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Turmeric powder enhances the chemical, microbiological, sensorial, and shelf-life quality of bun-bread

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Abstract

The impacts of the addition of turmeric powder (0, 0.100, 0.133, and 0.167% of flour) in the chemical, microbiological, sensorial, and shelf-life quality of bun-bread were examined to obtain a stable bread with acceptable chemical and sensorial properties. The chemical composition, microbiological, and sensory analysis of the supplemented bun-bread were measured. Results showed that the lowest amount of turmeric powder (0.100%) revealed the best value of sensorial scores, in terms of its colour and nature of crust, crumb colour, texture, aroma, and taste, with near acceptable scores with the control one after baking. The results revealed that 0.100% of turmeric powder can be involved in bun-bread preparation without modifying dough processing and bun-bread overall features, where this ratio approximates chemical compositions, microbiological stability, and shelf-life of bun-bread. Among the explored samples, bun-bread with 0.100% of turmeric powder could be utilized industrially with acceptable properties and shelf-life stability. Therefore, turmeric powder can be deemed as a prospective health-boosting functional component. Currently, we are commercially evaluating the bun-bread with turmeric powder and wholly analysing its antioxidant, bioactive components, and functional profiles.

1. Introduction

The association between health and food had an expanding influence on food modernization due to the publicity of the conception of techno-functional foods. The way of employing nutritious information in foodstuffs is to enhance the health of buyer types (Peressini and Sensidoni, 2009). Increasing functional bakery-based stuff, such as bun-bread, is demanded to innovate an outcome with acceptable physicochemical, microbiological, shelf life, and sensorial characteristics (Siro *et al*., 2008). Meanwhile, bread is an essential solid food, which is mainly manufactured from wheat flour, salt, and yeast, in addition to its wide consumption worldwide (Fan *et al*., 2007). On the other hand, consumers, desire to eat healthier foods to avert and/or mitigate non-infectious diseases (Hathorn *et al*., 2008). Thus, the fortification of bread with natural bioactive substances at the industrial scale was recently spotlighted by the scientific community (Balestra *et al*., 2011; Lim *et al*., 2011; Amoah, 2020).

Herbs and spices are valuable parts among the involved ingredients in the formulation of bread (Ibrahim *et al*., 2015). These ingredients have been utilized several years ago to improve the colour, flavour, and aroma of foodstuffs. Most importantly, such substances have potent preservatives, antioxidative, antimicrobials and other techno-functional effects (Das *et al*., 2013). For example, the addition of *Auricularia auricular* polysaccharides in bread noticeably boosted the antioxidant activity of bread (Fan *et al*., 2007). The amalgamation of barley also heightened the sensory scores, where the high bioactive substances the high sensory attributes (Holtekjølen *et al*., 2008). Lin *et al*., (2009) noticed that buckwheat might be integrated with wheat bread to enhance the overall quality of bread.

Turmeric (*Curcuma longa* L.) is one of the key common spices having natural phytoconstituents with several health-promising effects i.e., antioxidant, anti-protozoal, anti-tumour, anti-venom, and anti-inflammatory (Yousefsani *et al.,* 2021). The key biologically effective substances of turmeric are curcuminoids that involve curcumin, bis-desmethoxycurcumin, and demethoxy curcumin (Soleimani *et al*., 2018). Curcumin is a yellow-coloured phenolic pigment and is an efficient antioxidant that can mitigate different free radicals. Turmeric has been,

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therefore, utilized in different foodstuffs, such as bread (Lim *et al*., 2011), butter cakes (Lean and Mohamed, 1999), milk (Park *et al*., 2019), parboiled rice (Palamanit *et al*., 2019), street-vended drinks (Idowu-Adebayo *et al*., 2021), jam (Rozan, 2017) and lentil soup (Rozan *et al.,* 2018) as an antioxidative and antimycotic agent. Fortifying the bread with turmeric is still demanding.

In this study, the effects of some amounts of turmeric powder (1.5, 2, and 2.5 g / 1.5 kg flour) in the approximate chemical composition, microbiological, sensorial (hedonic test), and shelf-life quality of bun-bread were evaluated. The microbiological and shelf-life qualities of the stored bun-bread at 25 and 35°C for 7 days were also evaluated.

2. Materials and methods

2.1 Raw ingredients and chemicals

The turmeric powder was purchased from a local company (Alexandria, Egypt) with about 99% purity as specified by the supplier. The physical and chemical specifications of turmeric powder were supplemented in Table 1. The European wheat flour (Abo-Dongle - Borg-Al Arab- Alexandria, Egypt) was also used in the current study, and its chemical characteristics were also tabulated in Table 2. All other ingredients utilized in the formulation of each sample were acquired from a regional bakery company (Alexandria, Egypt). All the chemicals and kits utilized were of analytical reagent grade. Distilled water was also used in our current study.

Table 1. The physical and chemical specification of turmeric powder.

Purity of RM	99%
Deal/live insect	Absent in practical terms
Light metal	Less than 0.0002%
Practical size (95% passing thru)	30 BSS (0.5 mm)
Moisture	10%
Total ash	8.0%
Acid insoluble ash	2.0%
Curcumin	1.5%

Table 2. The chemical characteristics of European wheat flour.

Characteristics	Specification
Moisture	12-14%
Ash	0.45-0.58%
Total proteins (N×5.7)	13.0%
Dry glutens	11.0%
Aflatoxin	Less than 20 ppb

2.2 Dough and bun-bread formulation

The sample of wheat flour was mixed with turmeric powder at the 0, 1.5, 2, and 2.5 g/1.5 kg flour levels. White wheat bread prepared without turmeric powder (0%) was utilized as a control. The ratios of turmeric powder were selected based on earlier sensorial trials achieved in our laboratory to improve stuff to fit the customer's satisfaction (data not shown). The investigational doughs were acquired with a sponge formulated with 1500 g of flour, 950 g of water, 150 g of sugar, 27 g of baker's yeast, 45 g of vegetable oils, 27 g of salt, 97 g of bread improver, 7.5 g of emulsifier, and 4.5 g of preservative (Table 3). The turmeric powder was mixed with the wheat flour using the previously mentioned levels. The improver was invented wheat flour, ascorbic acid, α-amylase, and malt flour. The procedure considerations and the quantity of the material were selected based on a current and well-specified recipe observed by an international bakery company. Dough and bun-bread were cooked using a sponge-dough assay. Firstly, a bun was made by blending the elements in a household mixer (Kenwood Chef Major KM 005, Treviso, Italy) for 8 mins at speed 1, the resultant dough was put onto a proofer at a temperature of 25°C for 3 hrs before inserting it into bread dough. After relaxing, the bun was blended with dough for a sum of 11 min *via* a similar blender in the upcoming g arrangement: flour, improver, turmeric powder, and water. All the components were blended for 2 min at rate 1. Then, the suspended yeast in H_2O was inserted and blended at a similar velocity for 2 min, and then salt was combined. Lastly, the whole blend was combined for 7 mins at a rate of 1. After that, the dough was maintained for 10 mins at room temperature (22±1°C), and the studies on the acquired doughs were performed in triplicates. To create the end product, after 20 min of relaxing at RT, the dough was formed to about 1 cm width and then chop by a stainless-steel quadrilateral mould (15×6 cm). Approximately fifteen slices of dough (125 g) were acquired from each batch. Subsequently, the dough was fermented in a proofer for 1 hr at 32°C and 70% of relative humidity. The fermented dough was cooked in a convection oven (FC61, ANGELO PO-GrandiCucine S.p.A, Carpi, Italy) at 210°C for 23 min. After baking, bun samples were chilled for about 2 hrs at

Table 3. The ingredients of the bun-bread formulas with and without three ratios of turmeric addition.

Ingredients (g)	Samples			
	Control	T1	T2	T3
Flour	1500	1500	1500	1500
Sugar	150	150	150	150
Yeast	27	27	27	27
Vegetable oil	45	45	45	45
Salt	27	27	27	27
Bread improver	97	97	97	97
Emulsifiers	7.5	7.5	7.5	7.5
Preservative	4.5	4.5	4.5	4.5
Turmeric	0.0	1.5	2.0	2.5
Water	950	950	950	950

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RT and were presented to instrumental and sensorial investigations.

2.3 Analysis of bun-bread

2.3.1 Determination of the approximate chemical composition

The standard methods (AACC 44-19.01 and 44-16.01, 2001) were used to determine the moisture content of each sample. The ash matter was also done via the assay of the AACC international assay (08-01.01 and 08-03.01, 2001). Meanwhile, the total protein was determined using the standard method of Kjeldahl. The fat content (%) of each sample was assessed according to AACC (2001). Total dietary fibre matter was measured using the AOAC assay (AOAC, 2001), using termyl (amylolytic), protease (proteolytic) and amyloglucosidase (amylolytic) as the active enzymes. All kits used were of analytical grade. Total available carbohydrates were expressed by the difference.

2.3.2 Microbiological analysis

Total viable bacteria count (TBC), coliform group, *Escherichia coli, Staphylococcus aureus, Bacillus cereus, Salmonella*, and yeast and moulds were assessed occasionally in each sample during the storage periods (0 and 7 days) at 25 and 35°C using the method of Debonne *et al*. (2018). Under sterile conditions, the prepared samples serial dilutions by weighting 10 g of each sample with 90 mL of sterilized saline solution (NaCl 8.5 g/L) were inoculated (1 mL of each dilution) on plate count agar, potato dextrose agar, tryptone bile x-glucuronide medium. All dishes were hatched at 37°C for 48 hrs for bacterial count, while at 28°C for 3-5 days for yeast and mould (AACC-42-50-2, 2001W). The same incubation conditions with TBC were used for *E. coli, S. aureus, B. cereus,* and *Salmonella*. The shelf-life testing of the bread with and without three ratios of turmeric addition, after storing for one week was performed by observing the fungal growth, undesirable changes in taste/aroma, and undesirable changes in texture by manually counting and observing the microbial growth and fungal existence on the bread. Meanwhile, we also counted the colonies by the traditional method by count each colony and combine each.

2.3.3 Texture profile analysis of bread slices

To achieve the image analysis, the end-products were cut into ordinary slices of 20 mm width. The internal portion of the pieces was measured for crumb grain elements. The pictures were taken using an icon procurement system comparable to that established by Mendoza and Aguilera (2004). Crumb morphological features were also evaluated.

2.3.4 Sensory evaluation

The sensory assessment was performed on bun-bread samples with various levels of turmeric powder after 2 hrs of baking. The portion of each bread type (2 cm thick), teased with a number, was aided to each panellist under regular (daylight) lighting. The organoleptic properties were performed in a consistent practice room in morning meetings (11:00-13:00 hrs) by appropriately 28 well-skilled panellists using the assay of Khalifa *et al*. (2015). Mineral water was utilized by the panellists to rinse the mouth among samples. To determine the acceptability of turmeric-enriched bread samples with scores ranging from 0-100 of softness, slicing, symmetry of form, colour and nature of crust, crumb colour, texture, aroma, taste, and total acceptability (Lin *et al*., 2009).

2.4 Statistical analyses

Analysis of variance and least significant difference at $p \leq 0.05$ were directed. The statistical analyses of data were achieved using SPSS, ver. 24, where Duncan's test was used to check the significance, $p<0.05$ (Khalifa *et al*., 2015).

3. Results and discussion

3.1 Approximate chemical composition of bun-bread fortified with turmeric

Proximate compositions of turmeric powder and wheat flour are displayed in Tables 1 and 2. The turmeric powder was featured by its high purity, low moisture content (10%), acceptable ash content (8%) content, and suitable particle size. Meanwhile, the wheat flour had moisture, ash, proteins, and dry glutens of 12-14, 0.45-0.58, 13.0, and 11.0%, respectively, with low aflatoxins content. The ash matter in turmeric powder was superior to that of wheat flour, as earlier informed by Kang (2007) and Lim *et al*. Park (2011) that fresh turmeric enclosed comparatively high amounts of minerals (K, P, and Ca). Alternatively, the adjacent chemical components of bun-bread with and without turmeric powder were measured, and data was tabularized in Table 4. Slightly, adjoining turmeric powder decreased the moisture content of the bun-bread with a value of 36.17 and 36.14 for the control and 2.5% turmeric fortified bun-bread samples, respectively. Inversely, crude protein, ash, and fat were all increased after fortifying the bun-bread with turmeric powder, where the bun-bread sample with 2.5% of turmeric powder peaked. Likewise, available carbohydrates and crude fibre were slightly increased after adding turmeric powder. Adding different ratios of potato peels altered the chemical composition of the cupcake, matching our results well (Khalifa *et al*., 2015). Wheat bran and germ also altered the chemical composition of high-fibre toast bread (Sidhu *et al.,* 1999). Psyllium husk addition also changed the chemical composition of high-fibre wheat pan bread and buns (Abdullah *et al.,* 2021). It also was found that subjoining of bun with orange peel powder accompanied the enlarging of moisture, protein, ash, fibre, fat, and carbohydrate. This rise in moisture, protein ash, fibre, and fat may be due to the comparative rise of such nutrients in orange peel powder. Protein contents subsidize the capability of dough to rise and preserve its form as it baked, and thus, could rise the integration time. Ash content is a sign of the minerals level extension of foodstuffs. This proposes that orange peels can aid in enhancing the mineral content of wheat bread (Raj, 2014). Control buns had slightly lower ash, fat, protein, and dietary fibre content than the buns augmented with either coriander or curry leaves, due to the addition of mineral-rich cilantro and curry leaves (Sudha *et al.,* 2014). Dachana *et al.* (2010) supplemented wheat flour with dried moringa leaves with 1a 0 % dose in cookie formulation and noted a significant rise in protein, dietary fibre, and iron content. Borneo *et al.* (2008) displayed that pasta made with either amaranth or spinach leaves had a comparable chemical constitution, i.e., elevated content of protein and iron being subsidized by the amaranth and/or spinach leaves.

Table 4. The chemical characteristics of the bun-bread with and without three ratios of turmeric addition.

Parameters	Samples				LSD $p<0.05$
	Control	T1	T2	T3	
Moisture (%)	36.17	36.15	36.14	36.14	0.01
Crude protein (%)	14.85	14.96	15.00	15.04	0.08
Ash (%)	2.42	2.55	2.60	2.64	0.05
Fat (%)	2.54	2.84	2.88	2.89	0.05
Available carbohydrates	44.78	44.79	44.80	44.81	0.07
Crude fiber (%)	0.73	0.74	0.75	0.75	0.01

3.2 Microbiological and shelf-life evaluation of bun-bread fortified with turmeric

The microbiological attributes such as TBC, Coliform*, E. coli, S. aureus, B. cereus, Salmonella*, and yeast and mould of the different bun-bread substituted with turmeric powder during storage at 25 and 35°C for zero and seven days were observed, data was tabularized in Table 5. The TBC and yeast and mould decreased as storing time was prolonged significantly ($p<0.05$). Meanwhile, the addition of turmeric powder decreased both TPC and yeast and mould especially during storage at 35°C compared with the control one. For example, the values of TPC and yeast and mould of T3 were about 1.6×10^2 and 40 cells after storage at 35°C for 7 days. The counts of *Salmonella* were absent in all samples before and after storage at different temperatures. In addition, Coliform and *E. coli* were also below 10 cells, and *B. cereus* was below 100 cells in all samples before and after storage at different temperatures. The count of *S. aureus* was also below 10^2max, where turmeric powder decreased it after storage with values below 100 cells of T2 and T3. Our results are well-matched with previous reports. For example, the repressing influence of turmeric was previously considered on the *Rhizopus stolonifer* growing on bread, which showed a good inhibition ratio against *R. stolonifer* during the storage of bread (Muhammad *et al.,* 2014). The annatto natural dye also declined the level of moulds and yeasts with almost no growth found compared with the control bread (Habibi *et al.,* 2018). In addition, turmeric was effectual versus mould growth in butter cakes (Lean *et al*., 1999). The shelf-life testing, including fungal growth, and undesirable changes in taste, aroma, and texture, of the bun-bread with and without three ratios of turmeric addition, after storing for one week was tabulated in Table 6. It was found that all samples have undesirable changes before storage at 25 and 35°C. Most importantly, all bun-breads showed undesirable changes in taste, aroma, and texture, as well as fungal growth after storing at 25 and 35°C for 7 days, but the addition of turmeric powder prevented the appearance of such changes. For instance, the addition of 1.5, 2, and 2.5 g of turmeric powder prevented the fungal growth of bun-bread samples after storage at 25°C for 7 days, mostly due to the antifungal activity of turmeric powder (Muhammad *et al*., 2014). Interestingly, 2.5 g of turmeric powder prohibited the undesirable changes in taste, aroma, and texture of bun-bread samples after storage at 25°C for 7 days, showing the stability and prolonging effects of turmeric powder which led to enhancing the shelf-life of bun-bread. In this context, ingredients with high polyphenol content enhance the shelf-life of bread (Amoah *et al*., 2019). Previous outcomes showed that curcumin microcapsules had protection impacts on food when its level was above 0.035%, even if it was simmered. Curcumin microcapsules, thus, could present a greater worth for protective food, specifically during thermal processing (Wang *et al*., 2012). It was also suggested that adding green tea maintained the baking quality of pan bread and shelf-life *via* enhancing its antioxidant effects and reducing the manufacture of peroxide through storing (Ning *et al*., 2017).

3.3 The sensorial and morphological evaluation of bun-bread fortified with turmeric powder

Findings of sensory scores indicated that the addition of turmeric powder in the bun-bread formulation would impede completely on the bun-bread appropriateness

Table 5. The microbiology examination of bun-bread with and without three ratios of turmeric addition, after storing for one week.

Parameters (CFU/g)	Control				T1				T2				T3				LSD p<0.05
	25°C		35°C		25°C		35°C		25°C		35°C		25°C		35°C		
	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7	
TPC	10^3	2.2×10^2	10^3	2.3×10^2	10^3	1.3×10^2	10^3	1.6×10^2	10^3	1.3×10^2	10^3	1.6×10^2	10^3	1.3×10^2	10^3	1.6×10^2	3.8
Coliform	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	--
E. coli	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	--
S. aureus	10^2 max	<100	10^2 max	<100	10^2 max	<100	10^2 max	<100	10^2 max	<100	10^2 max	<100	10^2 max	<100	10^2 max	<100	--
B. cereus	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	--
Yeast and mould	2×10^3	30	2×10^3	60	2×10^3	<10	2×10^3	50	2×10^3	<10	2×10^3	50	2×10^3	<10	2×10^3	40	2.9
Salmonella	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

Remarks:<10 = No colony observed (Applicable to TPC, Coliform, *E. coli* and yeast and mould), <100 = No Colony observed (Applicable to *S. aureus*, *B. cereus* in food sample), --: Absent.

Table 6. The shelf-life testing of the bun-bread with and without three ratios of turmeric addition, after storing for 7 days.

Parameters (CFU/g)	Control				T1				T2				T3			
	25°C		35°C		25°C		35°C		25°C		35°C		25°C		35°C	
	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7	Day 0	Day 7
Fungal growth	-Ve	+Ve	-Ve	+Ve	-Ve	-Ve	-Ve	+Ve	-Ve	-Ve	-Ve	+Ve	-Ve	-Ve	-Ve	+Ve
Undesirable changes in taste/	-Ve	+Ve	-Ve	+Ve	-Ve	+Ve	-Ve	+Ve	-Ve	+Ve	-Ve	+Ve	-Ve	-Ve	-Ve	+Ve
Undesirable changes in texture	-Ve	+Ve	-Ve	+Ve	-Ve	+Ve	-Ve	+Ve	-Ve	+Ve	-Ve	+Ve	-Ve	-Ve	-Ve	+Ve

-ve: no undesirable observation, +ve: there is an undesirable observation.

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(Figure 1). The bun sample with the bottom quantity of turmeric powder (1.5 g) revealed the greatest value of "total acceptability" with a value of 80.8. The samples established with 2.5 g of turmeric followed the least appropriate displaying an acceptability value of 70.4, which was followed by the control bun-bread with a total acceptability value of 75.1. Inversely, T3 with 2.5 g of turmeric powder showed the best softness, slicing, and symmetry of form, representing the effects of turmeric powder on the inner texture of bun-bread. Meanwhile, T1 with 1.5 g of turmeric powder showed the highest colour and nature of crust, crumb colour, texture, aroma, and taste with values of 12.5, 12.5, 8, 12, and 12, respectively, showing similarity and even preferability with the control one. These results agreed with that achieved by Shalini and Devi (2005) who noticed that bread with 10% of ginger. To deliver a more complete understanding of the bun-bread texture, digital snaps were presented of bun-bread samples with various doses of turmeric powder (Figure 2). The crust, heel, and crumb of T1 were almost the same as the control bun-bread, representing the desired effects of low values of turmeric powder on the morphology characteristics of bun-bread. Meanwhile, the morphology characteristics of T3 were not acceptable compared with the control one. Overall, it was noted that crust, heel, and crumb quality were insignificantly influenced by the low dose of turmeric powder, whereas the high concentrations of turmeric negatively influenced these parameters. The crust's colour was manipulated not just by several ginger powder levels utilized, but mainly by Maillard reaction interpretation (Michalska *et al.,* 2008) because of the cooking process. As a substitute pertaining to the colour results of bun-bread crumb, the acquired data for each factor differed significantly and proportionately with the doses of turmeric powder combined. This implies that the crumb soiled on a darker colour, leaning to brown and presuming a more vibrant colour matched with the control bun-bread. Regarding previous results, bread with 3% of ginger powder demonstrated the highest sensorial acceptability compared with the control bread (Balestra *et al*., 2011). A 4% replacement of wheat flour with turmeric powder also revealed satisfactory sensory results which were like the wheat-based bread sample (Lim *et al*., 2011). Green tea powder also enhanced the colour parameters of whole-wheat flour pan bread (Ning *et al*., 2017). In addition, grape seed extract did not imply any significant modification in stickiness, astringency, porosity, and sweetness of bread with a consistent visible assessment of colour variation with the findings from the colourimetric analysis, and 70% of the panellists preferred its colour (Peng *et al*., 2010). Likewise, the sensory assessment revealed that the substitution of wheat flour in bread with up to 3% dry onion skin powder offered adequate consumer appropriateness (Gawlik-Dziki *et al*., 2013). Similar results of sensory scores of cupcakes with low ratios of potato peels, guava seeds, and guava pomaces were also reported (Khalifa *et al.,* 2015 and 2016).

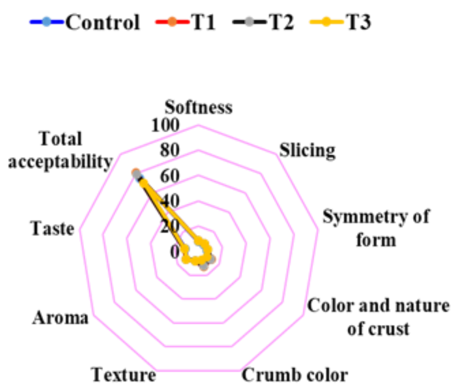

Figure 1. The sensory scores of the bun-bread with and without three ratios of turmeric addition.

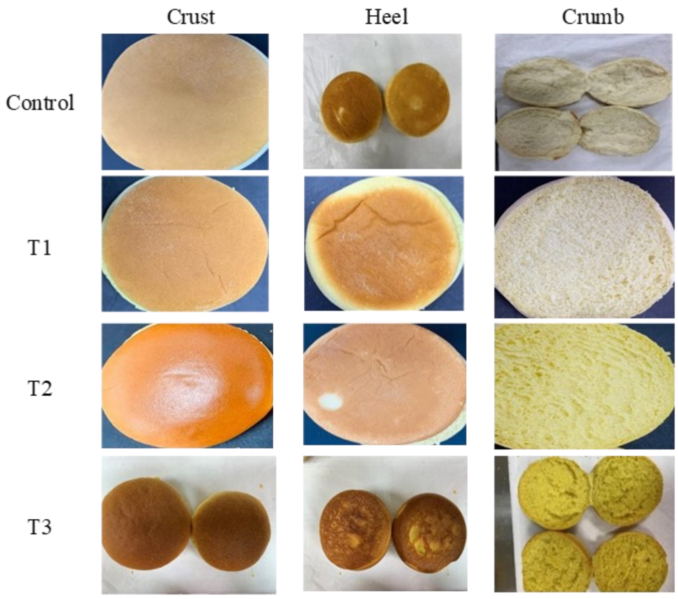

Figure 2. The morphology characteristics of the crumb and crust of the bun-bread with and without three ratios of turmeric addition.

4. Conclusion

Overall, the incorporation of turmeric powder in the preparation noticeably enhanced the approximate chemical compositions, microbiological stability, and shelf-life of bun-bread. Therefore, turmeric powder could be deemed as a prospective health-boosting functional component. Further studies are demanded to evaluate the total bioactive substances, antioxidant activity, colourimetric colour, physical properties, total carotene, and the rheological properties of bun-bread using the best addition level of turmeric powder found. Thus, it is vital to select a suitable amount of turmeric powder and treating factors to acquire a healthful baked good, with high levels of antioxidants and without indorsing negative effects on the manufacturing properties of dough, and without altering the wanted physical and sensorial features of the bun-bread.

Conflict of interest

The authors declare no conflict of interest.

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