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Original Article

Effect of Bakery Process Waste as Partial Flour Substitute on Toast Bread Properties

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ABSTRACT

Background and Objectives: Bread of any kind is a staple food in many countries and supplies some important macro- and micro-nutrients. Now global challenges such as climate change, drought and wars have triggered increase in wheat price, and thus, food insecurity.

Materials and Methods: To reduce bread waste and increase its productivity, we studied the effect of adding toast bread waste powder at the levels of 2, 3, 5 and 7% (samples 2-5, respectively) to dough as flour substitution, on toast bread properties. Other ingredients and bakery processes were the same as the control bread (sample 1). Moisture, porosity and specific volume of all samples were determined. Finally, rheological tests (hardness, adhesiveness, cohesiveness, gumminess, springiness and chewiness) and sensory evaluation (crust and crumb color, taste, chewability, surface shape and overall acceptability) were carried out.

Results: The results showed that by increasing the inclusion rate of bread waste into the dough, the bread's moisture content was increased significantly while its porosity and specific volume were declined. Although some rheological attributes (hardness and chewiness) did not present clear trends, there was a negative relation between springiness and the substitution levels on both days (1 and 3) while adhesiveness on day 1 and gumminess on day 3 displayed positive correlation with bread waste inclusion. In sensory data analysis, samples 2 and 3 appeared to be more similar to the control one.

Conclusions: The authors recommend up to 2% of flour substitution by bread waste, which had no significant or minimal effect on toast bread properties.

Keywords: Toast bread, Process waste, Rheology, Sensory evaluation

Introduction

Bread has a major part in the food basket of billions of people worldwide and is the main source of protein, energy and some other nutrients, especially for low- income people (1). It is believed that the bread history goes back to about 12000 years ago when man learned how to make bread by baking a mix of water and grain flour (2). Since then, bread making techniques and raw materials have been continuously modified so that now we have the practical knowledge to produce various kinds of bread. In response to numerous needs, the bread diversity has increased at national and international levels. Based on the volume, as a variation factor we can categorize breads into three groups of flat, semi-voluminous and voluminous.

The voluminous toast bread is baked in pans to have a cuboid shape and has a soft texture (3). In the industrial production, toast bread is removed from the loaf pan or baking pan as soon as it leaves the oven. Then a visual inspection is performed using a quality assessment system for bread loaves, according to the criteria set by the bakery's R&D or a governmental department. The most important visual quality parameters of toast bread are shape symmetry, crust color, loaf volume, break and shred, and crust surface (4). In this step, a few percent of the bread loaves cannot pass the criteria due to asymmetric shape, low volume or dark crust color; so, they are eliminated as the process waste.

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It is estimated that the waste rate in small bakeries is about 1.5% of total bread produced; in larger bakeries, the rate is 3-5%, which can reach up to 20% when the returned bread is included (5). Now-a-days, the bakery waste is usually used in biotechnological processes (6) and animal feed (7). Taking into account the growing population of the world, the unsustainability in natural resources, food shortage, and the estimated of 8-10% impact of unconsumed food on global greenhouse gas emissions, it is of great importance to reduce food waste or reuse it as a new food component (8). Our literature review showed that bread waste had not been used as a food ingredient in the baking industry and there was just one paper reporting flour substitution by bread waste flour in cake production (9). Due to low or no safety concerns in clean recovery of eliminated toast bread loaves, this study aims to evaluate the effect of bread waste inclusion in dough formulation on the physical, chemical and sensory properties of toast bread.

Materials and Methods

Bread samples

The study was conducted in Nami-Nik-Nahad Food Industries (namely, Cenan Co.), Iran. The factory uses commercial white flour (from Kordan Flour Milling Co.), bakery yeast (from Golmayeh Co.), margarine (from Golnan Co.), sugar, salt, bread improver and water as raw materials. Toast bread waste was separated and the very dark/burned parts were removed. Then they were dried (at 105°C), powdered and sieved (through 125 and 106 µm sieves) to have a fine powder. The wheat flour was replaced by 2, 3, 5 and 7% of the waste powder (samples B2 to B5). Dough preparation, baking conditions (in a continuous tunnel oven) and other ingredients used in the bread recipe were the same as the Cenan instructions. Cenan toast bread was selected as the control sample (B1). All samples were packed in sealed plastic containers and stored in cool place to save moisture during the study.

Methods

Flour and bread samples were analyzed in accordance with the AACC approved methods for moisture (44–15.02), protein (46-30.01), fat (30-25.01), ash (08-01.01) and specific volume (55-50.01) (10). Bread crumb porosity (area fraction %) was tested using a scanner and ImageJ software to process the scanned picture of the samples (11). To have the best pictures, a square hole (20× 20mm) was cut in a paper sheet and the sheet placed on the table of the scanner (HP, G2410 flatbed). Each sample was placed on the sheet and the hole area was scanned at dpi 1200. Bread crust color parameters, including a*, b* and L* were determined using Adobe Photoshop (ver. 11) illustrated by Mahsa Majzoobi *et al.* (12). A wooden box (50 × 50 × 60 cm) with a fluorescent white lamp fixed on the top and a camera (Canon, Model IXUS 230 HS, 14.0 Megapixels, Japan) fixed at 25 cm distance from the sample (with an angel of 45° between the camera lens and the sample surface) were applied. Pictures of five different points of each sample were taken in JPEG format.

The texture profile (including hardness, adhesiveness, cohesiveness, gumminess, springiness and chewiness) of the samples was analyzed on days 1 and 3 using a Brookfield texture analyzer (LFRA 4500) equipped with a probe-type TA43. A test sample of crumb (20× 20× 20 mm) was cut from the center of bread loaves. The cylindrical probe moved downward at the speed of 1 mm/s and stopped automatically when the sample was compressed up to 50% of its original height (13). The textural parameters were determined by TexturePro Lite software.

Food sensory evaluation is the evaluation of signals received by human senses (sight, smell, taste, touch, and hearing) based on scientific principles and techniques to analysis food attributes. One of these techniques is hedonic, which was applied in the present study. We performed the sensory evaluation on day 1 by nine experienced panelists using a 5-point hedonic scale (1= extremely dislike to 5= extremely like) for the crust and crumb color, taste, chewability, surface shape and overall acceptability of the samples (14).

All samples were selected randomly and all tests were conducted in triplicate. The results were expressed as means± SD. For data analysis, ANOVA was performed with SAS 9.0 and the least significant difference (LSD) comparison test was used to statistically interpret the possible differences in the mean values at 95% accuracy level.

Results

The results given in Table 1 show the compositions of the control and treatment samples with different levels of flour substitution. It is observed that increasing the amount of substitution had a direct impact on the bread's moisture content such that sample 5 had the highest moisture content. Sample 2 was not significantly different with the control and sample 3.

Table 1. Moisture, porosity and specific volume of samples

Samples	Moisture (%)	Porosity (%)	Specific volume (cm^3/g)
B1	35.53 ± 0.11 a	30.32 ± 0.09 a	2.62 ± 0.30 a
B2	36.02 ± 0.42 ab	29.32 ± 0.17 b	2.59 ± 0.14 a
B3	36.63 ± 0.35 b	28.11 ± 0.43 c	2.57 ± 0.21 a
B4	38.79 ± 0.23 c	27.63 ± 0.27 c	2.49 ± 0.11 a
B5	42.31 ± 0.61 d	22.03 ± 1.03 d	2.18 ± 0.08 a

In each column, similar letters indicate no significant difference at $p \leq 0.05$.

As indicated in Table 1, the porosity and specific volume of the bread loaves have a decreasing trend from sample B1 to B5 though the differences in specific volume are not statistically significant. The moisture content of the bread samples increased along with the increase of flour substitution.

Color data analysis showed no significant difference among the color parameters (a*, b* and L*) values. Although sample B3 obtained the lowest value of L* (36.61 ± 0.77) and the highest value of b* (17.09 ± 3.03), sample B5 had the highest value of L* (37.90 ± 0.25) and sample B2 gained the highest value of a* (21.88 ± 1.89).

Figure 1 shows the texture profile analysis of toast bread samples on days 1 and 3 of production. As clearly illustrated in the figure, the hardness of all samples was increased from day 1 to day 3. On day 1, just the hardness value of sample 5 (with 7% of flour substitution) was significantly different with the other samples; however, on day 3 it was statistically different only with samples 2 and 3.

Springiness is defined as the recovery force of a product after deformation and is associated with freshness. In the present study, all samples' springiness reduced by increasing the flour substitution on both test days (1 and 3), except for sample 2 on day 1 that showed a non-statistical difference with the control one. On day 1, cohesiveness of sample 3 was statistically different with sample 5 while on day 3, sample 5 was significantly different with samples 1, 2 and 3. Besides the significance of differences on day 1, the results showed that the strength of internal structure increased from sample 1 to sample 3 and decreased afterwards; however, on day 3, a slow increasing trend was observed from samples 1 to 5 in this regard.

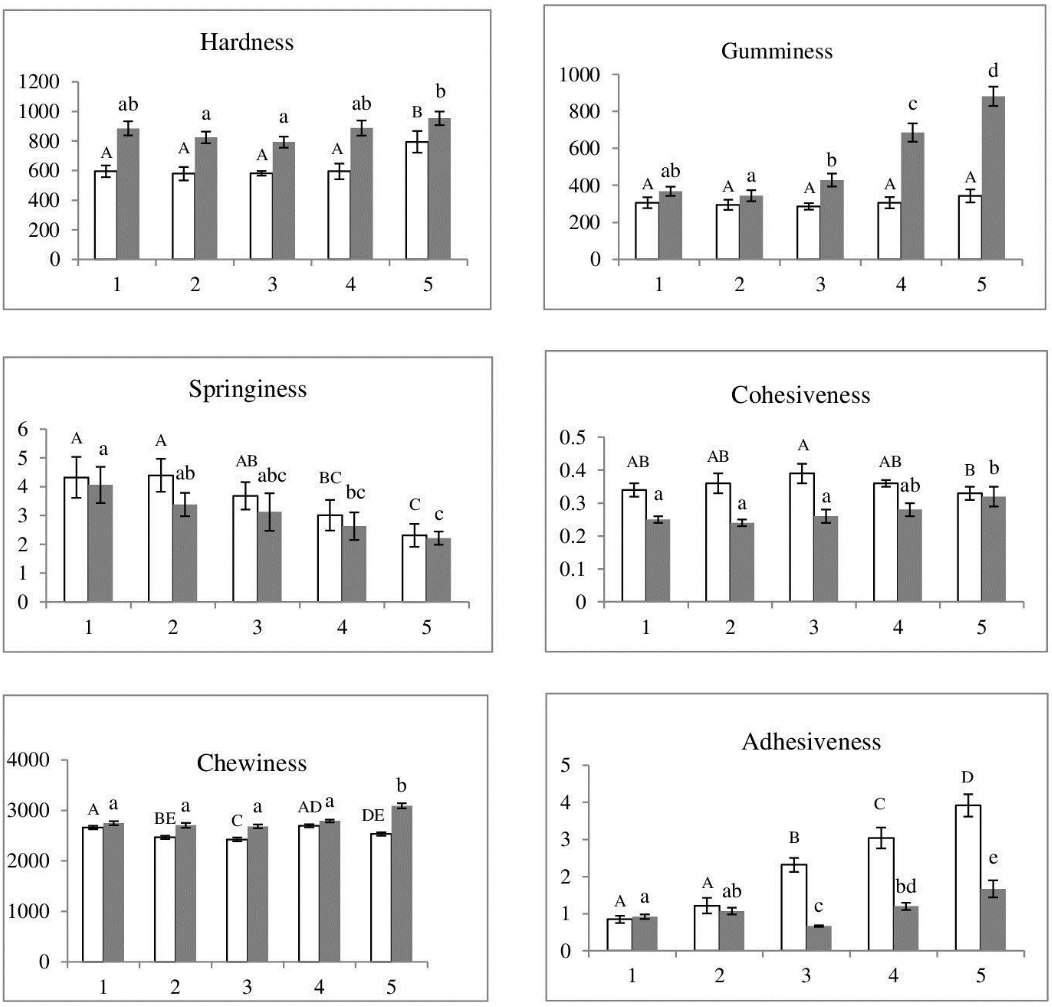

Figure 1. Texture profile analysis of toast bread samples on days 1 ☐ and 3 ■

There was no significant difference in the attribute of gumminess on day 1. On day 3, just samples 2 and 3 were not statistically different with the control. Interestingly, samples 4 and 5 showed absolutely higher gumminess values compared with the sample 1 (control). On day 3, the chewiness values showed a rising slope and were higher than those on day 1 which displayed a fluctuation pattern, not taking into account the significant differences. The results given in Figure 1 (on day 3) show a negative correlation between chewiness and cohesiveness and a positive correlation between chewiness with hardness.

In our study, adhesiveness increased in all samples on day 1 as the substitution percentage increased in the formulations. No significant difference was seen between samples 1 and 2 on both days (1 and 3) but other samples (3-5) showed statistical differences among themselves and between the test days.

The results of sensory evaluation showed that the mean scores of attributes were not statistically different though there were some differences among the values (Table 2). Sample 5 gained the lowest scores in sensory profiles, especially for overall acceptability, and samples 2 and 3 were more similar to the control sample.

Table 2. Sensory scores of bread samples

Samples	Crust color	Crumb color	Surface shape	Taste	Chewability	Overall acceptability
B1	3.73±0.46	4.00±0.76	4.13±0.59	4.07±0.88	4.37±0.62	4.40±0.51
B2	3.53±0.52	3.93±0.80	4.33±0.46	3.93±0.80	4.48±0.50	4.67±0.32
B3	3.73±0.88	3.93±0.96	3.93±0.88	4.03±0.91	4.47±0.44	4.20±0.71
B4	3.53±0.52	4.00±1.00	4.00±0.84	3.67±0.82	4.23±0.72	3.80±0.77
B5	3.40±0.74	4.00±0.65	3.67±0.62	3.47±0.64	4.07±0.88	2.87±1.19

In all columns, no significant difference was observed at $p \leq 0.05$.

Discussion

The increased moisture could be attributed to the composition difference of the bread waste powder due to its different components and yeast fermentation activity as compared with the flour (15). These results are confirmed by other publications, which showed a positive relationship between increasing the water binding compounds and fermentation activity (16).

The higher values of the porosity and specific volume of the bread loaves are observed at smaller median gas cell diameters (17). These results are in agreement with other experimental findings regarding the influence of long proofing time and moisture content on gas void growth (18, 19) and the effects of waste bread powder substitution in sponge cake formulation (9). The raised moisture content along with the high amount of fermentation products could be the causes of declined crumb porosity and specific volume in the present study.

It can be said that the crust color of the samples was independent of the substitution levels tested in our study. It is obvious that bread color changes depend on the formulation and interfering factors, so researchers have reported conflicting results regarding color differences between the control and treatment samples (20, 21). The only report in this field (waste bread powder as a food ingredient) showed that in sponge cake samples L* could be statistically different when the waste bread powder was substituted at the level of 10% meanwhile a* and b* parameters and layer cake samples fallowed different patterns (9). The maximum level of flour substitution ion our samples 7% which was apparently lower than 10% to cause color difference.

The hardness of all samples was increased from day 1 to day 3 as a result of moisture loss (22). On day 3, sample 5 was statistically different only with samples 2 and 3, which could be related to less moisture content. The obtained data on day 1 were consistent with those for porosity and specific volume (Table 1), which could reflect thinner cell walls in more porous samples (17).

Costumers usually prefer breads with high value of springiness during bread shelf-life (23). The relations which we observed among moisture, hardness and springiness were completely in agreement with the results of other reports (24). Cohesiveness is described as "the ratio of positive force areas during the second and first compressions (Area 2/Area l), which presents the strength of the internal bonds of the sample (25). Similar to our findings, other publications tell us that cohesiveness can vary with the changes of internal structure due to different additives and material concentrations (26).

Gumminess can be called "the amount of energy needed for disintegration of the gel before swallowing" and seems to be a product of hardness and cohesiveness. It is said that breads with higher gumminess value have lower quality (26). The rise observed in gumminess values on day 3 could be due to the increase of hardness and decline of moisture during the storage time (27, 28). The results for chewiness are in good agreement with Sun, X., *et al.*

findings where smaller specific volume was introduced as an influencing factor for chewiness (29). Adhesiveness is the work needed to conquer the attractive forces between the product surface and the material surface (the probe). Adhesiveness can grow up along with the increase of moisture content and vice versa; this was clear from the comparison of days 1 and 3 data. So the adhesiveness decline in day 3 could be related to water loss (29).

The sensory scores recorded by experienced panelists showed no significant differences among the control sample and samples 2 and 3, so we could assume that from the sensory characteristics point of view, consumers would not detect the differences among samples. Some researchers have reported promising results regarding the positive/negative effects of flour substitution on bread quality; however, we could not find any report for bread waste reuse in bread dough formulation. By the way, flour substitutions up to 5% by materials other than wheat flour have represented similar findings (30, 31).

Conclusion

Wheat flour was partially substituted with bread waste powder and its effects on toast bread were assessed. The results showed that the addition of bread waste powder (collected, dried and powdered hygienically) to bread formulation could improve the bread productivity. Overall, it can be concluded that by addition of bread process waste up to 2% to dough, the quality parameters of toast bread will remain mostly unchanged; it is also a suitable way to recycle and reduce the waste in the bakery industry.

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References

1. Amini-Rarani M, Abutoraabi SH, Nosratabadi M. The Role of Social Health and Demographic Factors in Bread Quality: An Ecological Study in Isfahan, Iran. Journal of Food Quality. 2021;2021.
2. Mondal A, Datta A. Bread baking–A review. Journal of food engineering. 2008;86(4):465-74.
3. Hadaegh H, Seyyedain Ardabili S, Tajabadi Ebrahimi M, Chamani M, Azizi Nezhad R. The impact of different lactic acid bacteria sourdoughs on the quality characteristics of toast bread. Journal of Food Quality. 2017;2017.
4. Suleria H, Khalid N, Sultan S, Raza A, Muhammad A, Abbas M. Functional and nutraceutical bread prepared by using aqueous garlic extract. Internet Journal of Food Safety. 2015;17:10-20.
5. Iakovlieva M. Food waste in bakeries-quantities, causes and treatment. 2021.
6. Mehri D, Perendeci NA, Goksungur Y. Utilization of whey for red pigment production by Monascus purpureus in submerged fermentation. Fermentation. 2021;7(2):75.
7. Tiwari MR, Dhakal HR. Bakery waste as an alternative of maize to reduce the cost of pork production. Nepalese Journal of Agricultural Sciences. 2021:28.
8. Koester U, Galaktionova E. FAO Food Loss Index methodology and policy implications. Studies in Agricultural Economics. 2021;123(1):1-7.
9. Guerra-Oliveira P, Belorio M, Gómez M. Wasted bread flour as a novel ingredient in cake making. International Journal of Food Science & Technology. 2022;57(8):8.
10. Committee AAoCCAM. Approved methods of the American association of cereal chemists: Amer Assn of Cereal Chemists; 2000.
11. Lakmali H, Wijesinhe D, Arampath P. Determination of Calcium in Selected Eggshell Types and Selection of Best Calcium Level for Bread Enrichment. 2020.
12. Majzoobi M, Raiss Jalali A, Farahnaky A. Impact of whole oat flour on dough properties and quality of fresh and stored part-baked bread. Journal of Food quality. 2016;39(6):620-6.
13. Salehi F, Kashaninejad M. Influence of Guar Gum on Texture Profile Analysis and Stress Relaxation Characteristics of Carrot Sponge Cake. Journal of Food Biosciences and Technology. 2021;11(1):1-10.
14. Ayoubi A, Balvardi M, Akhavan H-R, Hajimohammadi-Farimani R. Fortified cake with pomegranate seed powder as a functional product. Journal of Food Science and Technology. 2022;59(1):308-16.
15. Taglieri I, Macaluso M, Bianchi A, Sanmartin C, Quartacci MF, Zinnai A, et al. Overcoming bread quality decay concerns: main issues for bread shelf life as a function of biological leavening agents and different extra ingredients used in formulation. A review. Journal of the Science of Food and Agriculture. 2021;101(5):1732-43.
16. Graça C, Edelmann M, Raymundo A, Sousa I, Coda R, Sontag-Strohm T, et al. Yoghurt as a starter in sourdough fermentation to improve the technological and functional properties of sourdough-wheat bread. Journal of functional foods. 2022;88:104877.
17. Dessev T, Lalanne V, Keramat J, Jury V, Prost C, Le-Bail A. Influence of baking conditions on bread characteristics and acrylamide concentration. Journal of food science and nutrition research. 2020;3(4):291-310.
18. Esteller MS, Zancanaro O, Palmeira CNS, da Silva Lannes SC. The effect of kefir addition on microstructure parameters and physical properties of porous white bread. European Food Research and Technology. 2006;222(1):26-31.
19. Monteiro JS, Farage P, Zandonadi RP, Botelho RB, de Oliveira LdL, Raposo A, et al. A systematic review on gluten-free bread formulations using specific volume as a quality indicator. Foods. 2021;10(3):614.
20. Kaur A, Tyagi S, Singh K, Upadhyay SK. Exploration of glutathione reductase for abiotic stress response in bread wheat (Triticum aestivum L.). Plant Cell Reports. 2022;41(3):639-54.
21. Aguiar EV, Santos FG, Centeno ACLS, Capriles VD. Defining amaranth, buckwheat and quinoa flour levels in

gluten-free bread: A simultaneous improvement on physical properties, acceptability and nutrient composition through mixture design. Foods. 2022;11(6):848.

22. Kotsiou K, Sacharidis D-D, Matsakidou A, Biliaderis CG, Lazaridou A. Physicochemical and functional aspects of composite wheat-roasted chickpea flours in relation to dough rheology, bread quality and staling phenomena. Food Hydrocolloids. 2022;124:107322.

23. Tóth M, Kaszab T, Meretei A. Texture profile analysis and sensory evaluation of commercially available gluten-free bread samples. European Food Research and Technology. 2022;248(6):1447-55.

24. Wulandari D, Amin M, Masithah E, Lamid M, Alamsjah M, editors. Replacement of gum arabic by dry Spirullina sp. biomass as a food emulsifier in bread making. IOP Conference Series: Earth and Environmental Science; 2019: IOP Publishing.

25. Rosenthal AJ, Thompson P. What is cohesiveness?—A linguistic exploration of the food texture testing literature. Journal of Texture Studies. 2021;52(3):294-302.

26. Hussain S, Alamri MS, Mohamed AA, Ibraheem MA, Qasem AAA, Shamlan G, et al. Exploring the Role of Acacia (Acacia seyal) and Cactus (Opuntia ficus-indica) Gums on the Dough Performance and Quality Attributes of Breads and Cakes. Foods. 2022;11(9):1208.

27. Susmitha T, Bagchi TB, Deb BS, Biswas T, Adak T, Banerjee H, et al. Evaluation of colour, texture and nutritional properties of Pigmented Rice Based Fermented Steamed Food-Idli. Food Chemistry Advances. 2022;1:100021.

28. Alamri MS, Mohamed AA, Hussain S, Ibraheem MA, Qasem AAA, Shamlan G, et al. Functionality of Cordia and Ziziphus Gums with Respect to the Dough Properties and Baking Performance of Stored Pan Bread and Sponge Cakes. Foods. 2022;11(3):460.

29. Sun X, Ma L, Zhong X, Liang J. Potential of raw and fermented maize gluten feed in bread making: Assess of dough rheological properties and bread quality. LWT. 2022;162:113482.

30. Aljahani AH. Wheat-yellow pumpkin composite flour: Physico-functional, rheological, antioxidant potential and quality properties of pan and flat bread. Saudi Journal of Biological Sciences. 2022;29(5):3432-9.

31. Masood MAB. Chia Seeds As Potential Nutritional and Functional Ingredients: A Review of Their Applications for Various Food Industries. Masood, M A B Chia Seeds as Potential Nutritional and Functional Ingredients: A Review of their Applications for Various Food Industries, J Nut Food Sci Tech. 2022;4(1):1-14.