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Food Quality Evaluation of *Manihot esculenta* Crantz Gluten–Free Noodles

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ABSTRACT:
Gluten-free noodles are frequently less acceptable in terms of cooking behavior and performance compared to gluten-containing noodles. In this study, the cooking and color characteristics of Manihot esculenta Crantz flour–based gluten-free noodles fortified with xanthan gum (XG), guar gum (GG), whey protein, and egg were investigated. The effects and interactions among the ingredients were estimated using a fractional factorial design on the cooking time (OCT), cooking loss (CL), cooking yield (CY), and swelling index (SI). Whey protein had the most impact on OCT, CL, and CY. While XG had the most dominant to SI, followed by whey protein. The interactions of the components in the formulation significantly prolong the OCT, increase CY, CL, and SI, especially for the whey-egg interaction. Egg contributed the most to the yellow color. Overall, the Manihot esculenta Crantz gluten-free noodles quality was acceptable in terms of the cooking quality and color. These findings provide a predictive framework for quality Manihot esculenta Crantz *gluten-free noodles to diversify gluten-free products.*

KEYWORDS: **Cassava, Gluten-free, Cooking quality, Fractional factorial design, Hydrocolloid**

Introduction

Manihot esculenta Crantz has gained prominence as a staple crop in ensuring food security, ranking as the third most important source of dietary energy in tropical regions [1]. It is highly valued for its starch–rich composition, resilience to drought, and ability to thrive in nutrient–poor soils, making it a reliable food source in vulnerable regions [1]. *Manihot esculenta* Crantz flour and starch are increasingly utilized in noodle formulations due to their functional versatility. When *Manihot esculenta* Crantz was blended with soy flours, it has been shown to improve noodle texture [2]. Hydroxypropylated *Manihot esculenta* Crantz starch added to wheat noodle contributes a soft and elastic mouthfeel [3], while innovations such as porous *Manihot esculenta* Crantz starch have been reported to enhance cooking quality [4]. Besides, the amylopectin-dominated amorphous regions in *Manihot esculenta* Crantz improve water mobility and decrease crystallinity, which help to produce acceptable functional properties such as syneresis and water solubility index [5].

Hydrocolloids enhance the texture, moisture retention, viscosity, and overall quality of gluten-free noodles [6,7]. By forming hydrogen bonds with amylose and amylopectin, they delay starch retrogradation, thereby improving textural stability and shelf life [8]. Their high water–holding capacity reduces cooking loss (CL) and improves cooking yield (CY) [9]. For example, Kaur et al. [10] reported that 0.25% xanthan gum (XG) or guar gum (GG) reduced CL from 0.46% to 0.13% in corn starch noodles, highlighting their strong binding and shear-resistance effects. Similarly, Dahal et al. [8] demonstrated the role of XG and GG in enhancing water retention and textural properties.

Experimental design approaches such as fractional factorial design (FFD) provide an efficient tool to unravel complex multi-factor interactions. Unlike single-variable studies, FFD allows systematic evaluation of main effects and interactions among hydrocolloids and proteins, offering predictive models for key quality parameters. This approach is particularly valuable in gluten–free noodle development, where multiple components interact nonlinearly to determine cooking performance and visual attraction. Therefore, the objective of this study was to develop gluten–free noodles from *Manihot esculenta* Crantz flour using FFD, besides understanding the hydrocolloid–protein interactions.

2.0 Materials and methods

2.1. Materials : Eight months of cassava roots grown from fields in Jaya Gading, Kuantan, Malaysia were used. Commercial cassava flour (Agricore, Thailand), wheat flour (Anchor, Malaysia), sodium chloride (NaCl) (Selangor, Malaysia), XG, and GG (Chemiz (M) Sdn. Bhd., Shah Alam, Malaysia) were purchased locally.

2.2 Noodle formulation : The gluten–free noodle dough formulation contained 1% (w/w) NaCl. Dry ingredients were premixed for 4 min in a commercial noodle maker (Pensonic/ PNM–01, Malaysia), followed by 4 min of distilled water mixing or egg and 1 min of kneading. The dough was rested at 25 °C for 20 min in a zip–lock. Wheat–based noodles were prepared as the control, with a basic formulation comprising wheat flour, 1% (w/w) NaCl, and distilled water.

2.3 Experimental design of noodle formulation : The experimental work was done using a FFD 2^4, being set by Design Expert (Version 7.1.6, 2008, Minneapolis MN, USA). Table 1 shows the design factors and their related values, where the minimum and maximum ranges for each factor are denoted by -1 and +1, respectively. The ranges of independent variables were selected based on the preliminary study.

Table 1. Experimental range of independent variables for the noodle formulation

Independent variables	Range	
(% w/w)	-1	+1
XG	2	8
GG	2	8
Egg	10	30
Whey protein	10	30

2.4 Analytical method: The cooking quality of the noodles was evaluated on optimum cooking time (OCT), CL, CY, and swelling index (SI) according to the American Association of Cereal Chemists Official Methods [11] with slight modification. The 10 g noodle was cooked in 120 mL boiling water until the central opacity of the sample disappeared [9]. For the CL, the combined cooking and rinse water was oven-dried at 105 °C for 24 h, and the dried residue was weighed. CL was determined by dividing the weight of the residue by the sample weight and multiplying by 100. The CY and SI were determined using equation (1) and (2), respectively [12].

$$\mathrm{CY}\left(\frac{\mathrm{g}}{100\mathrm{g}}\right) = \frac{(Cooked\ Noodles\ (g) - Raw\ Noodles\ (g))}{Raw\ noodles\ (g)} \times 100 \quad (1)$$

$$\mathrm{SI}\left(\frac{\mathrm{g\ water}}{\mathrm{g\ dry\ noodles}}\right) = \frac{(Cooked\ noodles(g) - Cooked\ noodles\ after\ drying\ (g))}{Cooked\ noodles\ after\ drying\ (g)} \quad (2)$$

The color of cooked noodles was evaluated using a NH300 portable colorimeter (3NH, China). Colour parameters L*, a*, and b* were recorded.

3.0 Results and Discussion

3.1 Experimental Design of Gluten–free Noodle Formulation: Table 2 summarises the FFD results, illustrating the influence of XG (A), GG (B), whey protein (C), and egg (D) on the cooking and colour attributes of gluten–free cassava–based noodles. The OCT ranged from 1.75 to 20.50 min. Longer OCTs were consistently observed in formulations containing higher whey protein, particularly at 30% w/w (e.g., Runs 6, 7, 8, 10, 11, 12, 13, and 15), where values exceeded 10 min. Formulations with 10% whey protein generally exhibited OCTs below 5 min. This effect is attributed to dense protein networks at high whey protein, which slow down water penetration and delay starch gelatinisation.

CL ranged from 1.57% to 5.65%, with high values typically occurring in high whey protein formulations. High CL values were consistently associated with 30% whey protein, reflecting high leaching due to extended cooking times. The FFD results showed a direct correlation between OCT and CL. This is due to the complex ingredient interactions in the multi-ingredient FFD formulations, where hydrocolloid–protein synergy altered water retention and matrix integrity.

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CY varied widely (57.41–211.60%). The maximum CY (Run 10) occurred in a formulation with 30% whey protein and 8% XG, suggesting that whey protein enhanced water retention through heat-induced gelation, particularly when supported by a strong hydrocolloid network. Conversely, Run 7, with lower XG (2%), showed markedly lower CY, highlighting the importance of an optimal XG and whey protein to maximise water absorption. SI ranged from 1.46 to 4.20. High SI values were observed in formulations containing higher XG and whey protein concentrations (e.g., Runs 8, 10, 12, 13), indicating synergistic effects improved water absorption, retention, and the subsequent expansion of the noodle matrix. These results aligned with previous discussions on CY and CL, reinforcing the critical role of hydrocolloid-protein interactions in controlling water absorption and noodle structure.Noodle appearance, particularly color, is a key determinant of consumer acceptance as bright and uniform tones enhance visual attraction and marketability. Instrumental color measurements using L* (lightness), a* (red–green), and b* (yellow–blue) values provide objective evaluation [13]. In the present study, L* values ranged from 60.09 to 69.11, with lighter noodles generally associated with high whey protein. This effect may be attributed to the swelling of milk proteins and starch granules, which increased surface area and enhanced light reflectance, thereby improving brightness [14]. Similar trends have been reported by Ghaemi et al. (2024), where whey protein incorporation significantly influenced lightness values. Redness (a*) values remained low (0.64–2.84), indicating minimal contribution from red hues. The small magnitude of a* change suggested that browning reactions were well-controlled, minimising any potential negative impact on consumer perception. Yellowness (b*) values ranged from 6.92 to 14.97, with the highest values observed in egg-containing formulations, reflecting the natural carotenoid pigments presented in egg yolk. In addition, higher b* values in certain high-protein formulations may be partially attributed to Maillard browning during processing, which intensified yellow tones.

Table 2. Experimental results for FFD

Run	Formulation (%w/w)				Responses						
	A	B	C	D	OCT (min)	CL (%)	CY(%)	SI	L*	a*	b*
1	8	8	10	30	4.75±1.06	2.32±0.25	118.13±3.31	2.92±0.33	65.61±0.32	1.93±0.59	12.03±1.07
2	2	8	10	10	2.50±0.00	1.69±0.48	88.85±8.89	2.42±0.07	64.99±0.13	1.60±0.27	10.02±0.46
3	2	8	10	30	2.75±0.35	1.70±0.49	89.87±10.75	2.46±0.15	60.09±5.49	1.64±0.41	13.29±0.79
4	8	8	10	10	1.75±0.35	1.57±0.07	99.35±4.32	2.54±0.01	62.57±4.19	1.61±0.58	10.61±0.02
5	2	2	10	10	1.75±0.35	1.64±0.09	85.11±3.50	2.05±0.03	68.80±0.07	1.98±0.71	12.85±1.47
6	2	8	30	10	10.5±0.71	3.74±0.11	137.91±2.58	2.87±0.11	63.65±1.23	2.84±1.97	12.86±2.86
7	2	2	30	10	11.5±0.71	3.65±0.35	57.41±4.07	1.46±0.05	64.11±3.46	1.94±2.50	10.95±4.59
8	8	2	30	30	16.5±0.71	4.17±0.44	184.05±6.40	3.73±0.04	66.46±2.78	1.50±3.07	10.34±4.41
9	8	2	10	30	5.00±0.00	2.17±0.07	126.28±2.08	2.82±0.06	67.91±1.19	0.89±1.05	11.48±2.82
10	8	2	30	10	19.00±0.00	4.52±0.06	211.60±0.11	4.20±0.14	68.16±0.02	0.64±2.01	6.92±3.40
11	2	2	30	30	17.5±0.71	4.31±0.13	144.31±3.83	2.99±0.10	61.99±3.93	1.81±3.18	12.14±3.45
12	8	8	30	10	10.75±1.06	3.76±0.58	167.45±8.92	3.47±0.10	69.11±1.20	1.43±1.83	8.77±2.86
13	8	8	30	30	20.25±1.06	4.95±0.09	192.29±9.33	4.09±0.43	66.07±4.08	1.58±1.79	10.73±1.84
14	8	2	10	10	3.75±0.35	1.92±0.05	116.96±2.09	2.80±0.13	67.60±2.17	1.05±0.39	8.99±0.59
15	2	8	30	30	20.50±0.00	5.65±1.31	160.55±3.82	3.33±0.04	61.34±5.06	1.72±2.18	11.33±4.10
16	2	2	10	30	4.25±0.35	2.14±0.23	103.18±3.16	2.31±0.04	67.07±1.55	1.67±2.12	14.97±6.24

Note: A represents XG, B represents GG, C represents whey protein, D represents egg, OCT represents optimal cooking time, CL represents cooking loss, CY represents cooking yield and SI represents swelling index**3.1.1 Analysis of main factors**

3.1.1.1 Cooking qualities: Figures 1(a–d) present the Pareto chart of the main and interaction effects on the OCT, CL, CY, and SI. The bar heights reflect the magnitude of the factor based on the square root of the F-values. The significance thresholds are indicated by the Bonferroni limit (4.122) and the standard t-value limit (2.306). Effects below these thresholds are not statistically significant at the 95% confidence level.

All factors that exhibited positive effects indicated that increasing concentrations directly correlated with the responses. Whey protein (C) had the most impact on OCT (81.76%), CL (86.06%), and CY (39.95%). When heated, whey denatures into a dense protein network, hence extended cooking time, increased solid leaching (higher CL), and enhanced water retention (higher CY).XG (A) was the most influential factor on SI (34.86%), promoting water absorption and matrix swelling. This differs from the earlier observations where high XG reduced SI, suggesting that ingredient interactions and processing conditions strongly affected hydrocolloid behavior. Egg (D) contributed moderately to OCT (7.36%) and CL (5.42%), attributed to protein coagulation that strengthened the matrix and extended cooking time. Egg is crucial for balancing the structure and minimizing the nutrient loss during cooking. Notably, XG and whey protein were also key contributors to CY and SI, with similar impacts (26.57% and 26.29%, respectively). Whey protein primarily enhanced CY via protein gelation and water entrapment, while XG improved SI through viscosity enhancement and matrix expansion.

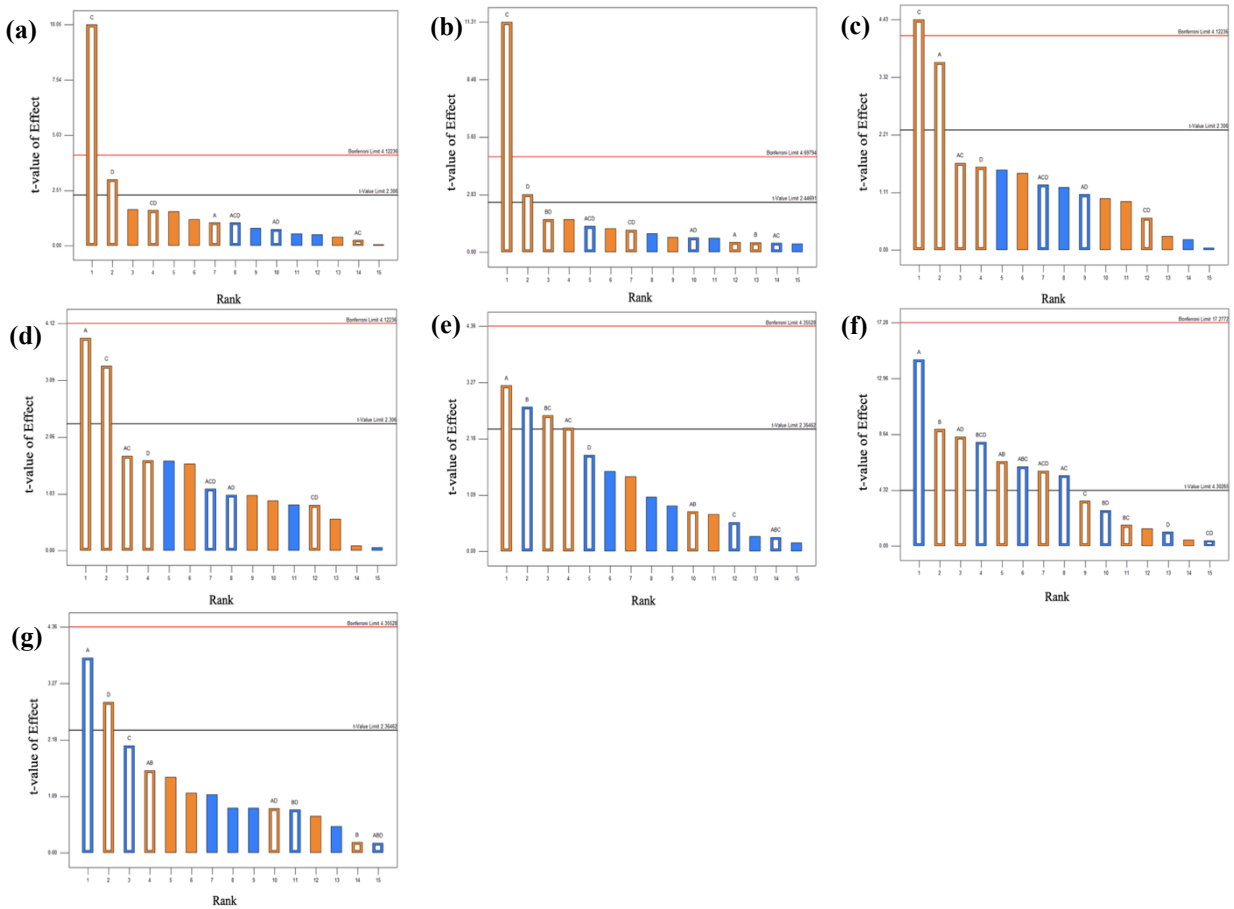

Figure 1 Pareto charts of formulation effects on: **(a)** OCT, **(b)** CL, **(c)** CY, **(d)** SI, **(e)** L*, **(f)** a*, and **(g)** b*

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3.1.1.2 Color profile analysis : Figures 1(e–g) present the Pareto charts of the main and interaction effects on the variables L*, a*, and b*. XG (A) was the most influential factor for noodle L*, contributing 24.4% with a significant positive effect (t > 2.36462 but < Bonferroni limit 4.35528). This is due to its water-binding and uniform starch–gum dispersion, which improved brightness. While GG (B) contributed 18.5% and reduced the noodle lightness due to the increasing structural density and reduced light reflection. Positive contributions from BC (16.4%) and AC (13.5%) suggested that gum–protein interactions promoted smoother and brighter surfaces. For the a* value, XG (A) was the dominant factor, contributing 35%, which exerted a strong negative effect that reduced redness. GG (B) contributed 13.65%, and the AD interaction contributed 12%, which positively affected a*, indicating that GG alone and in combination with egg increased redness, possibly through improved pigment retention and reduced leaching during cooking. BCD interaction showed a negative effect, indicating pigment instability in multi-component systems. Additional interactions, such as AB, AC, and ABC, moderately affected hue, highlighting the complex role of gum–protein interactions in color stability.XG (A) also had the strongest negative effect on the yellowness, b* value, with a 37.33% contribution. This reduction may be attributed to its high water-binding capacity, which diluted the color intensity and reduced the visibility of natural yellow pigments. While egg (D) contributed 22.31% increased yellowness due to its carotenoid and lipid content. These results highlight the XG reduced color intensity and egg enhanced yellowness, emphasizing hydrocolloid–protein balance as a key determinant in noodle color quality.

3.1.2 Interaction effect between factors

3.1.2.1 Cooking qualities: Figures 2(a–l) illustrate the interaction effects of hydrocolloid-protein on cooking qualities. In all cases, increased interaction levels were associated with longer cooking times. Figure 2(a) shows that higher whey protein (30% w/w) significantly prolongs OCT due to the formation of a dense protein matrix that hinders water penetration and delays starch gelatinization. XG further increased OCT through viscosity enhancement, particularly at higher whey protein levels. In figure 2(b), increasing egg concentration also increased OCT due to the formation of heat-induced protein networks that resist water diffusion. The CD interaction (figure 2(c)) shows the highest OCT, confirming the synergistic effect of whey protein and egg in forming a compact matrix.

Figures 2(d–f) show that CL trends closely similar to OCT. Interactions involving whey protein (AC) and egg (AD) resulted in higher CL due to extended cooking times and enhanced leaching from the dense protein networks. The highest CL is observed in the CD interaction (figure 2(f)), where the presence of two proteins amplified matrix compactness and leaching. Figures 2(g–i) display interaction effects on CY. High whey protein (figure 2(g) and (i)) enhanced CY due to the formation of heat-stable, hydrophilic networks that retained water. Figures 2h-i show that increasing AD and CD interactions further raise CY, suggesting enhanced gel and protein matrices that improve water retention.Figures 2(j-l) illustrate SI responses. All interactions result in higher SI, indicating improved water uptake and swelling. AC promotes hydrophilic network interaction, AD enhances gel structure, and CD reinforces protein interactions, all contribute to a more absorbent matrix. Synergistic effects in multicomponent systems within the FFD highlighted the role of ingredient interactions in enhancing swelling behavior.

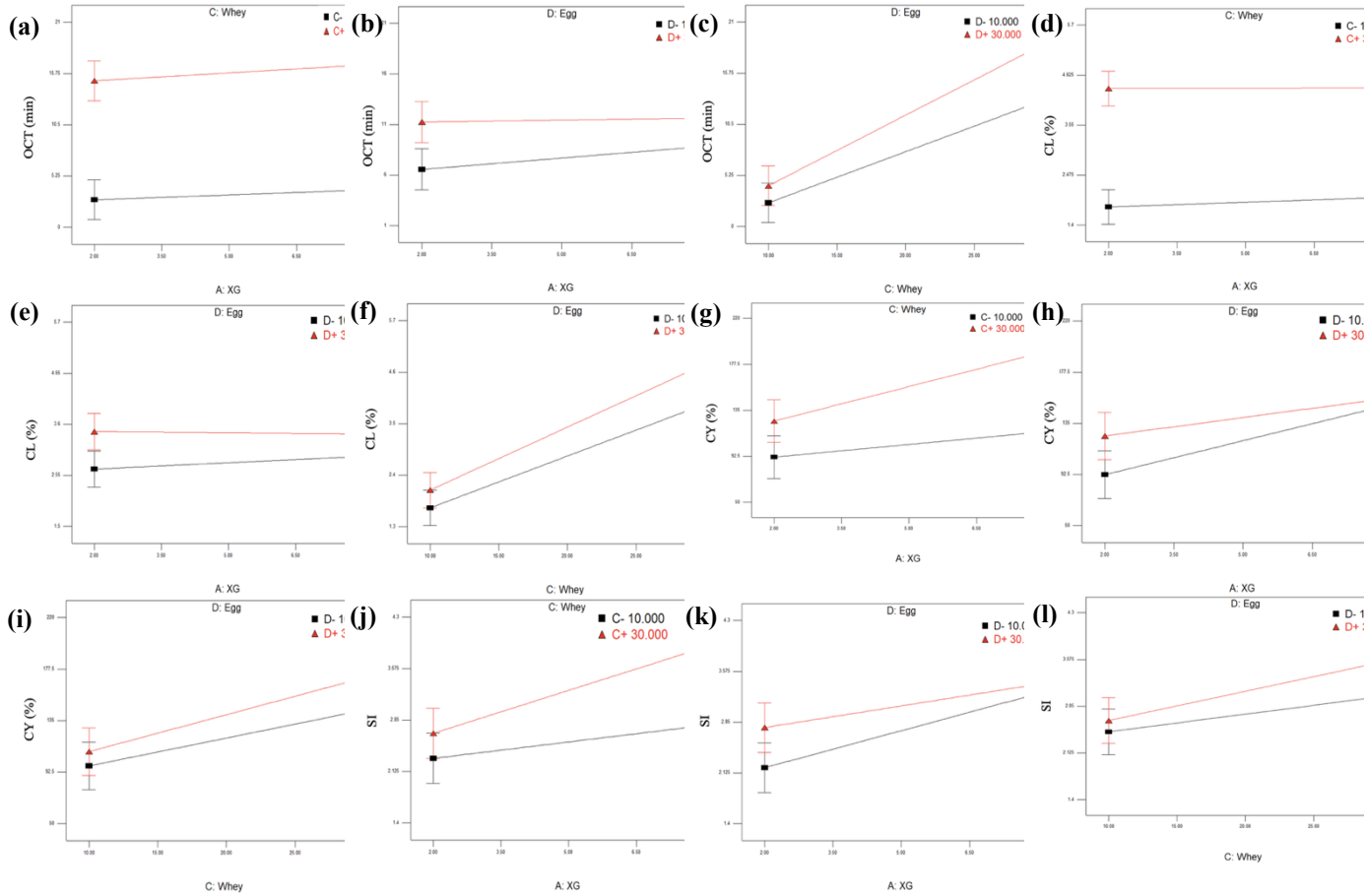

Figure 2 Interaction effect between factors on: **(a)** OCT – AC at 5% w/w B and 20% w/w D, **(b)** OCT – AD at 5% w/w B and 20% w/w C, **(c)** OCT – CD at 5% w/w A and 5% w/w, **(d)** CL – AC at 5% w/w B and 20% w/w D, **(e)** CL – AD at 5% w/w B and 20% w/w C **(f)** CL – CD at 5% w/w A and 5% w/w B, **(g)** CY – AC at 5% w/w B and 20% w/w D, **(h)** CY – AD at 5% w/w B and 20% w/w C, **(i)** – CD at 5% w/w A and 5% w/w B, **(j)** SI – AC at 5% B and 20% w/w D, **(k)** SI – AD at 5% w/w B and 20% w/w C, and **(l)** SI – CD at 5% w/w A and 5% w/w B**3.1.2.2 Color profile analysis**

Figures 3(a–l) show the interaction effects of hydrocolloid-protein on noodle color profile. Increasing XG consistently improved L*. The XG enhanced water binding and formed smooth, hydrated gel surfaces that promoted light scattering. On the other hand, at low GG (2%), the L* values were high, indicating that minimal GG favored brightness (figure 3(a)). A similar trend was reported by Ghaemi et al. [15], who observed that increased XG levels elevated the L* index of cake. In the XG–whey interaction, lightness increased with XG, particularly at high whey levels (figure 3(b)). Similar findings were reported by Prabhasankar et al. [16], who observed that increased whey protein from 5–10% significantly increased L*. For GG–whey, lightness declined sharply with high GG and low whey but improved at high whey (figure 3(c)). On the other hand, XG yielded more consistent improvements in noodle brightness across protein levels, whereas GG showed less stable effects.

Figures 3(d–i) show the interaction effects of XG–GG (AB), XG–whey protein (AC), XG–egg (AD), GG-whey protein (BC), GG-egg (BD), and whey protein-egg (CD) on noodle a* values. In figure 3(d), a* decreased with increasing XG regardless of GG level, indicating pigment dilution and increased translucency. This aligns with high L* values at high XG (figure 3(a)), where XG enhanced water binding and brightened noodles while hiding the red tones. In

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Figure 4e, redness was high at high whey protein (30%) but declined sharply with rising XG. This indicates that both XG and whey protein reduced redness, where the protein denaturation amplified pigment destabilization. Similarly, Ghaemi et al. [15] reported that the addition of XG to whey protein formulations reduced redness, confirming the role of XG in diminishing a* values. Figure 3(f) shows that egg counteracted XG's effect: at low egg (10%) and high XG, it lowered a*, whereas at high egg (30%), carotenoids from egg maintained the redness.

A different trend was observed in figures 3(g–i), where a* increased. In figure 3(g), GG and whey protein slightly increased a*, reflecting improved pigment retention, though this contrasted with the XG–whey protein interaction, where XG reduced a*. Similar findings were reported by Marti et al. [17], who observed that whey protein in rice-based pasta significantly increased a* due to non-enzymatic browning. In figure 3(h), egg consistently increased a*, indicating yolk carotenoids as the main source of redness; GG amplified the a* at low egg levels but had little impact at high concentrations. A similar pattern appeared in the whey protein–egg interaction (figure 3(i)), where egg enhanced a* at low levels.

Figures 3(j–l) show the interaction effects of XG–GG (AB), XG–egg (AD), and GG–egg (BD) on noodle yellowness, b*. Figure 3(j), increased XG reduced b* across both GG levels, indicating pigment dilution through water binding and matrix translucency, which covered natural yellow tones. Figure 3(k) shows the XG–egg interaction, at low egg (10%), XG sharply decreased b*, showing that gum-induced dilution overpowered limited carotenoid content. On the other hand, at high egg (30%), b* remained higher, confirming that egg carotenoids counteracted XG's dilution, though overall yellowness was still moderated by gum addition. Consistently, Ghaemi et al. [15] reported that XG with whey protein significantly decreased the b*. In figure 3(l), egg consistently increased b* at both low and high GG levels, reflecting its strong carotenoid contribution. Unlike XG, GG tended to enhance b*, likely due to its viscous, less translucent matrix that trapped pigments and intensified visible yellowness. Overall, XG reduced b* by dispersing and masking pigments through strong hydration and translucency, whereas GG enhanced b* by retaining carotenoids within a denser matrix. This highlights the contrasting roles of hydrocolloids, with XG shifting color toward brightness (higher L*) and GG amplifying pigment expression (higher b*).

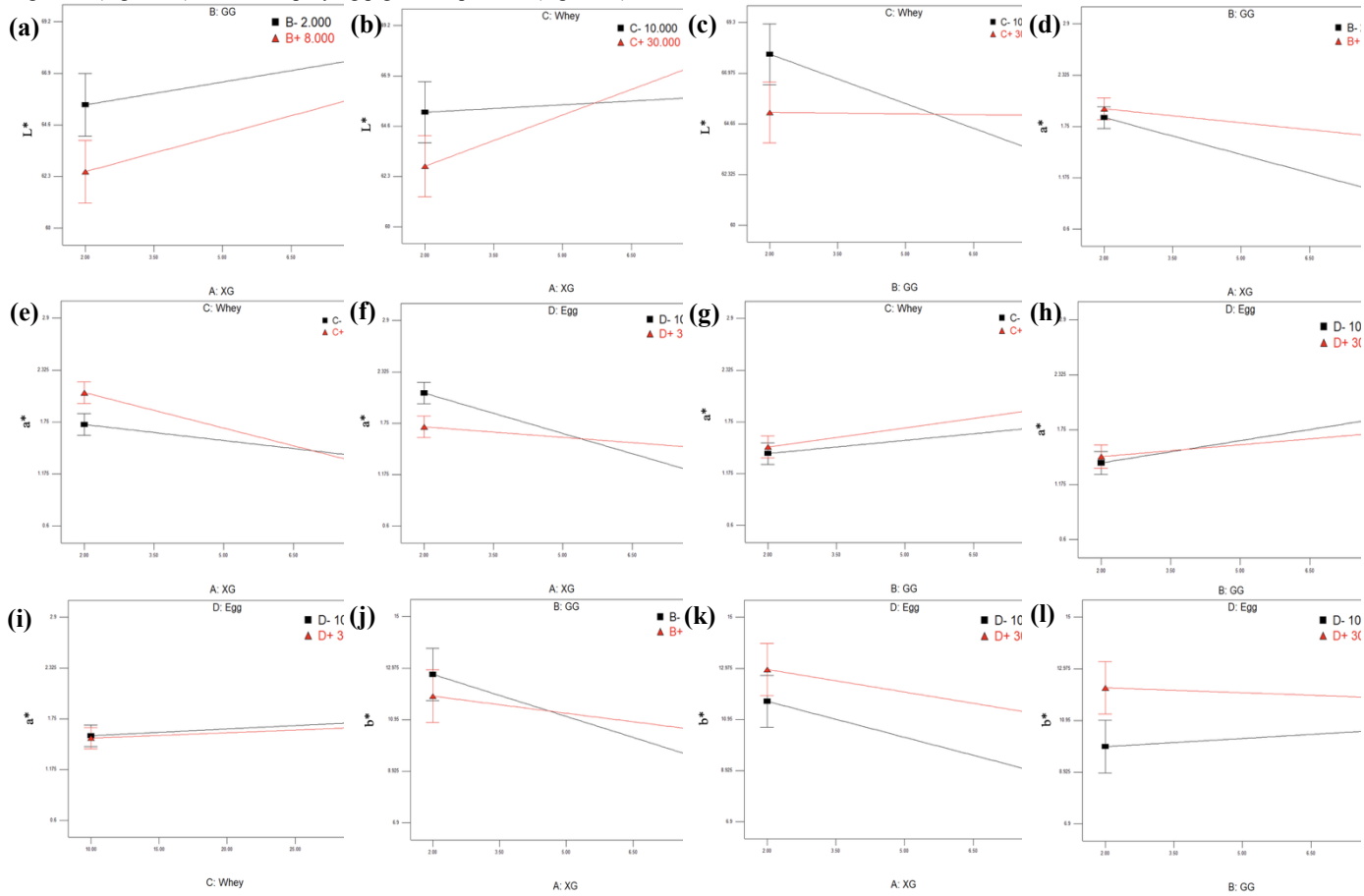

Figure 3 Interaction effect between factors on noodle: **(a)** L* – AB at 20% w/w C and 20% w/w D, **(b)** L* – AC at 5% w/w B and 20% w/w D, **(c)** L* – BC at 5% w/w A and 20% w/w D, **(d)** a* – AB at 20% w/w C and 20% w/w D, **(e)** a* – AC at 5% w/w B and 20% w/w D, **(f)** a* – AD at 5% w/w B and 20% w/w C, **(g)** a* – BC at 5% w/w A and 20% w/w D, **(h)** a* – BD at 5% w/w A and 20% w/w C, **(i)** a* – CD at 5% w/w A and 5% w/w B, **(j)** b* – AB at 20% w/w C and 20% w/w D, **(k)** b* – AD at 5% w/w B and 20% w/w C, and **(l)** b* – BD at 5% w/w A and 20% w/w C**4.0 Conclusion**

This study demonstrated the quality of *Manihot esculenta Crantz* gluten–free noodles on the hydrocolloid–protein interactions through FFD. Whey protein had the most impact on OCT, CL, and CY. XG was the most dominant over SI. The interaction of the components significantly prolongs the OCT, increases CY, CL, and SI, especially for whey–egg interaction. While for the color profile, XG contributed the most effect to L*. The interaction of XG and the proteins improved the L*, compared to GG-whey. But XG discovered that the most negative effect on a* and b*, which reduced the color intensity. Hence, interaction XG and the proteins reduced a* and b*. While interaction between GG and the proteins enhanced a* and b*. This highlights the roles of different types of hydrocolloids. Overall, the *Manihot esculenta* Crantz gluten–free noodles quality was acceptable in terms of the cooking quality and color. These findings provide a predictive framework for high-quality cassava-based GF noodles, supporting food security and consumer health.

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References

1. Borku AW, Tora TT, Masha M. Cassava in focus: A comprehensive literature review, its production, processing landscape, and multi-dimensional benefits to society. Food Chemistry Advances. Elsevier Ltd; 2025. https://doi.org/10.1016/j.focha.2025.100945
2. Huh HJ, Shin WK,, Kim Y. Textural and cooking qualities of noodles made with soy flour and hydroxypropyl methylcellulose. Int Food Res J. 2019;26.
3. Fukuzawa S, Ogawa T, Nakagawa K, Adachi S. Moisture profiles of wheat noodles containing hydroxypropylated tapioca starch. Int J Food Sci Technol. Blackwell Publishing Ltd; 2016;51:1516–22. https://doi.org/10.1111/ijfs.13108
4. Pokharel A, Jaidka RK, Sruthi NU, Bhattarai RR. Effects of Incorporation of Porous Tapioca Starch on the Quality of White Salted (Udon) Noodles. Foods. MDPI; 2023;12. https://doi.org/10.3390/foods12081662
5. Daud NFS, Said FM, Adam F. Assessing the physicochemical and functional properties of cassava and wheat flour. AIP Conf Proc. 2026;3380:060008. https://doi.org/10.1063/5.0313304
6. Clapassón P, Merino NB, Campderrós ME, Pirán Arce MF, Rinaldoni AN. Assessment of brea gum as an additive in the development of a gluten-free bread. Journal of Food Measurement and Characterization. Springer; 2020;14:1665–70. https://doi.org/10.1007/s11694-020-00414-3
7. Zoghi A, Mirmahdi RS, Mohammadi M. The role of hydrocolloids in the development of gluten-free cereal-based products for coeliac patients: a review. Int J Food Sci Technol. Blackwell Publishing Ltd; 2021;56:3138–47. https://doi.org/10.1111/ijfs.14887
8. Dahal A, Sadiq MB, Anal AK. Improvement of quality of corn and proso millet-based gluten-free noodles with the application of hydrocolloids. J Food Process Preserv. Blackwell Publishing Ltd; 2021;45:15165. https://doi.org/10.1111/jfpp.15165
9. Sutheeves S, Chai-Uea P, Thirathumthavorn D. Impact of Hhydrocolloids on the Physico-chemical and Sensory Properties of Gluten-free Instant Noodles from Rice Flour and Mung Bean Starch. Ital J Food Sci. 2020;32:2020–439. https://doi.org/10.14674/IJFS-1551
10. Kaur A, Shevkani K, Singh N, Sharma P, Kaur S. Effect of guar gum and xanthan gum on pasting and noodle-making properties of potato, corn and mung bean starches. J Food Sci Technol. Springer India; 2015;52:8113–21. https://doi.org/10.1007/s13197-015-1954-5
11. AACC. Approved Methods of the American Association of Cereal Chemists. 2000.
12. Gasparre N, Rosell CM. Role of hydrocolloids in gluten free noodles made with tiger nut flour as non-conventional powder. Food Hydrocoll. Elsevier B.V.; 2019;97. https://doi.org/10.1016/j.foodhyd.2019.105194
13. Li M, Dhital S, Wei Y. Multilevel Structure of Wheat Starch and Its Relationship to Noodle Eating Qualities. Compr Rev Food Sci Food Saf. Blackwell Publishing Inc.; 2017;16:1042–55. https://doi.org/10.1111/1541-4337.12272
14. Kumar M. Technology of Gluten-free Pasta from a Composite Dairy-millet Base. M.Tech. (Dairy Technology) Division of Dairy Technology. Deemed University; 2018.
15. Ghaemi P, Arabshahi-Delouee S, Aalami M, Hosseini Ghaboos SH. The Effect of Whey Protein Concentrate, Soy Protein Isolate, and Xanthan Gum on Textural and Rheological Characteristics of Gluten-Free Batter and Cake. J Food Process Preserv. Wiley-Hindawi; 2024;2024. https://doi.org/10.1155/2024/5571107
16. Prabhasankar P, Rajiv J, Indrani D, Rao GV. Influence of whey protein concentrate, additives, their combinations on the quality and microstructure of vermicelli made from Indian T. Durum wheat variety. J Food Eng. 2007;80:1239–45. https://doi.org/10.1016/j.jfoodeng.2006.09.013
17. Marti A, Barbiroli A, Marengo M, Fongaro L, Iametti S, Pagani MA. Structuring and texturing gluten-free pasta: Egg albumen or whey proteins? European Food Research and Technology. 2014;238:217–24. https://doi.org/10.1007/s00217-013-2097-4