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Effects of Glazing, Packaging and Phosphate Treatments on Drip Loss in Rainbow Trout (*Oncorhynchus mykiss* W., 1792) During Frozen Storage

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Abstract

Fresh rainbow trout (*Oncorhynchus mykiss* W., 1792) were frozen with different pre-freezing treatments in an air blast freezer (–35°C) and stored at –25°C for 12 months. The treatments were done using 10% sodium polyphosphate and 3% sodium metaphosphate with 4% NaCl solutions and glazing + packaging to prevent drip loss in the frozen fish. The effect of glazing + packaging treatment on drip loss during frozen storage was significant ($p<0.05$) but none of the other treatments were effective ($p>0.05$). In other words, neither phosphate usage nor glazing treatment was effective when used by itself to prevent drip loss in the frozen rainbow trout. However, the combination of glazing + packaging did prevent drip loss and protect the moisture content of the inner and surface layers of the product. In addition, the effect of gutting during the pre-freezing stage on drip loss during frozen storage was not significant.

Key Words: Rainbow trout, phosphate, glazing, drip loss, packaging.

Introduction

Deterioration of seafood begins immediately upon harvest, and continues to various degrees depending on storage conditions. The best method of preserving of seafood is freezing and storing at low temperatures. If properly frozen, seafood retains quality and flavour. Quickness of freezing determines the quality after thawing (Pigott and Tucker, 1990). Upon thawing, there is a loss of fluid from the flesh of any fish product, which is explained by the denaturation of protein during the freezing process, which causes the protein to lose its water-binding capacity. The amount of protein denaturation depends on the concentration of enzymes and temperature (Garthwaite, 1992). Drip loss, or the release at water during thawing, implies nutrient loss. Little drip loss occurs when the products are frozen quickly and stored properly, but if not, excessive drip loss can occur and render making the products unfit for consumption (Graham, 1982). It has been reported that the usage of polyphosphate dips increases water-holding capacity of flesh and reduces drip and deterioration of the quality (Pigott and Tucker, 1990). Polyphosphates are legally permitted additives that are widely used to facilitate processing or to improve the quality of many foods, particularly that of meat and fish products. The main value of polyphosphates lies in increasing the water-retaining capacity of protein in fish. The phosphates used in foods may be simple phosphates, containing one phosphate unit; pyrophosphates, containing two phosphate units; tripolyphosphates, containing three units; or polyphosphates, containing more than three phosphate units (Aitken, 1975). Monophosphates and polyphosphates are used alone or in combination with salt in meat and fish processing (Antoine *et al*., 2000). Polyphosphates are generally used in 10% concentration commercially (Graham, 1982). However, polyphosphate with salt is used in a concentration of 3-8% phosphate + salt (Sutton, 1969). Phosphates ability to stabilize proteins against denaturation, increase of water binding capacity, improve emulsification and buffering capacity (acid-base relationships), contribute nutrients, chelate metal ions and function as antioxidants are among their contributions to a variety of foods and food products. Protein reactions and water binding are perhaps the most important reasons for the usage of phosphates in seafoods. Phosphates are effective on fish and shellfish in preventing drip loss when frozen products are thawed and in enhancing tenderness by restricting protein denaturation during freezing and frozen storage (Reddy and Finne, 1986). Hydrolysis of polyphosphates either enzymatically or nonenzymatically readily occurs during fresh and frozen storage with orthophosphate, which cannot be differentiated from the naturally occurring phosphate (Sturno *et al*., 1987).

Polyphosphate treatment of fish before freezing often reduces the amount of thaw drip that is the liquid released when frozen fish is thawed. Good quality fish with properly frozen and cold stored, normally develops little thaw drip; therefore, application of polyphosphate to such material is generally only of slight value. The poor quality fish may drip much more after freezing and thawing stages and treatment will reduce the loss to some

extend. However this is not a sufficient reason for using polyphosphates. Poor quality fish should not be frozen, since the product will be poor irrespective of treatment. The first and universal effect of all polyphosphate treatment is to increase the weight of the fish by retaining water. The weight gain is not only technological benefit but also represents to the producer a gain in weight of product sold. Polyphosphates should be added to fish only for technically justifiable purposes (Aitken, 1975).

One problem encountered by producers of both fresh and frozen seafood is dehydration of product and so the product must be protected from dehydration. Two protective methods are used, usually in combination: glazing and packaging. Good packaging prevents the circulation of air over the surface of the product and protects the moisture in the surface layers of the product (Dore, 1991).

The aim of this study was to determine the effects of phosphates and glazing + packaging treatments on the drip loss in frozen rainbow trout.

Materials and Methods

Sampling and Experimental Design

Ninety eight rainbow trouts (*Oncorhynchus mykiss)* used (14 fish in each group) in this experiment were obtained alive from a commercial firm. Their average weight was 236, 36 ± 9, 85 g. This experiment was carried out with two replicates. Samples of the fish were treated under the following conditions:

1st group- Gutted fish were washed, dipped into 10% sodium polyphosphate solution for 3-4 minutes, and then were individually frozen, glazed and packaged with shrink film.

2nd group- Whole fish were washed, dipped into 10% sodium polyphosphate solution for 3-4 minutes, and then were individually frozen, glazed and packaged with shrink film.

3rd group- Whole fish were washed, dipped into 10% sodium polyphosphate solution for 3-4 minutes, and then were individually frozen, glazed but unpackaged.

4th group- Whole fish were washed, individually frozen, glazed but unpackaged.

5th group- Gutted fish were washed, dipped into 3% sodium metaphosphate with 4% NaCl solution for 3-4 minutes, and then were individually frozen, glazed and packaged with shrink film.

6th group- Whole fish were washed, dipped into 3% sodium metaphosphate with 4% NaCl solution 3-4 minutes, and then were individually frozen, glazed and packaged with shrink film.

7th group- Whole fish were washed, individually frozen, glazed and packaged with shrink film.

All fish were individually frozen on polystyrene dish in air blast freezer with 5m/s air velocity at –35°C. Glaze was carried out that by dipping of fish into the ice water (0°C) for 3-6 sec. Glaze were repeated three times with 5-10 sec intervals. Glazed fish were packaged manually with shrink film. All the groups were stored at –25°C in deep-freezer for 12 months. Analyses of the frozen rainbow trout were carried out at 2nd, 4th, 6th, 8th, 10th, 12th months from the beginning of frozen storage.

Preparation of Fish Samples for Analysis

Two frozen fish were selected randomly from each group for each month and thawed in refrigerator conditions (+4°C) overnight. Thawed fish were weighed and the amount of thaw drip was calculated according to the following formula:

% Thaw drip = [(Initial wt of fish- Final wt of fish) / Initial wt of fish] x 100 (Santos and Regenstein, 1990).

Statistical Analyses

Data were analyzed statistically by the ANOVA-Two way with replication methods. Statistical significance was indicated for 0.05 levels. Comparisons between treatments were made by Duncan tests where appropriate (Düzgüneş *et al*., 1993).

Results

The results concerning the drip losses are shown in Table 1 and Figure 1.

According to results of the analysis of ANOVA, the effect of both storage period and pre-freezing/post-freezing treatment on drip loss was found significant ($p<0.05$). The Duncan multiple range test was performed on the data to assess any significant differences between the groups and months (Table 1).

There was no difference with regard to drip loss during the storage period between gutted fish (1st group) and the whole fish (2nd group) both dipped into 10% sodium polyphosphate solutions separately. Same result was observed between 5th and 6th groups. These results indicated that gutting has not affected the drip loss. The effect of different phosphates on drip loss (between 1th 2nd group dipped into 10% sodium polyphosphate and 5th 6th groups dipped into 3% sodium metaphosphate with 4% NaCl) was not significant.

In the 1st and 2nd groups dipped into 10% sodium polyphosphate that were pre-frozen and glazed, wrapped post-freezing were observed weight loss of average 2%. In the 5th and 6th groups dipped into 3% sodium metaphosphate with 4% NaCl solution and glazed, wrapped post-freezing were observed weight loss of average 3% during the storage period. Average 4.2% weight loss was observed in the 7th group during

Table 1. Weight loss (%) of rainbow trout during the storage period

MONTH	1.GROUP [A]	2.GROUP [A]	3.GROUP [B]	4.GROUP [B]	5.GROUP [A]	6.GROUP [A]	7.GROUP [A]
Initial	100.00±0.00[a]	100.00±0.00[a]	100.00±0.00[a]	100.00±0.00[a]	100.00±0.00 [a]	100.00±0.00[a]	100.00±0.00[a]
2	98.28±0.41[bc]	99.04±0.04[ac]	95.96±0.49[bc]	96.73±1.68[b]	99.59±0.01 [ab]	99.60±0.01[a]	99.59±0.00[ab]
4	99.42±0.35[ab]	99.11±0.25[ac]	96.97±0.19[bc]	96.23±0.03[b]	99.26±0.00[abc]	99.28±0.01[ab]	99.24±0.00[ab]
6	99.54±0.37[ad]	99.31±0.25[ac]	94.89±0.14[c]	95.56±0.46[b]	98.83±0.00[abc]	98.87±0.02[ab]	98.47±0.00[bc]
8	99.82±0.17[a]	98.96±0.17[ac]	93.56±0.60[d]	93.36±0.56[c]	98.72±0.01[bc]	98.74±0.00[ab]	98.58±0.51[bc]
10	97.81±0.44[c]	97.70±0.69[b]	92.45±0.40[d]	93.26±0.22[c]	98.23±0.00[cd]	98.25±0.01[bc]	97.34±0.01[c]
12	98.37±0.09[cd]	98.12±0.57[bc]	90.19±0.79[e]	90.39±0.33[d]	97.11±0.00[d]	97.25±0.01[c]	95.87±0.01[d]

[A, B] (→): Statistical significance of differences between groups ($p<0.05$)
[a, b,...e] (↓): Statistical significance of differences between months ($p<0.05$)

the storage period. No difference was observed between the 7th group and 1st, 2nd, 5th, 6th groups from the point of view of mean values obtained during the storage period. That is to say; usage of 10% sodium polyphosphate and 3% sodium metaphosphate with 4% NaCl solution was not effective in preventing drip loss. There was a weight loss of average 10% in the 3rd group and the 4th group during the storage period. Difference between these two groups was insignificant from the point of drip loss.

Discussion

The drip loss values for all groups are presented in Figure 1. In detail, there was a significant decrease in weight of 3rd and 4th groups among all the groups. In general, less drip loss was observed in packaged samples than the unpackaged samples. The differences between groups with and without phosphate were not significant while the differences were significant between the packaged and unpackaged ones. Although more drip loss was expected in gutted than ungutted groups, the result was not observed. This case may be attributed to glazing and packaging treatment. In our experiment, usage of sodium polyphosphate and sodium metaphosphate with NaCl was not effective in preventing drip loss of rainbow trout. These results suggested that the glazing + packaging were more protective than using of phosphate against drip loss in rainbow trout during frozen storage.

Numerous investigators have reported varying results on the use of polyphosphates in fish. Dyer *et al.* (1964) have found that treatment with sodium tripolyphosphate (STPP) had no effect on drip loss although the net weight of the muscle increased, while MacCallum *et al.* (1964) found that it was only effective in some instances. Pre-slaughter injection of hexametaphosphate into lingcod was found to be effective in reducing drip by Buttkus and Tarr (1962). Mahon (1962) and Tanikawa *et al.* (1963) came to similar conclusions with dipped fresh haddock and frozen cod.

Whitefish fillets (*Coregonus clupeaformis*) treated with 11.8% sodium tripolyphosphate (STPP) showed better textural properties (reduced centrifugal drip, cooked drip) than untreated control samples (Krivchenia and Fennema, 1988).

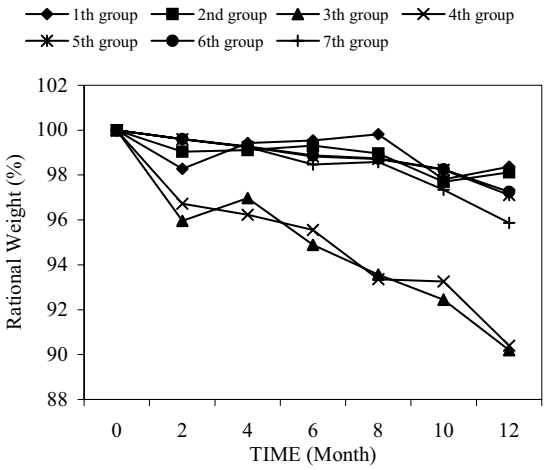

Figure 1. Changes rational weight (%) during the storage period in different groups.

According to Maccallum *et al.* (1964), cod treated with sodium tripolyphosphate (STPP) and twice-frozen were significantly better than untreated twice frozen samples as indicated by texture and thaw-drip assessments and equal to once-frozen untreated fish. This can be the result of weakening of flesh consistency due to thawing with consequent presentation of increased surface areas of the fillet to the dip solution. There was no clear evidence of improvement in single and double frozen flounder after the application of STPP dips used commercially in processing this species (MacCallum *et al.*, 1969). In some species, such as Dover sole (*Microstomus pacifucus*), Pacific cod (*Gadus macrocephalus*), halibut (*Hippoglossus stenolepis*) and red snapper (*Sebastodes ruberrimus*), STPP was effective in reducing thaw-drip in comparison with water-dipped controls but was not effective in others, e.g. Chinook salmon (*Oncorhynchus tschawytscha*) (Dyer, 1969).

Both sodium tripolyphosphate (STPP) and hexametaphosphate reduced total weight loss after cooking in Dover sole although not in Pacific salmon

(Boyd and Southcott, 1965).

The combination of brine and STPP at ionic strengths sufficiently high to promote actomyosin dissociation has recently been tested and found to be more effective than brine alone. With South African hake, stored at –12°C, STPP treatment reduced thaw-drip to about 3% from 10% to untreated control (14% in water-dipped control); a half-saturated NaCl dip gave 2% thaw-drip but the combination of half-saturated NaCl followed by STPP was more effective reducing thaw-drip to about 1% (Dyer, 1969). Half-saturated brine was compared with a dip in a mixture of half-saturated brine plus half-saturated STPP on cod fillets. Uptake of dip was very variable but greater in the mixed dip. In these samples thaw-drip levels were low initially, about 1.5%, and while levels increased on storage, the mixed dip treatment resulted in considerably less thaw-drip than brine alone (Dyer, 1969).

Sutton (1969) has found that sodium tripolyphosphate (STPP) (4, 6, 8%) definitely reduced the weight losses due to processing, and that it was more effective than pyrophosphate (2.2, 3.4, 4.5%) in cod fillets. Only a light treatment in the STPP, i.e. 0.5 min dip in a 4% solution was required to produce improvements in both the water retention and texture properties of the muscle. Addition of sodium chloride did not produce any improvement over phosphate alone.

Antonie *et al.* (2000) studied the effects of sodium tripolyphosphate (STPP) in brine (NaCl) on smoke adsorption and overall quality of cold smoked mullet. Fillets treated with 5 and 10 % STPP or 5% NaCl had 1.20, 1.45 and 2.45 % more moisture, respectively, than control. Treatment with 5 or 10 % STPP both with 5% NaCl absorbed 1.25 and 0.95% more water, respectively; water loss occurred with fillets treated with 15% NaCl, 5 and 10% STPP plus 15% NaCl. STPP enchanced the sensory perception of moistness in treated fish, because of its water retention ability. STPP in combination with NaCl, tended to reduce the relative free moisture level of the product, and at 5 and 10% did not affect the sensory evaluation of saltiness.

The greatest advantage in using brine or phosphate treatment is the increase in yield of frozen, thawed and perhaps also of cooked product. Yield of frozen product will be higher in the dipped samples by the amount of dip absorbed. With half-saturated brine (20 sec dip) this absorption is about 2 to 5% in haddock and in cod about 4% in Pacific cod and 3% in halibut and in pacific salmon. The uptake was very variable, even in fillets of the same size and from the same lot of fish (Dyer, 1969).

In our experiment, usage of sodium polyphosphate and sodium metaphosphate with NaCl was not effective to prevent drip loss in rainbow trout. This condition may be due to insufficant penetration of the chemical used into tissue of fish. A white and dry layer was seen on the surface of trout during the frozen storage may be phosphate solution that was not absorbed and than deposited. We think that glazing + packaging may be more important than phosphate treatment in frozen rainbow trout.

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