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Physical and chemical analysis of *Cynoscionstriatus* fillets immersed under different saline concentration

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Abstract**—***The aim of this work was to accomplish an investigation post-treatment in Cynoscionstriatus fillets, using different concentrations of sodium tripolyphosphate and blends containing sodium tripolyphosphate and sodium chloride, and evaluate the weight of loss and their influence on the content of total protein, moisture and phosphate. Samples underwent four treatments: sodium tripolyphosphate solutions (TPFS) 2% and 10% and blends containing sodium tripolyphosphate with sodium chloride (NaCl) 2% and 10%. 148 fillets were immersed in each treatment for 2 hours and weighted individually at three moments: prior to immersion, post-immersion and post-defrosting. Gravimeter results showed weight gain in all treatments ($p>0.05$). When TPFS 2% (0.28%) and blend 2% (8.38%) were compared, samples immersed in $Na_5P_3O_{10}$ revealed a weight gain ($p>0.01$). In treatments TPFS 10% (12.48%) and blend 10% (9.19%), the samples with only TPFS had weight increase ($p>0.01$). Solution with TPFS 10% within the context of the four treatments had the greatest weight in immersion (12.48%) and the lowest loss of water in defrosting (3.72%). Physical and chemical analyses for moisture, total proteins and phosphate had differences in weight for the four treatments ($p>0.01$), with the exception of the treatments blend 2% and blend 10%. The four treatments did not exceed the standard established by the Ministry of Agriculture (until 0.5% TPFS for every 100 g of fillet).*

Keywords**— blend, Cynoscionstriatus, freezing, gravimeter, striped; sodium tripolyphosphate.**

I. INTRODUCTION

Fish commercialization in Brazil is generally limited to fresh fish, which is composed about 60 to 80 % of water. The quality of the end-product is directly related to handling, storage and transport conditions (Santos, 2006), and fish preservation methods are significant factors for the maintenance of the product's quality for the consumption.

Since water loss occurs in fish from capture to industrial processing, hydration and moisture retention of fish is highly recommended through the addition of phosphate as a guarantee of quality. Water loss during industrialization and storage is significant to determine the products quality and its shelf-life (Suñe et al., 2009). Sodium tripolyphosphate (TPFS) is one of the most employed phosphates in fish industry, since it is a compound that maintains moisture (FDA, 1993). Phosphates increase the capacity of retaining water, protect the product from oxidative rancidity, enhance quality and warrant improvement in taste (Marujo, 1988).

After capture, the myofibrillar proteins of fish deteriorate fast, at a refrigeration temperature of 5 °C and may lose 80 % of their water-retaining capacity in up to 5 days. If the proteins remain unprotected, significant loss occurs causing a lower net weight, with economical liabilities for the fish industry (Lampila, 1992; Schnee, 2004). The consumer is directly affected when fish loses great quantities of water, which involves loss of weight and quality, and may alter texture, color and tenderness of the fish fibers and, consequently, a low-quality product is obtained.

Phosphates restore the capacity of the proteins water retention, since they keep the products natural moisture and minimize loss by drip loss during freezing storage, defrosting and cooking. Sodium chloride (NaCl) presents an important role in increasing water retention capacity, reduces drainage and, together with phosphate, has a synergic effect. However, water retention capacity by fish fibers and TPFS activities at different concentrations has not yet been successfully explained. According to Castro

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(2007), water retention capacity is directly related to the tenderness of processed products and decrease in size and tastiness is related to water loss during the products storage and cooking. According to the Brazilian legislation (BRASIL, 1970), up to 0.5 g of TPFS is allowed for every 100 g of fillet.

Based on the current problematic, the aim of this work was to accomplish an investigation post-treatment in *Cynoscionstriatus* fillets, using different concentrations of sodium tripolyphosphate and blends containing sodium tripolyphosphate and sodium chloride, and evaluate the weight of loss and their influence on the content of total protein, moisture and phosphate.

II. MATERIALS AND METHODS

Fish fillets came from an industry from Porto Belo City, Santa Catarina State, Brazil. When fish was hauled up at the industrial premises, filleting was processed and 37 samples of fresh striped weakfish (*Cynoscionstriatus*) were retrieved for each of the four treatments: TPFS 2%; TPFS 10%; blend 2% (TPFS + NaCl) and blend 10% (TPFS + NaCl), with a total of 148 fillets.

All fillets were identified with a numbered tag and weighed individually on an analytic scale. They were weighed again after immersion and after defrosting. Weight gain was given in percentage (%, w/w) as water absorbed after immersion (drained weight) and calculated according to Equation (1).

$$\text{WG } (\%) = \frac{\text{net weight} - \text{initial weight}}{\text{initial weight}} \times 100 \quad (1)$$

After weighed each one, fillet samples were immersed during 2 hours. After resting for 30 minutes to drain waste water, they were weighed again. Chemical analyses for protein, moisture and phosphate for each variable were undertaken for each treatment.

Samples were fast frozen in a freezing tunnel at -38°C after immersion. After a 22 day freezing, the fillets were thawed for 24 h at room temperature and samples were collected for physical and chemical analyses.Seven samples were collected at random from each of the four treatments. Three distinct instances were taken into account for physical and chemical analyses: fish fillet without any immersion; fish fillet after 2 h of immersion; thawed fish fillet after 22 days in a freezing chamber. Total proteins, moisture and phosphate rates were analyzed according to AOAC (1999).

Statistic SPSS 17.0 was used for statistical analysis. Data analysis was based on parametric descriptive statistics whereas Student´s t test was used for dependent samples at significance level up to $p<0.05$.

III. RESULTS AND DISCUSSION

Table 1 shows that fish fillets immersed in a solution of TPFS 2% increase in weight, from T0 to T1, or rather, from 60.73 g to 66.60 g. In T2 the same fillets lost weight, reaching 61.53 g. In spite of losing weight in T2 (thawing), weight rates were higher (61.53 g) than those at T0. Weight rates of fish fillets varied between 41 and 97 g. Results for immersion in TPFS 2% on Table 1 demonstrated that weight gain was significant when T0 and T1 were compared at significance level ($p<0.01$).Weight gain between T0 and T2 and between T1 and T2 was also significant ($p<0.05$). Results of fish fillet immersion in TPFS 10% (Table 1) showed T0 weight average at 58.26 g, whilst mean of T1 revealed a higher rate (65.46 g). Weight mean 63.06 g was reported in T2. Rates of fillet weight ranged between 43 and 92 g in the treatment. Results for solution TPFS 10% revealed that weight gain of fish fillet was significant when T0 and T1 and when T0 and T2 were compared ($p<0.01$). There was significant difference in weight between samples ($p<0.01$) when T1 and T2 were compared.

Table 1. Descriptive statistics of fish fillets immersed in solutions TPFS 2% and 10%, in grams.

TPFS 2%					
	N	Minimum	Maximum	Means	DP
T0	30	41.00	90.00	60.73	11.66
T1	30	46.00	97.00	66.30	12.32
T2	30	42.00	94.00	61.53	11.99
TPFS 10%					
	N	Minimum	Maximum	Means	DP
T0	30	43.00	85.00	58.26	12.64
T1	30	48.00	97.00	65.46	13.87
T2	30	46.00	92.00	63.06	13.60

T0 – initial weight (fish in natura) of fillet;T1 – weight after immersion process of fish fillet; T2 – weight after defrosting of fish fillet.

Higher aggregation of water in fish fillets in solutions TPFS 2% and 10% is probably due to the fact that, in the production of frozen products, phosphates solubilize proteins which help in the water retention of the fillets. Phosphates, therefore, decrease loss of juice with proteins during thawing, resulting in a tenderer, tastier and more succulent product (FANI, 2009).

According to Table 2, Blend 2% (TPFS + NaCl) revealed that mean weight of fish fillets at T0 was 54.93 g, whereas T1 provided a higher rate (59.36 g), which is different from T2, with 55.20 g. Weight rates of fish fillet in this treatment ranged between 40 and 88 g. When differences between T0 and T1 and between T0 and T2 are taken into account, it may be stated that weight gain of fish fillets was significant ($p<0.01$).

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Table 2.Descriptive statistics of weights T0, T1 and T2 of fish fillets immersed in Blend 2% and 10%, in grams.

			Blend 2%		
	N	Minimum	Maximum	Means	DP
T0	30	40.00	83.00	54.93	12.50
T1	30	43.00	88.00	59.36	12.77
T2	30	40.00	82.00	55.20	12.08
			Blend 10%		
	N	Minimum	Maximum	Means	DP
T0	30	41.00	94.00	59.60	13.88
T1	30	46.00	101.00	65.00	14.79
T2	30	43.00	98.00	62.36	14.64

T0 – initial weight (fish in natura) of fillet; T1 – weight after immersion process of fish fillet; T2 – weight after defrosting fish fillet.

Table 2 shows results after treatment on fish fillets immersed in Blend 10% (TPFS + NaCl). T0 provided weight 59.60g and T1 65 g. As in all treatments, T2 with 62.36 g had the lowest weight when compared to that of T1. Weight rates of fillets varied between 41 and 101 g. Results showed that weight gain of fish fillets was significant ($p<0.01$) when T0 was compared to T1 and T0 was compared with T2. Weight gain in T1 occurred in the four different solutions. According to Fani (2009), the above was due to the fact that myofibrillar proteins, myosin and actin constituted a significant volume of the muscle. In fact, changes in the retention capacities of water in the muscles occur because of water retention in the myofibrils. It is precisely the high capacity of protein water retention in fish muscles that provides fish meat with its typical succulence. The enzymes activity in fish after death, may have affected the aggregation of water in the muscle fibers. Due to the activity of tissue proteases and lipases, autolysis softens fish meat (Tavares et al., 1988). Meat softening means the loosening of muscle fibers and the increase of the space between, which provide more space for the incorporation of water among the muscle fibers.

There was a weight loss in T2 for all treatments with regard to T1. Figure 1 shows that, when fish is frozen, freezing nuclei do not lie among the myofibrils but among the muscle cells. As ice crystals increase, water is removed from the myofibrils and cells are condensed. Freezing causes the condensation of fibers and myofilaments become closer (Figure 1). Since fish was already frozen when stored for 22 days, interactions among the myofilaments might have occurred. Water does not return to the cells during thawing and extracellular spaces are left. Some water may actually be lost by drip loss and thus loss of moisture (Fani, 2009). Crystal formation during freezing also deforms the cell membrane with subsequent dehydration and atrophy of the muscle tissue. During thawing, cell liquid is lost with a consequent undesirable texture and taste when compared to the in natura prime matter (Chevalier; Le Bail; Ghoul, 2000).

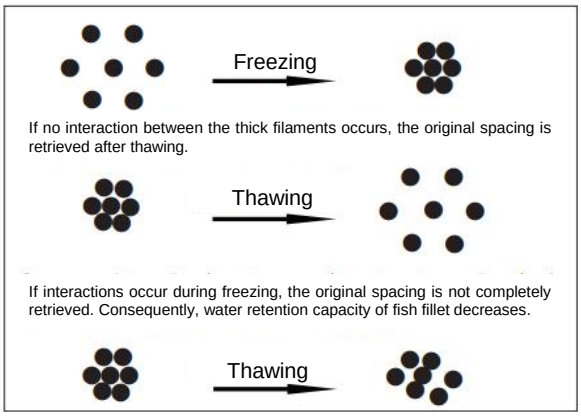

Fig.1:Interaction of filaments of myofibrils during the freezing process.
Source: Fani, 2009.

Weights compared treatments with TPFS and Blends 2% in immersion. Comparisons were undertaken by the differences between gains and losses of weight between T0 and T1; T0 and T2; T1 and T2 (Figure 2).

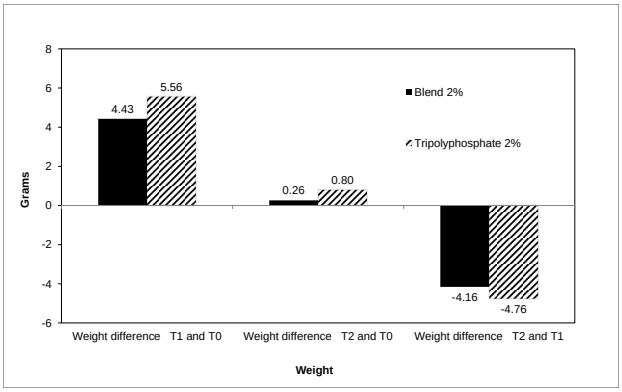

Fig.2: Weight differences between immersion in blend and sodium tripolyphosphate 2%.

Figure 2 demonstrates that treatment with TPFS 2% provides the highest weight gain when the differences between T0 and T1 and between T0 and T2 are compared, with their respective rates 5.56 g and 0.80 g in weight gain. Treatment with Blend 2% revealed very low differences in weight gain, with rates 4.43 g and 0.26 g. Contrastingly, when T1 and T2 were compared, TPFS provided the highest loss (4.76 g), whereas Blend 2% lost 4.16 g. Significant differences in weight gain occurred between T0 and T1 ($p<0.01$).TPFS had the highest weight gain between T0 and T1 and between T0 and T2, respectively 7.02 g and 4.80 g, when treatments of concentrations TPFS and Blend 10% in immersion solutions were compared (Figure 3). Concentration of Blend 10% had the highest weight loss (2.63%) between

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T1 and T2. Significant differences in samples weight gain were registered between T0 and T1; T1 and T2; T0 and T2 ($p<0.01$).

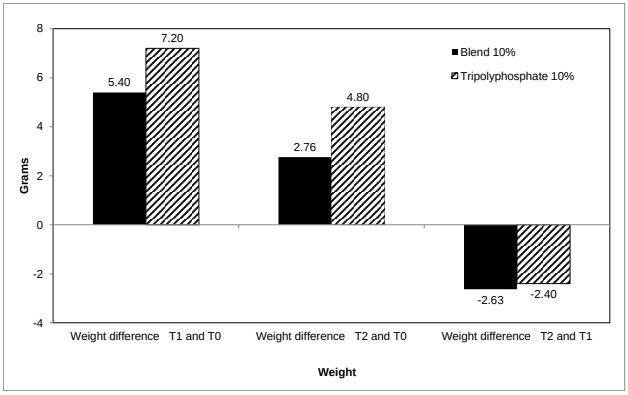

Fig.3: Weight differences between Blend and TPFS 10% immersions.

Actually TPFS 10% treatment caused highest weight gain and the lowest water loss rate. High percentage concentration in TPFS solution may have affected directly the final result. Maki (1987) reported that a significant increase of total and sarcoplasmatic proteins of muscle fibers occurred when only phosphates were added to the immersion solution of meat products, with an improvement in their softness. In a study on turkey sausages, Teicher (1999) observed that phosphates made them more succulent when compared to control. Results showed the efficiency of TPFS when water is aggregated to fish fillets. The theory by Brasil (2003) that there was significantly less protein loss during defrosting with TPFS in the meat has been thus corroborated

Table 3 presents the results of moisture percentage of fish fillet.

Table.3.Moisture percentage of fish fillet immersed in treatment TPFS and Blends 2% and 10%.

Treatment	Post-immersion (%, w/w)	Post-defrosting (%, w/w)	Difference (%, w/w)
TPFS 2%	83.28	81.20	2.08
TPFS 10%	84.20	83.01	1.19
Blend 2%	83.01	80.70	2.30
Blend 10%	84.05	82.10	1.95

Moisture percentage is directly related to the amount of water available in fish fillet. Moisture rates are weight losses of fillet when heated and water is removed. Moisture percentage in fish ranged between 60% (w/w) and 85% (w/w) (Ogawa & Maia, 1999). After TPFS treatments, moisture rates 83.28% (w/w) and 84.20% (w/w) were reported for concentrations 2% and 10%, respectively. Moisture rates 83.01% (w/w) and 84.05% (w/w) were respectively registered for treatments with Blends 2% and 10% (Table 3). On the other hand, fresh fillets *in natura*, revealed a moisture rate of 81.74% (m/m).All moisture percentages in all treatments in current assay were higher than those in natura when moisture rates of fresh fish, without immersion, were compared. Lampila (1992) reports that the moisture rate of commercial fillet is expected to be lower than 80%, and rates above 80% indicate pre-treatment of fillets. Current results partially agree with those by Lampila (1992), since moisture of fresh fillet revealed rates above those in the literature. Results on moisture rates may have been affected by the temperature of the buffer and environment humidity, with changes in the final percentage.

All treatments showed decrease in moisture levels for weights in the post-defrosting period (Table 3). In experiments with shrimps immersed in TPFS, Garrido (2005) reported lower rates in post-defrosting weight than those in post-immersion weight. Moisture loss in the post-defrosting period may show that TPFS and Blends tended to retain water in fillets. Gonçalves (2005) registered that freezing might decrease moisture rates in shrimps and might affect their acceptability by consumers. Dehydration and atrophy of the muscle tissue was common since defrosting caused the loss of much cell liquid (Chevalie; Le Bail; Ghoul, 2000). Moisture rates in fillets were thus decreased (Table 3).

Table 4 shows that protein rates increased in the four treatments when compared with post-immersion and post-defrosting weights.

Table 4.Protein rates in fish fillets immersed in treatments with TPFS and Blends 2% and 10%.

Treatment	Post-immersion (%, w/w)	Post-defrosting (%, w/w)	Difference (%, w/w)
TPFS 2%	15.19	15.72	3.37%
TPFS 10%	14.8	15.49	4.45%
Blend 2%	15.05	15.57	3.34%
Blend 10%	15.43	16.09	4.10%

Results contrast the theory that the quality of frozen meat products was affected by moisture loss during freezing, with a decrease in succulence and other changes due to protein denaturation (Gonçalves, 2005). The defrosting system failed to decrease the protein rates, probably due to the phosphates cryoprotectant activity. Research with treatments involving immersion of phosphate with shrimps and with chicken sausages also showed higher post-defrosting protein rates(Gonçalves, 2005). Lampila (1992) showed that phosphates warranted cryoprotection to fish fillet proteins. Table 4 actually shows that phosphate immersions of fillets have greater differences in the increase of protein rates after defrosting. Table 4 demonstrates that, when treatments with phosphates in

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immersion are compared, treatments with high rates of TPFS 10% had the highest increase in protein quantity, with an increase of 4.45 % (w/w), with regard to post-immersion and post-defrosting weight difference. According to Varnam& Sutherland (1995), phosphates ruptured protein structures, decreased the interaction of proteins and increased protein solubility. In other words, water was incorporated owing to the protein´s electric unstableness with polyphosphates owing to an increase of the product´s moisture rate. TPFS is employed as a quality-improving agent in fish fillet processing (Cui; Cai; Xui, 2000).

Table 5 demonstrated that amount of TPFS in the post-immersion weight of fish fillet was directly proportional to the concentration of the immersion solution. The higher the solution´s concentration, the higher TPFS rates were absorbed in fish fillets. Difference in post-immersion and post-defrosting weight in the four treatments was low (Table 5). Loss of TPFS in post-defrosting weight occurred in all treatments. In his experiments with shrimps, Gonçalves (2005) found that defrosting after immersion maintained the same TPFS rates in the two weightings.

Table 5.Phosphate percentage in fish fillets immersed in treatments TPFS and Blends 2% and 10%.

Treatment	Post-immersion (%, w/w)	Post-defrosting (%, w/w)	Difference (%, w/w)
TPFS 2%	0.30	0.32	0.02
TPFS 10%	0.41	0.39	0.03
Blend 2%	0.32	0.30	0.01
Blend 10%	0.38	0.36	0.02

The four treatments, including treatment with immersion solution TPFS 10%, revealed phosphate rates within the allowed limits, or rather, 0.5% phosphate established by BRASIL (1970). Rodrigues (2005) treated conger fillets with phosphates, albeit with different solution concentrations and immersion time (TPFS 5% for 60 minutes; Blend 10% for 30 minutes) and provided phosphate rates below 0.5%, complying with Brazilian legislation. In his studies on pre-cooked de-shelled mussels immersed in the same concentrations and times, following Rodrigues (2002), Rech (2005) reported phosphate rates lower than 0.5% in the end-product, after defrosting, or rather, within MAPA standards.

IV. CONCLUSION

Results in current study showed that: treatments with TPFS 10%, Blend 2% and Blend 10% provided significant weight gain (p>0.01). Treatment with TPFS 2% also had a significant weight gain at 5% significance level.Comparison of immersed treatments at 2% showed that TPFS had higher significant weight gain (p>0.01). Samples with immersed treatments at 10%, with only TPFS, showed greater weight at significance level p>0.01. Although NaCl had a synergic activity with TPFS, it did not show the same efficiency in weight gain when compared to solution with TPFS only.Solution with TPFS 10% had the highest weight gain in immersion and lost less water in defrosting, when compared to all the other treatments.Moisture and total protein analyses revealed significant difference (p>0.01). The freezing process affected the number of protein through the phosphates cryoprotection activities.Phosphate quantity analyses also showed significant alterations (p>0.01), with the exception of treatment with Blends 2% and 10%. All four treatments demonstrated phosphate rates within standards, namely, up to 0.5% of sodium tripolyphosphate per 100g of fillet.

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