by incorporation of high dietary fiber containing mango (Mangifera indica var. Chokanan) pulp and peel flours. International Journal of Food Sciences and Nutrition, 62(6), 559-567. DOI: 10.3109/09637486.2011.562883

[21] Radočaj, O., Dimić, E. and Tsao, R. 2014. Effects of hemp (Cannabis sativa L.) seed oil press-cake and decaffeinated green tea leaves (Camellia sinensis) on functional characteristics of gluten-free crackers. Journal of Food Science, 79(3), 18-25. DOI: 10.1111/1750-3841.12370

[22] Shevkani, K., Kaur, A., Kumar, S. and Singh, N. 2015. Cowpea protein isolates: functional properties and application in gluten-free rice muffins. LWT-Food Science and Technology, 63(2), 927-933. DOI: 10.1016/j.lwt.2015.04.058

[23] Naji, S., Razavi, S.M.A. and Karazhiyan, H. 2012. Effect of thermal treatments on functional properties of cress seed (*Lepidium Sativum*) and xanthan gums: Comparative study. Food Hydrocolloids, 28(1), 75-81. DOI: 10.1016/j.foodhyd.2011.11.012

[24] Zieliński, H., Zielińska, D. and Kostyra, H. 2012. Antioxidant capacity of a new crispy type food products determined by updated analytical strategies. Food Chemistry, 130(4), 1098-1104. DOI: 10.1016/j.foodchem.2011.08.009

[25] Preichardt, L.D., Vendruscolo, C.T., Gularte, M.A. and Moreira, A.D.S. 2011. The role of xanthan gum in the quality of gluten free cakes: improved bakery products for coeliac patients. International Journal of Food Science & Technology, 46(12), 2591-2597. DOI: 10.1111/j.1365-2621.2011.02788.x

[26] Singh, J.P., Kaur, A., Shevkani, K. and Singh, N. 2015. Influence of jambolan (Syzygium cumini) and xanthan gum incorporation on the physicochemical, antioxidant and sensory properties of gluten-free eggless rice muffins. International Journal of Food Science and Technology, 5(50), 1190-1197. DOI: 10.1111/ijfs.12764

[27] Torabı, S., Mohtarami, F. and Dabbagh Mazhary, M.R. 2020. The influence of acorn flour on physico-chemical and sensory properties of gluten free biscuits. Journal of Food Science and Technology (Iran), 16(97), 171-181. DOI: 10.29252/fsct.16.97.171

[28] Papagianni, E., Kotsiou, K., Matsakidou, A., Biliaderis, C.G. and Lazaridou, A. 2024. Development of “clean label” gluten-free breads fortified with flaxseed slurry and sesame cake: Implications on batter rheology, bread quality and shelf life. Food Hydrocolloids, 150, 109734. DOI: 10.1016/j.foodhyd.2024.109734

[29] Aslan Türker, D., Göksel Saraç, M. and Doğan, M. 2023. Development of gluten-free cake formulations: the role of tapioca & potato starch and quinoa in the rheological, textural and powder flow properties. European Food Research and Technology, 249(3), 675-684. DOI: 10.1007/s00217-022-04164-y

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آرد کینوا و پودر پنیرک به عنوان ترکیبات فراسودمند جهت بهبود کیفیت فرمولاسیون کیک برنج بدون گلوتن

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چکیده

کیک به عنوان یکی از محصولات آردی دارای تنوع بالا بوده که در بین افراد جامعه به خصوص کودکان و نوجوانان طرفداران زیادی دارد. پروتئین گلوتن در کیک برای بیماری سلیاک مضر است زیرا مصرف آن با التهاب و تورم روده باعث ایجاد سندروم تحریک‌پذیر در فرد مبتلا می‌شود، البته به دلیل خواص ساختاری ویژه گلوتن انتخاب جایگزین مناسب آن، یک مشکل عمده فناوری غلات به حساب می‌آید. در این پژوهش هدف بهینه سازی مناسبترین فرمولاسیون کیک برنج بدون گلوتن جهت بهبود خصوصیات کیفی و حسی با روش آماری سطح پاسخ بود. بدین منظور از آرد سیب زمینی ۱۰، ۲۰ و ۳۰٪، پودر کینوا ۵۰، ۶۰ و ۷۰ ٪و پودر گیاه پنیرک ۰، ۲/۵ و ۵ ٪ در ۱۵ فرمولاسیون نمونه‌های کیک برنج استفاده شد، سپس آزمون‌های تعیین رطوبت، خاکستر، فیبر، حجم مخصوص، بافت، خاصیت آنتی اکسیدانی و ارزیابی حسی با سه تکرار روی نمونه‌ها انجام شد، در انتها با طیف سنج مادون قرمز ترکیبات نمونه کنترل و بهینه مقایسه شدند. نتایج آزمون‌های رطوبت ۲۰/۱۰ تا ۳۰/۲۰ ٪، خاکستر ۰/۵۰ تا ۲/۵۱ ٪، فیبر ۰/۲۱ تا ۰/۵۸ ٪، حجم مخصوص ۱/۰۲ تا ۳/۶۱ Cm^3/g ، بافت ۱۷/۹۰ تا ۳۵/۲ N ، خاصیت آنتی اکسیدانی ۱ تا ۷/۱۷ DM μmol Trolox g^{-1} و ارزیابی حسی ۲/۷ تا ۵ گزارش شد. شرایط بهینه تولید فرمولاسیون کیک بدون گلوتن با بیشترین رطوبت ٪۰۷/ ۲۷، خاکستر ٪۲/۱۹، فیبر ٪۰/۵۱، حجم مخصوص ۳/۰۹ Cm^3/g ، خاصیت آنتی اکسیدانی ۶/۶۹ DM μmol Trolox g^{-1} و ارزیابی حسی ۳/۴۶ همچنین کمترین سختی ۲۶/۰۸ N مربوط به مقادیر سیب زمینی ۱۸/۰۸٪، کینوا ۶۵/۱۵ ٪و پودر پنیرک ۴/۸۱ ٪ بود. نتایج کلی نشان داد جایگزینی آرد کینوآ و حضور پودر گیاه پنیرک در کیک‌های به طور قابل‌توجهی باعث افزایش خواص کیفی نمونه‌های کیک برنج شد که می‌توان به عنوان فرمولاسیونی جدید جهت تولید کیک فراسودمند به صنعت ارائه داد.