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Incorporation of common carp meat paste in bread formulation as a strategy to increase the usage of fish meat in the human diet and investigation of the physicochemical and organoleptic properties of bread

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Abstract

Background and objective: Bread is an important staple food and is widely consumed throughout the world. Therefore, its enrichment can improve consumers' health. Bread enrichment is done in different ways. This study aims to enrich bread with one of the world's most widely farmed fish species, the common carp (*Cyprinus carpio*), which has a lower market price than other warm-water fish species due to the unpleasant smell of its flesh. In addition, fresh fish meat is used for bread enrichment to maintain fish quality and eliminate drying costs.

Materials and methods: Common carp meat paste was used to enrich the wheat bread at amounts of 0, 5, 10, 15, 20, and 25%, and the impact of this enrichment on the bread's physicochemical, textural, and sensory characteristics was investigated.

Results and conclusion: The bread samples' moisture content and specific volume were measured in the range of 38.85-48.40% and 1.74-3.18 (cm^3/g), respectively. Meat pastes higher than 10% in bread formulation significantly increased the moisture and reduced the specific volume of the bread. Texture analysis results showed that by increasing the amount of meat paste to 20%, the bread's hardness, gumminess, resilience, and springiness did not change significantly. The maximum hardness (1305 g) and gumminess (515.66 g), and minimum resilience (0.147 ratio) and springiness (0.64 ratio) were achieved in the treatment with 25% meat paste. The cohesiveness and chewiness of the resulting bread did not have significant differences. The results of the sensory evaluation showed that all formulations were acceptable. According to the results, using common carp meat paste up to 20% in bread formulation can produce bread with acceptable texture and flavor. However, the production of bread with lower meat paste (10%) resulting a product with a better specific volume.

Keywords: Bread, Common carp, Enrichment, Fish paste

1. Introduction

Carp is one of the most widespread fish species in the world due to its resistance to environmental conditions and low basic needs. Among the carp, common carp (*Cyprinus carpio*) is an economically important aquaculture species worldwide, which is very important to the aquaculture industry [1,2]. In 2020, the world production of common carp was 4236.3 thousand tons (live weight), equivalent to 8.6% (ranking fourth) of the world's inland aquaculture of

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Finfish [3]. Carp meat is a valuable raw material because it has very nutritious protein, fat, vitamins, and minerals [4]. However, some consumers do not choose carp because they are bony. In addition, the common carp is a bottom feeder and searches mud to find food, so its meat has an unpleasant smell, and its price is the lowest among warm-water fish species. Therefore, to increase carp consumption, more research studies should be conducted [1,5].

In recent years, the enhancement of the nutritional value of food products has been noticed due to the increased interest in consuming healthier food products. Fish is a highly nutritious food because of its high levels of protein, essential amino acids, and long-chain unsaturated fatty acids [6,7]. For this reason, fish protein powder has been successfully used in formulating noodles, ice cream, corn snacks, pasta, chocolate biscuits, crackers, salty cookies, and bread [6].

Among these, bread is the most critical cereal-based food in the world. However, bread is rich in carbohydrates and poor in protein and essential fatty acids, so it has a high glycemic index, which can lead to obesity, diabetes, and biliary tract cancer [7]. Therefore, by increasing the amount of protein in bread, the health status of many people can improve. Adding ingredients such as fish protein concentrate increases the protein content of bread and compensates wheat deficiencies of two essential amino acids, lysine and threonine [8]. Many studies have reported nutritional enhancement of bread by adding ingredients such as flour or powder from various marine sources such as tilapia, red-tailed Brycon, and shrimp [9]. Bastos *et al.* [10] used residues from the processing of *Brycon cephalus* to enrich bread and evaluated its effect on the sensory and chemical properties of the product. Cercel *et al.* [8] evaluated the nutritional effects of fish proteins in wheat bread. In the study of Hosseini Shekarabi and Shahbazi [6], the effect of the relative replacement of wheat flour with fish protein powder on the rheological, physico-chemical, and sensory properties of bread, dough, and flour was evaluated. In many of these studies, powdered fish products have been used in the formulations. The processing method can influence the quality and characteristics of fish product powders [6]. For instance, although drying is a prominent way to process and preserve aquatic products, due to protein denaturation, oxidation and hydrolysis of lipids, and browning, significant changes in these products' physical, chemical, nutritional, and taste can occur. Drying also increases energy consumption [11].

To increase the consumption of common carp, reduce drying costs, and maintain fish quality, this study aims to add different amounts of fresh meat paste to the bread formulation and evaluate its effects on the product's physicochemical, sensory, and textural properties.

2. Material and methods

The yeast (*Saccharomyces cerevisiae*) was prepared from the Tabriz Golmayeh company (Tabriz, Iran), and the flour with a 79-80% extraction rate, 10% protein, 0.69% Ash, and 12% moisture was obtained from the Alborz flour factory (Alborz, Iran). All applied chemical reagents were of analytical grade.

2.1. Preparation of fish paste

Common carp (*Cyprinus carpio*) fish, weighing 700-900 g immediately after catching, were transferred to the laboratory. Then the processes of deheading, eviscerating, peeling, filleting, and washing with cold water were carried out. The fish fillets were minced by a meat grinder (Pars Khazar, Iran) with a 2 mm hole size. The minced meat was washed two times with chilled water and two times with chilled 0.3% NaCl solution, each time for 15 min. The minced meat and water/salt solution ratio was 1 to 4. Then, the mixture was poured into a cloth and squeezed manually to remove excess water [6]. A heavy weight was placed on it for 10 to 15 min to drain the water completely. The resulting paste had 78.28 ±0.73% moisture, 15.94 ±0.16% protein, 1.78 ±0.14% fat, 1.06 ±0.12% ash, and pH 6.57 ±0.18.

2.2. Bread production

The bread samples were manufactured according to Moeini *et al.* [12] with some modifications. Bread dough was prepared by combining 63% flour, 33.7% water, 0.9% salt, 0.9% yeast (*Saccharomyces cerevisiae*), 0.9% improver, and 0.6% sugar. The resulting dough was fermented for 60 min at room temperature (25 °C). Then, the fish paste was added to the dough. The percentage of fish paste in the final formulations was considered to be 0 (control), 5 (T1), 10 (T2), 15 (T3), 20 (T4), and 25% (T5). Again, the dough formulations were fermented for 30 min at 25 °C. Then, the baking process was done at 200 °C for 30 min in an electric oven (Pars-Azma, Iran). The buns were cooled at ambient temperature for an hour and then were packed in polyethylene bags.

2.3. Bread quality assessment tests

2.3.1. Moisture determination

Bread moisture was determined by the air-oven method according to AACC 44-15.02 and calculated according to the following equation [13]:

$$\%\text{Moisture} = \frac{\text{A}}{\text{B}} \times 100$$

Where, A = moisture loss (g), B = original weight of sample (g)

2.3.2. Analysis of specific volume

The volume of bread was measured using the rapeseed displacement method according to AACC 10-05.01 [14], and the specific volume was calculated by dividing the volume by the weight of the samples (cm^3/g) [15].

2.3.3. Textural analysis of bread

The bread texture analysis was done using the CT3 texture analyzer machine (Brookfield, USA). The bread was cut into cubes ($25\times25\times25$ mm^3) and pressed to a depth of 10 mm (40% initial thickness) at a speed of 60 mm/min by the glass plunger with a diameter of 38.1 mm and a constant pressing force of 500 Newtons [16].

2.3.4. Sensory evaluation

Thirty panelists performed the sensory analysis of bread. According to Poste *et al.* [17], this acceptance test was conducted using a 9-point hedonic scale (number 9 = like extremely and number 1 = dislike extremely).

2.4. Statistical analysis

All tests were run in triplicate, and the resulting data were expressed as mean ±standard deviation. The data analysis was done using Minitab 16 software version 16.0, which used a one-way analysis of variance (ANOVA). The comparison of the means was performed by Tukey at the probability of 5% ($p<0.05$).

3. Results and discussion

Figure 1 shows the results of measuring the moisture content of bread samples. In this study, the moisture of the control sample was 38.9%, and by increasing the fish paste in bread formulation to 15%, the moisture level increased to 48.4%. The increase in bread moisture is because fish paste has 78.28% moisture, so increasing its amount in the bread formulation leads to an increase in the bread's moisture. The moisture content decreased slightly (but not significantly, $P>0.05$) in samples with 20% and 25% fish paste, reaching 47.9% and 46.3%, respectively. Monteiro *et al.* [7] showed that, as tilapia-waste flour increased by 5% in bread formulation, the bread's moisture increased to 42.3%, and then by adding more fish flour to 20%, the moisture decreased to 36.2%. In Hosseini Shekarabi and Shahbazi [6], Desai *et al.* [18], and Zebib *et al.* [19] studies, by increasing the amount of fish protein powder, salmon powder, and labeobarbus fish flour, respectively, the moisture content of the bread samples decreased. This reduction in moisture percentage is due to the higher water-holding capacity of fish proteins compared to wheat flour protein, which decreases the product's moisture content by reducing the free water content [6]. On the other hand, protein denaturation and its interaction with polysaccharides through electrostatic forces causes the formation of an intermolecular network, trapping water and reducing the free water content, which is associated with a decrease in the moisture content of samples [7].

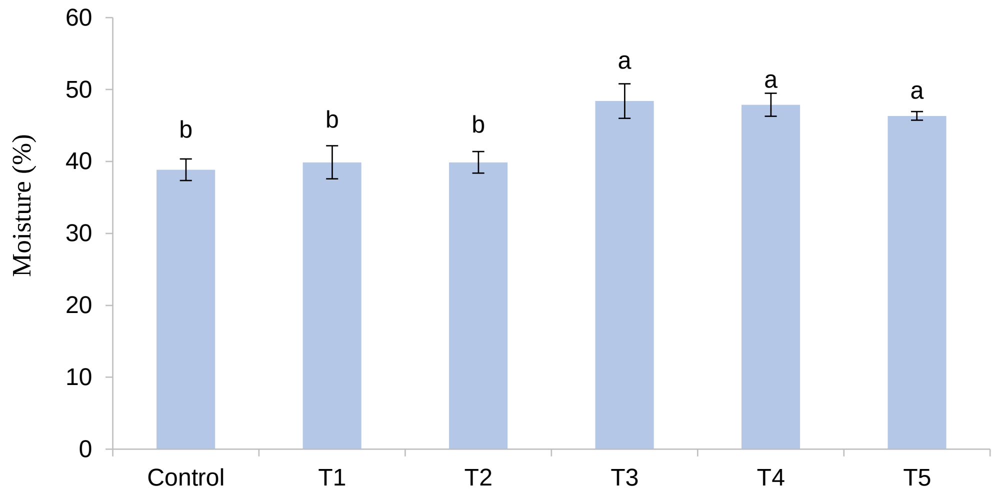

Figure 1- Effect of different amounts of common carp meat paste on the moisture content of bread samples. Control, T1, T2, T3, T4, and T5 are the bread samples with 0%, 5%, 10%, 15%, 20%, and 25% common carp meat paste.

The results of the specific volume of bread samples showed that by increasing the fish paste in bread formulations, their specific volume was reduced significantly ($P<0.05$) (Figure 2). Specific volume of control, T1, T2, T3, T4, and T5 samples were 3.18, 2.98, 2.63, 2.2, 1.77, and 1.74 cm^3/g, respectively. Therefore, the highest and lowest specific volumes were for the control sample and the sample with 25% fish paste. Cercel *et al.* [8], also observed that as fish protein concentrate increased in bread formulation, the specific volume of bread decreased. Desai *et al.* [18] showed that with the increase in salmon powder in bread formulation, the specific volume of bread decreases from 2.47 ml/g in the control sample to 2.16 ml/g in the sample containing 15% fish powder. Hosseini Shekarabi and Shahbazi [6] also achieved a similar result by adding fish protein powder to bread formulations. The decrease in specific volume is due to the reduction in the elasticity of the dough and the dilution of gluten. Wheat gluten is responsible for the viscoelastic property of dough and contributes to the shape of bread by trapping gases during fermentation. Unlike gluten, other plant (lentil, pea, or carob flower) and animal proteins, cannot contribute to holding and stabilizing carbon dioxide from yeasts during fermentation. As a result, their increase in bread formulation reduces the amount of gluten in the dough, causes adverse gluten interactions, creates weaker dough, reduces gas holding capacity, and thus decreases bread volume [6,18].

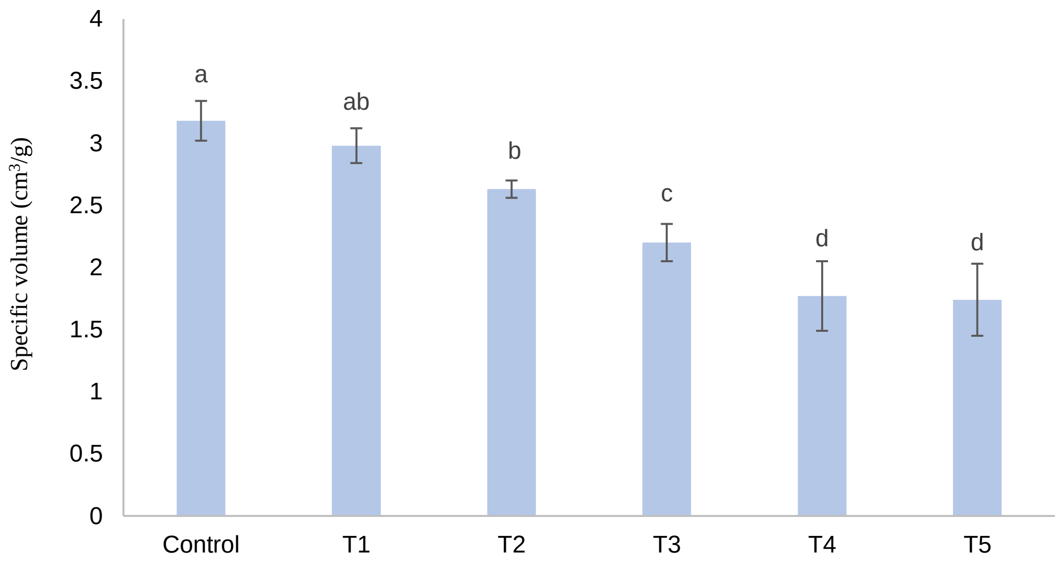

Figure 2- Specific volume of the bread formulations with different meat pastes of common carp. Control, T1, T2, T3, T4, and T5 are the bread samples with 0%, 5%, 10%, 15%, 20%, and 25% common carp meat paste.

In this study, the textural properties of bread, including hardness (the force required to achieve the desired deformation), cohesiveness (strength of internal bonds in the body of product), chewiness (energy needed to masticate a solid food to the extent that it is ready for swallowing), gumminess (energy needed to disintegrate a semi-solid food to the extent for being ready for swallowing), resilience and springiness (rate of return of a deformed substance to its original state after the removal of force) were evaluated [20,21].

The textural analysis of bread (Figure 3) showed that the highest hardness, chewiness, and gumminess and lowest resilience, springiness, and cohesiveness were for bread with 25% fish paste (T5). Desai *et al.* [18] also concluded that the lowest hardness was for the control sample, and by fortification of bread with salmon powder up to 10%, hardness, gumminess, and chewiness increased, and springiness, cohesiveness, and resilience decreased significantly. Monteiro *et al.* [7] also showed that as tilapia-waste flour increases in bread formulations hardness and chewiness increase and springiness, cohesiveness, and resilience decre-ase. The same results were obtained by Hosseini Shekarabi and Shahbazi [6] by adding fish protein powder to bread formulation. Fish protein does not form a network like gluten, leading to a more compact and stiff dough. On the other hand, due to sulfur amino acids (methionine and cysteine) in fish proteins, ss bonds (SS-bonds) may increase and cause alteration in gluten network structure and protein aggregation. Moreover, higher protein content in fortified samples can be partly responsible for decreased gas retention, causing gas cell instability and resulting in bread's compact structure and hardness [6,9,18]. The decrease in springiness, cohesiveness, and resilience of fortified bread can also be due to the weakening of the gluten network in the dough and bread. Enriching samples with proteins other than wheat protein weakens the gluten network and reduces the ability of samples to return to the previous state after deformation [6,18].

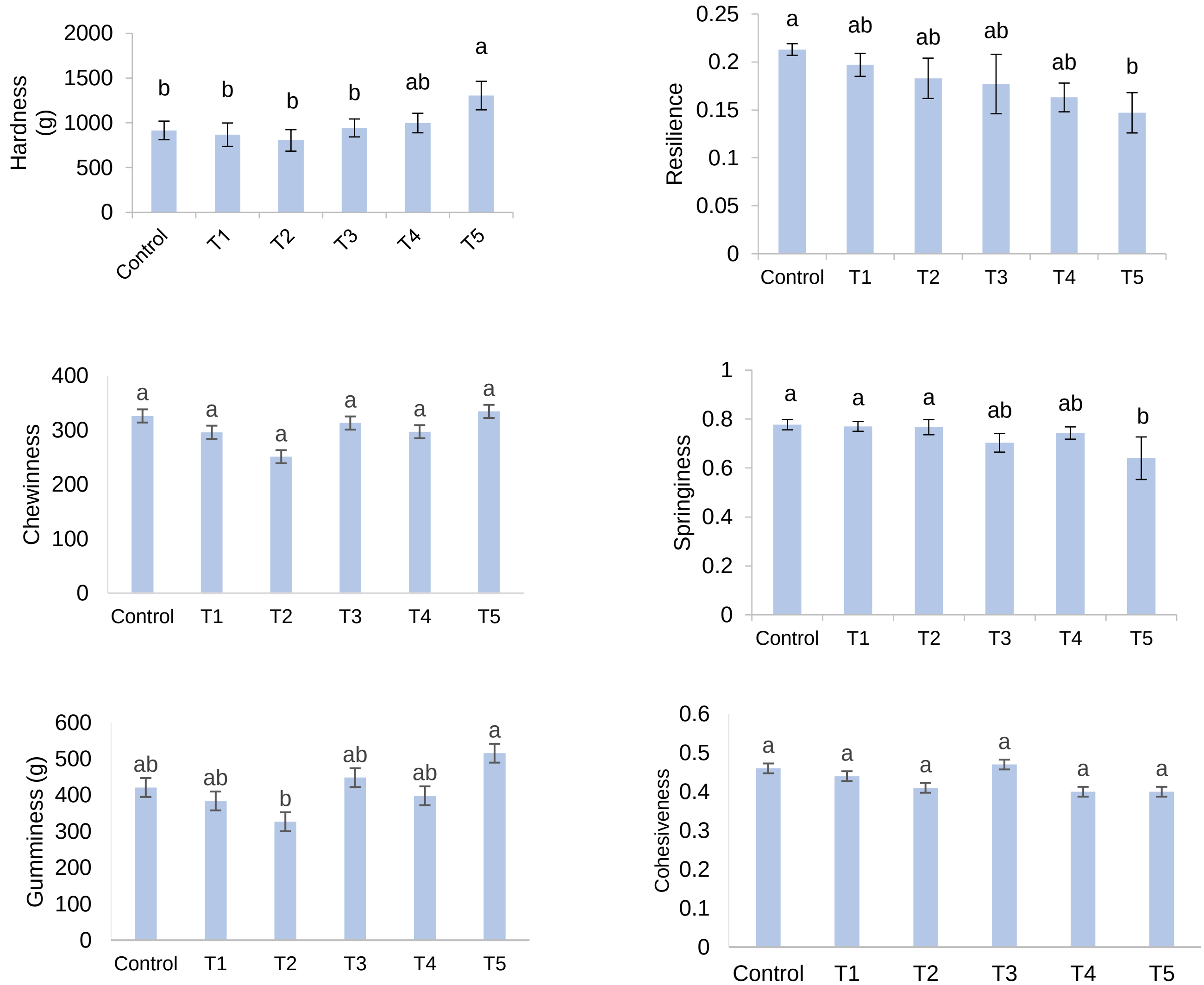

Figure 3- Textural properties of the bread formulations. Control, T1, T2, T3, T4, and T5 are the bread samples with 0%, 5%, 10%, 15%, 20%, and 25% common carp meat paste.

The results of the sensory evaluation of bread samples (Figure 4) showed that the effect of different percentages of fish paste on the taste of bread was not significant ($p>0.05$). Bastos *et al.* [10] also showed that bread formulations containing 5, 10, 15, and 20% fish flour had better acceptance or were as good as those without fish flour. In the Monteiro et al. [9] study, bread samples containing up to 5% tilapia-waste flour received the highest acceptance score, and samples up to 12.17% did not face consumer rejection. Hosseini Shekarabi and Shahbazi [6] concluded that replacing wheat flour with fish protein powder up to 6% did not cause a significant change in the taste of fortified bread. This acceptance rate seems to depend on the type of fish and how it is processed before being added to the bread formulation.

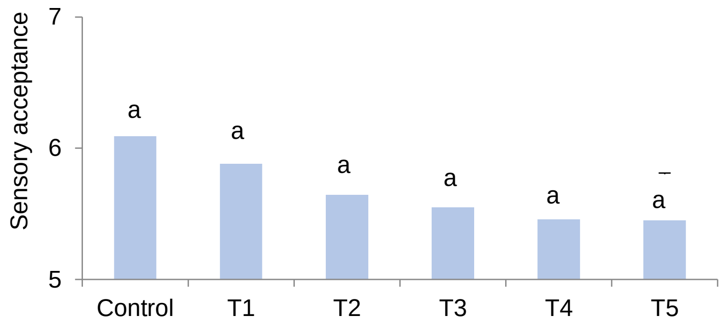

Figure 4- Results of sensory attributes in the bread samples. Control, T1, T2, T3, T4, and T5 are the bread samples with 0%, 5%, 10%, 15%, 20%, and 25% common carp meat paste.

4. Conclusion

Adding common carp meat paste to the wheat bread formulation increased the moisture of bread samples up to 20%. However, the moisture of bread samples increased, specific volume decreased, and textural and sensory properties did not change significantly. For the production of bread without any significant changes in moisture and specific volume, adding meat paste up to 10% can be helpful. More precise research is needed to determine the microbial and chemical changes of bread during shelf life.

5. Conflict of Interest

There are no competing interests to be declared.

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