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Investigation of the Use of Waste Commercial Plant Pulps as Edible Fish Coating Material

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ABSTRACT

In this study, the effects of pulps obtained after cold press oil production was tested as edible fish coating material. It was determined by peroxide value (PV) and thiobarbituric acid-reactive substances (TBARS) values that waste pulp prevented undesirable quality changes due to lipid oxidation. While coating process with black cumin, pumpkin seed and poppy pulp stopped yeast and mold (YM) count development, the lowest total viable count (TVC) values were observed in poppy and black seed groups. Sensory results showed that the use of plant pulps extended the shelf life of rainbow trout fillets, with poppy and black cumin pulps being the most effective groups in terms of odor, taste, texture and general acceptability.

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Introduction

The importance of the ability to fight spoilage bacteria and molds with natural instruments has been understood in the past few years, and many studies have been carried out on the antimicrobial effects of different plants (Aleksic Sabo and Knezevic 2019; Panda et al. 2019; Ghidey et al. 2020). Also previous studies (Yavuzer 2018; Yavuzer et al. 2020) demonstrated that storing rainbow trout meat in ice containing herbal extract positively affected the sensory, chemical and microbiological quality. It is also known that natural antimicrobials added to the food during the feeding of the culture fish make positive contributions to the meat quality in terms of processing and consumption of the product (Öz 2018).

Although it is known that improper use of antibiotics strengthens the resistance mechanisms of bacteria, it is very important to define the power of herbal materials precisely. Hence, most of the time, anonymous public information could lead to erroneous results and cause undesirable consequences, especially due to the microbial load in food storage. Important commercial herbal products include black cumin (*Nigella sativa*), pumpkin seeds (*Cucurbita pepo*), sesame (*Sesamum indicum*) and poppy (*Papaver somniferum* L). The oil that is extracted from these plants, particularly from black seed and pumpkin seeds, has been traded intensively.

Black cumin seed oil has been used as an important medical ingredient within the world throughout history and is known to be an important antioxidant/antimicrobial (Eid et al., 2017; Erisgin et al., 2019). Another study (Ashraf et al., 2018) reported that black seed oil was very effective on the antibiotic-resistant *Salmonella enterica*. The main reason why it is common in the street markets, natural markets, and the shelves of the pharmacies in capsule, liquid or other cosmetic forms is its use as a food supplement based on its ingredients. Studies on black cumin seed oil have shown that it is a good anti-diabetic, anti-tumor and heart protector (Eid et al., 2017; Mollazadeh and Hosseinzadeh, 2014). Pumpkin seed oil is also an herbal product that is produced extensively and has a commercial importance due to its medicinal properties. Besides, pumpkin seed oil is known to exhibit anti-inflammatory, antioxidant, phytoestrogenic, phenolic and hypolipidemic activities (Andjelkovic et al., 2010; Makni et al., 2011; Zuhair et al., 2000). Similarly, poppy oil, which is mostly used as a raw material for food due to its high polyunsaturated fatty acid level, is an important vegetable oil. The essential fatty acids in poppy oil are linoleic, oleic and palmitic acids (Lančaričová et al., 2016) and it is also known that it is a good antioxidant because almost every part of poppy is rich in phenolic components (Ghafoor et al., 2019; Koeduka et al., 2014). Sesame oil is an essential vegetable oil that contains 47%- 55% fat, 18-25% protein and 13-14% carbohydrate and shows better oxidative stability than many natural antioxidants (Mujtaba et al., 2020). In addition, previous studies (Liu and Liu, 2017; Saleem et al., 2013) reported that sesame oil has important effects on heart health.

Many analyses (Alqannam, 2020; Eid et al., 2017; Makni et al., 2011; Mujtaba et al., 2020) were performed on the antioxidant properties of cold press oils based on oxidative stress and their effects on human health. However, the literature is not very rich in terms of the effects of these plants' by-products. Therefore, in this study, waste pulps obtained after cold press oil production were examined in terms of their effects on certain parameters that cause essential problems in processing and storing of fish as a functional food and the potential use of waste pulp as coating material have analyzed during 20 days of storage.

Material and Method

Collection of Plant Materials and Obtaining Vegetable Oil and Pulps

The black cumin (*Nigella sativa*) seeds, pumpkin (*Cucurbita pepo*) seeds, sesame (*Sesamum indicum*) seeds and poppy (*Papaver somniferum* L) seeds used in the study were obtained from a local company in Konya, Turkey. The process of obtaining oil from plants was carried out with a cold press oil machine (MP 001 mini press) located in Kırşehir Ahi Evran University, Faculty of Engineering and Architecture, Food Engineering Department, Turkey.

Fish Material and Coating Process with Waste Plant Pulps

The trout used in the study was obtained from a trout production facility (EZG Corp. Hirfanlı Dam/Turkey) located 20 minutes from our university laboratory. The avarage weight of fish was 330 ±12 gr. A total of 12 kg (approximately 35±3) rainbow trout were used. The fish were cleaned and filleted as soon as they were transferred to the laboratory. The plant pulps remaining after the oil extraction process were milled and prepared for use. All samples of fish fillets kept for 1 hour in 4% salt solution were then filtered and coated homogeneously with plant pulps. The control group was covered with white flour; as white flour is generally used in frying fish. All fish samples stored in polyethylene bags at 3±1°C for use on the analysis days.

Chemical Analysis

The TBARS (mg malonaldehyde/kg) and PV (meqO2 kg-1) values of the rainbow trout analyzed during storage according to the methods given by Tarladgis et al., (1960) and AOCS (1994) respectively.

Microbial Analysis of Coated Fillets

For total viable count (TVC) and yeast and mold count (YM), 10 g samples of fish meat which coated by plant pulps were taken and mixed in 90 ml Ringer's solution for 5 minutes using a stomacher. While the incubation was applied at 30 degrees for 2 days in PCA (Plate Count Agar) for TVC (ICMSF 1986), it was waited for 24 hours in Dichloran Rose-Bengal Chloramphenicol at 37 degrees for YM (Yıldız et al. 2020).

Sensory Analysis of Coated Fillets

The measurement of the sensorial values of cooked fish in terms of odour, taste, and texture, a scheme was used where 10 points indicated the highest value and <3 points indicated spoiled fish (Howgate, 1982). All fish samples were fried at 250°C for 5 minutes. Figure 1 shows trout fillets covered with plant pulp and fried.

Statistical Analyses

Analyses were run in triplicate and results were reported as mean values ± standard deviation (S.D). Data were subjected to analysis of variance (one-way ANOVA).

Results and Discussion

Chemical Analysis

The fact that trout is rich in mono and polyunsaturated fatty acids makes it a perishable food. Therefore, PV analysis becomes important in determining the lipid oxidation of fish. Exposures such as heat and light on food result in harmful secondary products such as alcohols and ketones. (Ghohestani et al. 2023). With this, antioxidants are successful on unwanted lipid oxidation (Costa et al. 2022). PV changes of the groups coated with different pulps, fried and stored 3±1°C are given in Figure 2. PV values for all groups increased during storage, and there were statistically significant differences between the groups ($p < 0.05$). Initial PV was 2.65 meq O2/kg^{-1} for groups and this value of the present study was close to the initial PV value (2.85 meqO2 kg^{-1}) of our previous study (Yavuzer et al., 2020) where we stored trout on ice containing extract. From 5th storage day to the 20th storage day PV values of G2 and G3 were significantly lower than the others. However, the fact that other groups show lower peroxide values during storage than Cnt group shows that all of the pulps have antioxidant properties. Although the PV range accepted by the literature for many years (Gram and Huss, 1996) is 10 and 20 meq O2/kg^{-1}, these values were not reached in the current study. In the present study it was seen that testing groups with plant pulps showed slower lipid oxidation rate than the control so the results of the present study indicate that the using of the pulps especially G1, G2 and G3 are effective at delaying lipid peroxidation in rainbow trout.

TBARS value is an important quality parameter for healthy food consumption. TBARS values of the control and treatment groups are given in Figure 3. The TBARS value, which had an onset of over 0.50 in the study, tended to increase during storage. While G1 and G3 never exceeded the 2 mg malonaldehyde/kg level during storage, G1 had a lower TBARS value on the 10th and 15th days of storage compared to Cnt and G4. On the basis of all storage days, G1 and G3 significantly lowered TBARS levels.

Figure 1. Trout fillets covered with plant pulp and fried.

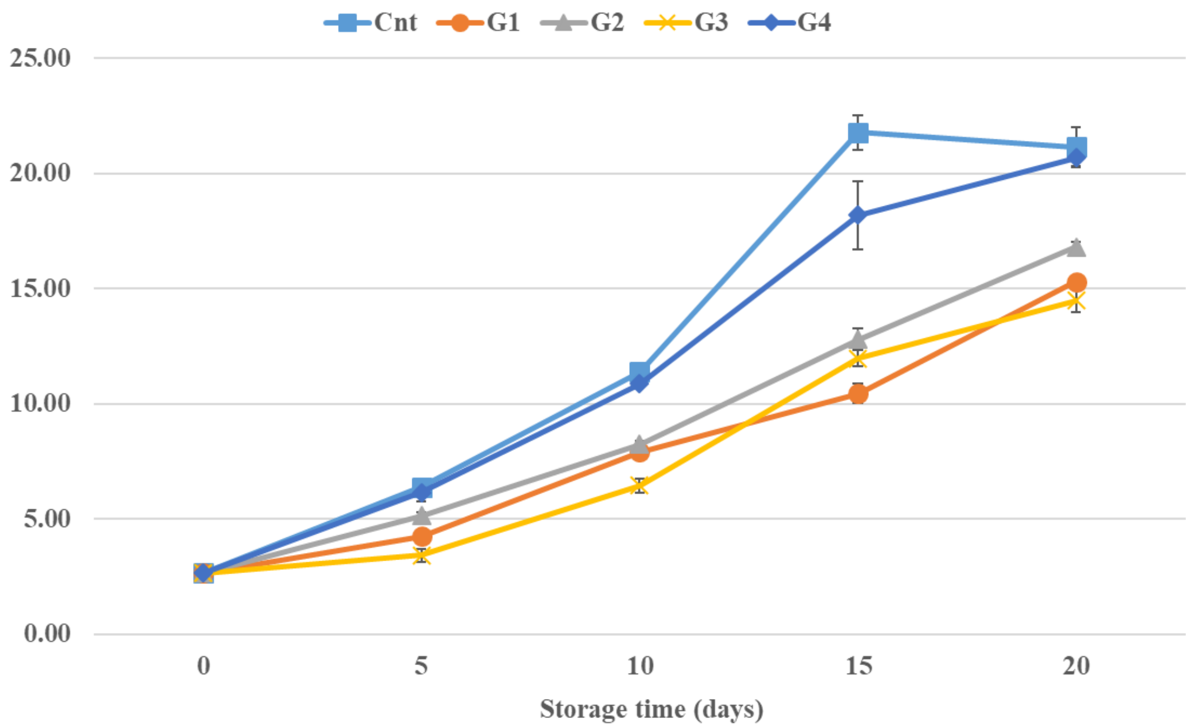

Figure 2. Changes in peroxide values (PV) (meq/kg) of rainbow trout fillets coated with plant pulps. Cnt: Control, G1: Poppy pulp, G2: Pumpkin pulp, G3: Black cumin pulp, G4: Sesame pulp

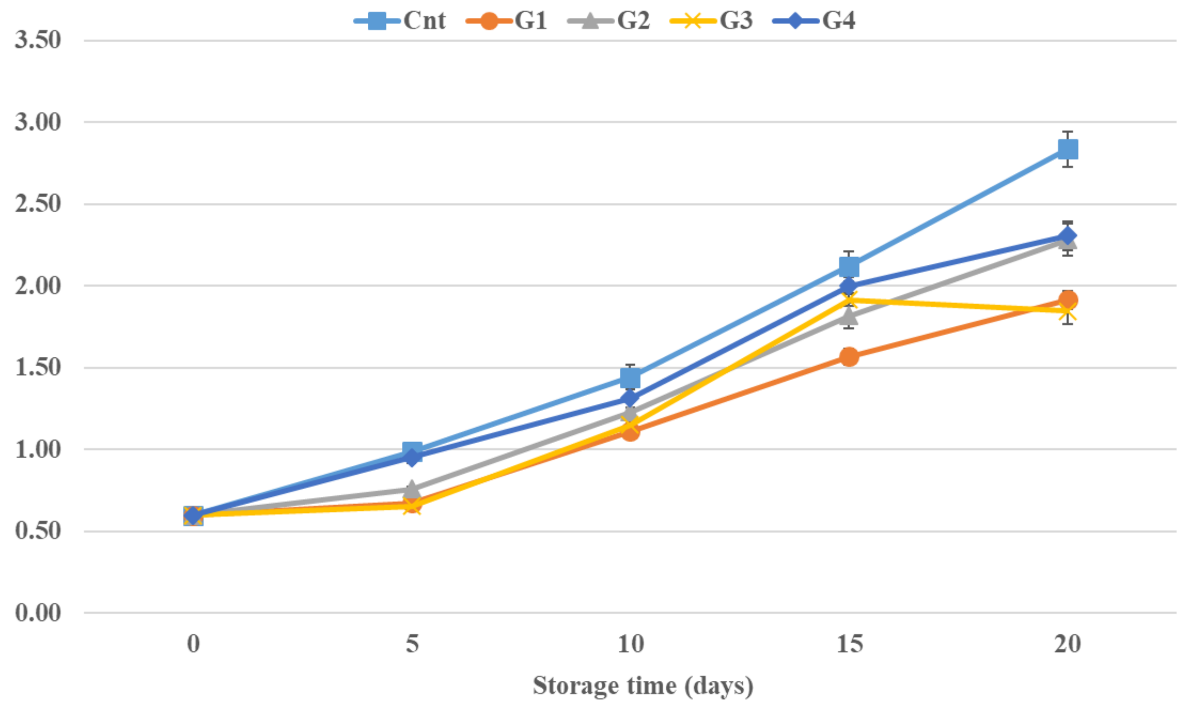

Figure 3. Changes in thiobarbituric acid reactive substances value (TBARS) (mg malonaldehyde/kg) of rainbow trout fillets coated with plant pulps. Cnt: Control, G1: Poppy pulp, G2: Pumpkin pulp, G3: Black cumin pulp, G4: Sesame pulp.

Table 1. Changes in the total viable count and yeast and mold count during storage.

	Days	Cnt x̄±Sd	G1 x̄±Sd	G2 x̄±Sd	G3 x̄±Sd	G4 x̄±Sd
Total Viable Count	12th hour	1.88±0.13^{aE}	1.60±0.10^{bE}	1.52±0.02^{bE}	1.50±0.03^{bE}	1.86±0.11^{aE}
	5	4.12±0.07^{aD}	2.80±0.07^{cD}	3.97±0.03^{bD}	2.77±0.08^{cD}	4.07±0.08^{aD}
	10	5.10±0.07^{aC}	3.58±0.08^{dC}	4.96±0.06^{bC}	3.11±0.06^{eC}	4.78±0.06^{cC}
	15	7.12±0.12^{aB}	4.87±0.06^{dB}	5.78±0.09^{bB}	4.91±0.07^{dB}	5.56±0.08^{cB}
	20	8.92±0.05^{aA}	5.14±0.03^{eA}	6.20±0.09^{cA}	5.41±0.08^{dA}	6.98±0.07^{bA}
Yeast and Mold Count	12th hour	-	-	-	-	-
	5	4.05±0.08^{aBC}	-	-	-	-
	10	3.94±0.05^{aC}	-	-	-	-
	15	4.13±0.09^{aB}	-	-	-	1.49±0.01^{bB}
	20	5.05±0.06^{aA}	-	-	-	1.62±0.09^{bA}

Different upper case (A-E) in the same column and different letters (a-e) in the same row show significant differences (P<0.05) Cnt: Control, G1: Poppy pulp, G2: Pumpkin pulp, G3: Black cumin pulp, G4: Sesame pulp. Different letters (a-d) in the same column and different letters (A-E) in the same row show significant differences (P<0.05).

Microbial Analysis Results of Coated Fillets during Storage

The data of TVC and YM results are given in Table 1. In terms of TVC data, all groups tested during storage performed much better than the control group. At 12th hours after plating, G4 and the Cnt had a significantly higher TVC value than the other groups. From the 5th storage day to the end of storage, G1 and G3 received significantly (P<0.05) lower TVC than other groups. Although G4 had antimicrobial effect on some bacteria used in this study, it was determined that it had weak property in fish coating in terms of TVC and YM. (Yavuzer, 2020) reported that trout was stored on ice, the TVC value was found to be 10.78 log cfu/g^{-1} on the 18th day of storage. In the present study, the highest TVC value was 8.92 log cfu/g^{-1} in the control group on the 20th day of storage. Although control group exceeded 7 log cfu/g^{-1} which is the undesired level for TVC on the 15th day, test groups did not reach this level. In terms of MY, no growth was observed in G1, G2 and G3 during storage, while growth was recorded only on the 15th and 20th days of storage in G4. However, the MY level in G4 was significantly lower than the control group. The increase in the control group in terms of MY, indicates that the fish coating with the tested pulps prevented the formation of yeast and mold.

Sensory Analyses

The sensory analysis performances of fish covered with plant pulp during storage are given in Table 2. In terms of taste, odor and texture, all test groups had significantly (P<0.05) higher sensory scores than the control group during storage. Although there was a prejudice by panelists about the black seed pulp that it would give the fish a bitterness, the expected bitterness did not occur. On the contrary, the odor parameter of black seed pulp was recorded at higher levels than the other groups at the 5th and 10th days of storage.

Table 2. Changes in sensory properties of rainbow trout fillets treated with plant pulps during 20 days of storage at 3°±C.

Storage	Storage Days	Control	G1	G2	G3	G4
Odour	12th h	9.71±0.49^{aA}	10.00±0.00^{aA}	10.00±0.00^{aA}	10.00±0.00^{aA}	10.00±0.00^{aA}
	5	7.07±0.19^{dB}	9.14±0.24^{abB}	9.14±0.24^{abB}	9.43±0.19^{aB}	8.79±0.27^{cB}
	10	4.43±0.35^{cC}	7.86±0.24^{aC}	7.93±0.19^{aC}	7.64±0.24^{aC}	7.29±0.27^{bC}
	15	3.00±0.00^{cD}	5.14±0.69^{aD}	5.71±0.27^{aD}	5.14±0.69^{aD}	4.43±0.53^{bD}
	20	3.00±0.00^{bD}	3.57±0.35^{aE}	3.07±0.19^{bE}	3.79±0.27^{aE}	3.00±0.00^{bE}
Taste	12th h	9.86±0.38^{aA}	10.00±0.00^{a}	10.00±0.00^{a}	9.71±0.49^{a}	9.71±0.49^{a}
	5	6.29±0.49^{dB}	8.71±0.49^{bcA}	9.14±0.48^{abA}	9.29±0.27^{aA}	8.43±0.53^{cA}
	10	4.29±0.49^{dC}	7.21±0.27^{bB}	6.79±0.39^{cB}	7.86±0.24^{aB}	6.64±0.38^{cB}
	15	3.00±0.00^{dD}	4.50±0.41^{abC}	4.86±0.38^{aC}	4.36±0.24^{bC}	3.64±0.48^{cC}
	20	3.00±0.00^{bD}	3.36±0.24^{aD}	3.07±0.19^{bD}	3.07±0.19^{bD}	3.00±0.00^{bD}
Texture	12th h	9.71±0.49^{aA}	10.00±0.0^{aA}	10.00±0.0^{aA}	10.00±0.0^{aA}	9.93±0.19^{a}
	5	7.71±0.49^{bB}	9.14±0.24^{aB}	9.21±0.27^{aB}	9.14±0.24^{aB}	9.00±0.50^{aA}
	10	5.29±0.49^{bC}	7.79±0.39^{aC}	7.71±0.49^{aC}	7.71±0.49^{aC}	7.50±0.50^{aB}
	15	3.86±0.24^{cD}	4.71±0.76^{abD}	4.71±0.76^{abD}	4.93±0.45^{aD}	4.36±0.24^{bcC}
	20	3.00±0.00^{bE}	3.36±0.24^{aE}	3.21±0.27^{abE}	3.36±0.24^{aE}	3.00±0.00^{bD}
General Acceptability	12th h	9.86±0.38^{aA}	10.00±0.00^{aA}	10.00±0.00^{aA}	10.00±0.00^{aA}	9.86±0.38^{aA}
	5	7.43±0.53^{dB}	9.07±0.19^{abB}	9.29±0.27^{aB}	9.21±0.27^{aB}	8.71±0.49^{cB}
	10	5.57±0.53^{cC}	7.79±0.39^{aC}	7.14±0.24^{bC}	7.86±0.24^{aC}	7.29±0.27^{bC}
	15	3.00±0.00^{cD}	4.86±0.24^{aD}	4.57±0.53^{aD}	4.71±0.49^{aD}	4.14±0.38^{bD}
	20	3.00±0.00^{bD}	3.57±0.19^{aE}	3.14±0.24^{bE}	3.43±0.19^{aE}	3.00±0.00^{bE}

Cnt: Control, G1: Poppy pulp, G2: Pumpkin pulp, G3: Black cumin pulp, G4: Sesame pulp. Different letters (a-d) in the same column and different letters (A-E) in the same row show significant differences (P<0.05).

It also scored high in terms of flavor parameters until the end of storage. Among the bacterial groups tested in the study, the sensory performance of pumpkin seed pulp, which did not show any antimicrobial effect, was high. The flavor parameter of the pumpkin seed pulp was scored significantly higher than the other groups until the 16th day of storage by the paneslites. Also, poppy pulp was in the second place in terms of flavor parameters after the pumpkin seed pulp group from the beginning of the storage, while the last two days of storage had the highest. When the sensory results were evaluated together with the microbiological and chemical results, it was observed that G1, G2 and G3 gave highly effective results as edible coating materials.

Conclusion

According to the results of the current study, the antimicrobial and antioxidant effects of the pulp differed depending on the species, all test groups benefited in terms of quality compared to the control. The results of the study revealed that using the pulp obtained from oil extraction from the plants, as fish coating material, decreased the TBARS, PV, TVC and MY values and increased the sensory quality. The positive effects of the waste pulp investigated in the study on the quality and taste of fish flesh will inspire industrial processing units as well as restaurants that cook fish as a new presentation style.

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