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Do phosphates improve the seafood quality? Reality and legislation

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Abstract: Phosphates are natural components of almost all foods and are also used as functional food additives in food processing. In the seafood industry, phosphates have a wide application and are providing many functional uses. Consumers should be able to acquire seafood with as little loss of content and quality as possible. An appropriate treatment of the seafood with phosphates should be chosen carefully, based on the seafood species, product type and according to the consumer's expectations and international legislations. Moreover, phosphates cannot substitute an inadequate handling and cannot improve the quality of a poor product. The conditions of the product and its quality should be evident and documented during the whole processing.

Key words: Seafood, phosphates, quality, legislation.

Resumo. Os fosfatos melhoram a qualidade do pescado? Realidade e legislação. Os fosfatos são componentes naturais de quase todos os alimentos e também são utilizados como aditivos alimentares no processamento dos alimentos. Na indústria do pescado, os fosfatos têm uma ampla aplicação e fornecem múltiplos usos funcionais. Os consumidores devem adquirir pescado com pouca perda de conteúdo de água e de qualidade, o máximo possível. Um tratamento adequado do pescado, com fosfato deve ser cuidadosamente escolhido, com base na espécie, tipo de produto e de acordo com as expectativas do consumidor e de legislações internacionais. Além disso, os fosfatos não podem substituir um tratamento inadequado e não pode melhorar a qualidade de um produto pobre. As condições iniciais do produto e sua qualidade devem ser evidentes e documentadas durante todo o tratamento.

Palavras chave: pescado, fosfatos, qualidade, legislação.

Industrial Relevance

This review intend to show for researchers and seafood industrials the potential use of additive phosphate in industrial applications; showing the importance of legislation and limit use. The phosphates application in seafood is shown promising, but it has to be used with criterion. The incorrect or abusive use will lead to sensorial failures and besides that, it can characterize economic frauds.

Introduction

Seafood is very popular in the world, with high nutritional value, what explains the high demands on the part of the consumers. Besides, the growing costs of these products generate higher quality expectations. Consumers should be able to obtain "seafood products" of high quality, best appearance and little weight loss, mainly the frozen products (Gonçalves 2004a, 2004b, 2005; Schnee 2004).

Shortly after the capture, a series of complex alterations (biochemical and microbio-logical) occurs on the surface and inside the edible portion of all seafood, resulting in a decrease of its quality. Water is the most abundant component in its muscle, considering weight as well as volume (70-80%). As a main component, it influences the seafood sensorial attributes, its shelf life and quality. However, a part of this water is lost during transportation, from its capture to its processing and posterior comer-cialization, through drip, evaporation and/or cooking (Toldrá 2003; Gonçalves 2004a, 2004b).

Thus, the seafood processing companies have a great concern in retaining this water, first for economic reasons (seafood is sold by weight) and secondly, for the quality of the final product (Toldrá 2003). On the other hand, an excessive loss of water can generate a great dissatisfaction on the part of the consumers for the following reasons: (a) the drip of the fish generates an undesirable appearance; (b) cooking reduces the size of the fish; (c) and mainly, the loss of the sensorial attributes (juice, texture and color) makes the seafood less attractive.

Use of phosphates in seafood

Aware of the loss of water during the capture and processing, the commercial practices have been involving the control, addition (hydration) and retention of the moisture of the fish during the capture, processing, distribution, storage and preparation. The treatment of the fish with phosphates, to guarantee its quality, has been used for many years. However, excessive addition of water can lead to adulteration resulting in economic fraud, while a limit of water and loss of water can endanger the quality, the shelf life and the acceptance of the product by the consumer (Schnee 2004; Garrido & Otwell 2004).

Among the functional properties changed by the addition of phosphates in seafood and its products are: (a) the retention of the moisture and natural flavor, inhibiting the loss of fluids during the distribution and the comercialization, (b) the emulsifying (mainly in sausage products), (c) the inhibition of the process of lipid oxidation (by the quelation of metallic ions), (d) the stabilization of the color, and (e) the cryoprotection which contributes to the extension of its shelf life (Neto & Nakamura, 2003; Schnee 2004; Ünal *et al.* 2004).

Recently, the use of phosphates in some segments of the fishing industry has been object of meticulous exam of the governmental institutions in several countries, including Brazil. When used inadequately, the excessive absorption of moisture can lead to economic fraud accusation. However, when applied criteriously, the phosphates retain the natural moisture resulting in softer and succulent products. It is important to highlight that the polyphosphates should never be used to mask an inferior or deteriorated quality product (Aitken 2001; Neto & Nakamura 2003).

Classification and nomenclature

The phosphates are obtained by the refine of the calcium phosphates that occur naturally in the mineral rocks. Through total or partial neutralization of the phosphoric acid with alkaline metallic ions (sodium, potassium or calcium), two phosphate classes are formed: orthophosphates and pyrophosphates (Dziezak 1990; Lampila 1992; Neto & Nakamura 2003; WFM 2004).

The basic structures for the salts of phosphate are the orthophosphoric acids. The salts formed by the reaction with a base, as the sodium hydroxide, are for that reason referred to as orthophosphates, besides other salts of sodium which are also presented on Table 1, with the common nomenclatures in the literature, as well as the code International Number System for Food Additives - INS (Marujo 1988; Dziezak 1990; Teicher 1999; Neto & Nakamura 2003; WFM 2004).

Table 1. Phosphoric acid and sodium orthophosphates.

Name	INS
Phosphoric Acid, Orthophosphoric Acid, Monobasic Sodium Phosphate (MSP)	338
Monosodium Phosphate, Monosodium Orthophosphate, Sodium Biphosphate	339i
Dibasic Sodium Phosphate (DSP), Disodium Phosphate, Disodium Orthophosphate	339ii
Tribasic Sodium Phosphate (TSP), Trisodium Phosphate, Trisodium Orthophosphate	339iii

Source: Teicher (1999)

When the orthophosphates are heated under controlled conditions of pH, reactions occurs, or they condense forming the pyrophosphates or diphosphates. If, under controlled conditions, higher temperatures are used, it will promote the polymerization, producing the tripolyphosphates and components of larger molecular weights. Table 2 presents the additives more commonly used in the processing of meats, chickens and seafood (Dziezak 1990; Teicher 1999; WFM 2004).

Table 2. Sodium pyrophosphates and sodium polyphosphates.

Name	INS
Sodium Acid Pyrophosphate (SAPP), Dihydrogen Sodium Pyrophosphate, Dihydrogen Sodium Diphosphate, Disodium Pyrophosphate, Dibasic Sodium Pyrophosphate	450i
Tetrasodic Pyrophosphate (TSPP), Sodium Pyrophosphate, Sodium Pyrophosphate Tetrabasic, Sodium Diphosphate	450iii
Sodium Tripolyphosphate (STP), Pentasodic, Sodium Triphosphate	451i
Sodium Hexametaphosphate (SHMP), Sodium Polyphosphate, Sodium Metaphosphate	452i

Source: Teicher (1999)

Physical and chemical properties and their functions

According to Marujo (1988), Food Chemicals Codex establishes the following specifications for the phosphates to be used in food: High degree of purity (variable according to the product), Arsenic (maximum 3 ppm), Fluoride (maximum 50 ppm), Lead (maximum 5 ppm), Heavy metals (maximum 10 ppm), Insolubles (maximum 0.1%).

In the seafood applications, the phosphates more commonly used are pure Sodium Tripolyphosphate (STP) or in mixtures with Sodium Hexametaphosphate (SHMP) or Sodium Acid Pyrophosphate (SAPP) and/or Tetrasodic Pyrophosphate (TSPP), because they show a combination of properties, such as solubility, adjustment of the medium pH and tolerance to the ions Mg^{2+} and Ca^{2+}, frequently present in the processing water. Some typical properties are summarized on Table 3 (Teichner 1999; Neto & Nakamura 2003; Ünal *et al.* 2004).

Table 3. Properties of the commonly used phosphates.

Properties	STP	SHMP	SAPP	TSPP
pH (aqueous solution 1%, 25°C)	9,8	6,9	4,4	10,2
Solubility (g/100g; sol./sol.)	13	> 60	13	6
P_2O_5 (%)	58	67	63	53
Total Na_2O (%)	42	32	28	46

Source: Marujo (1988); Dziezak (1990); Teicher (1999)

Hydration and water holding capacity

According to FDA (1993), sodium tripolyphosphates are additives of the phosphate family used in the seafood industry with a humectant function, i.e., those substances maintain the moisture of the product, being more used in scallops, shrimp and lobsters processing.

According to Detienne and Wicker (1999), interaction of the polyphosphates with the muscular tissue and the hydration and tenderization mechanism of the meat, have not been completely understood. Some hypothetical factors discussed among several researchers have shown that the actions of the polyphosphates in the muscular tissue can happen due to (a) the increase of the pH of the meat, (b) the increase of the ionic force, (c) the quelation of metallic ions and (d) the dissociation of the actomyosin complex.

The water holding capacity (WHC) involves an interaction between the protein or the proteic food and the water. The largest or smallest affinity of the protein with the water is also linked to other functional properties such as color, texture, firmness, softness and, above all, the juiciness (Sgarbieri 1996; Ordóñez-Peneda 2005).

There are several factors that modify WHC, among them, the ones that have a strong effect on the post mortem changes, leading to the production of lactic acid and the consequent reduction of the pH, to the loss of ATP, to the beginning of the rigor mortis and to the changes of the cellular structure associated with the proteolytic enzymatic activity (Ordóñez-Peneda 2005).

The polyphosphates help the muscular protein solubilization and the meat acidity decrease (increase pH), when there is an increase of space around the proteins and, thus, larger amount of water can be kept within the proteins (Minatti 2004).

The effect of the phosphates in the retention and connection with the molecules of water is due to a specific polianionic effect or to an alteration of the load of the muscle proteins. That effect is only reached through a group of special phosphates called "diphosphates", which make the proteins attract the molecules of water (Figure 1).

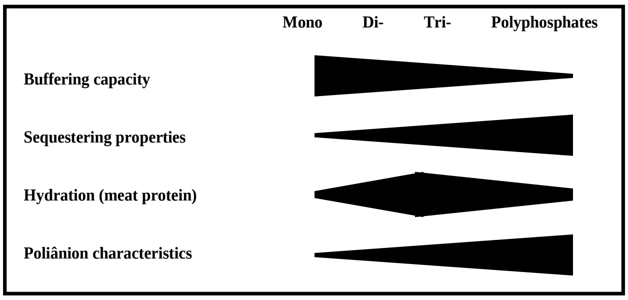

Figure 1. Chemical characteristics of the phosphates (Schnee, 2004).

The long chains of phosphates can be less effective, and their effectiveness will depend on how fast their conversion into diphosphates occurs, by means of the muscular enzymes (Marujo 1988; Dziezak 1990; Teicher 1999; Schnee 2004).

The moderated increase of the pH (less acid condition), due to the phosphate use, is also an important factor, but not the only one, in the retention of water. The fish proteins show less WHC when the muscular pH is around 5.4 (isoeletric point of the proteins).

The phosphates increase the pH at a high level of approximately 6.4 (Figure 2). If the final pH of the product is very high, the shelf life decreases and failures as sliminess, translucency and fat decomposition will be observed (Dziezak 1990; Teicher 1999; Schnee 2004).

As a result of the increase of the water holding capacity by the protein in cooked meat, the following improvements are generally observed: improvement in the yield (8 to 10%), better retention of the flavor and better texture (Teicher 1999; Neto & Nakamura 2003).

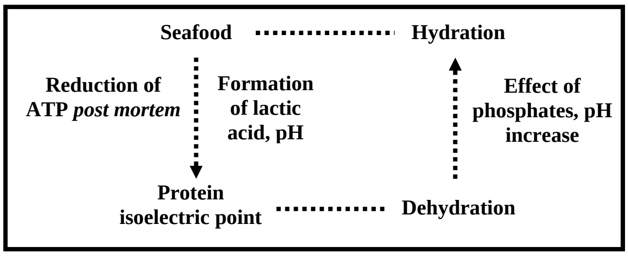

Figure 2. Effects of the phosphates in the biochemistry of the muscle (Schnee, 2004).

Other beneficial functions of the phosphates include the capacity of isolation and quelation of metallic cations as Ca^{2+}, Mg^{2+}, Fe^{2+} and Fe^{3+}. The ion quelation helps to inhibit the development of oxidative process, and to stabilize the color, considering that the quelation of Ca^{2+} Mg^{2+} also influences the capacity of water retention (Marujo 1988; Dziezak 1990; Teicher 1999; Neto & Nakamura 2003).

General applications of phosphates

Thorarinsdottir *et al.* (2004) proved that the effectiveness of the phosphates in the properties of retention of water in meat products depended on the type and on the amount of phosphates, as well as on the type of product that was processed with their addition.

The phosphates are generally applied by immersion, spray, injection or tumbling into phosphate solution with different concentrations. The dry addition is also used in minced meat systems. Among those presented systems, the most efficient way to apply the phosphates is through the vacuous tumbling. However, tumbling in excess can cause the extraction of proteins before the absorption of the phosphate solution (Otwell 1992; 1993; Lampila 1993; Ünal *et al.* 2004).

Researches developed by Aitken (2001) demonstrated that the easiest way to apply phosphates in food products is by immersion with light agitation so that the whole surface is contacted with the solution. Lately, the growing use of continuous systems of phosphate addition has been observed, besides discontinuous methods that are very much used, as the immersion of the fish in solutions with variable concentrations and times occurs. In either system, a uniform application of the phosphates is to be assured to guarantee good yield (Marujo 1988; Lampila 1992).

The phosphates are applied in solutions from 2 to 10% to obtain the great activation of the proteins, which results in approximately 0.5% of residual phosphates in the final product. The phosphates can also be applied by means of ice that has been prepared with phosphates and water. The exact concentrations and the time of treatment depend mainly on the seafood species. The treatment is more efficient soon after the capture and it should be done before any thermal treatment.

According to Schnee (2004), the concentrations more commonly used by industry are:

- Ice making: 3% solution
- Dipping/Washing: 2 – 6% solution for 2-20 min
- Spraying: 5 – 10% solution
- Tumbling: 2 – 6% solution
- Injecting: 5 – 8% solution
- Dry adding: 0.3 – 0.5% to minced systems
- Glazing: 5% solution

Specific applications of the phosphates

Removal of the shrimp exoskeleton

An alternative to help with the mechanical removal of the shrimp exoskeleton is the use of a solution of sodium tripolyphosphate (1 to 6%). In some cases, the concentration is higher reaching 8-10%. This technique increases the recovery of the shrimp meat from 20 to 30%, based on the initial weight (Henson & Kowalewski 1992; Neto & Nakamura 2003).

The shrimp is also immerged in tripolyphosphate solution, followed by vapor cooking, passing through flexible steel roller, where the meat is separated from the soft shell; packed and frozen (cooking is optional). The solutions are recycled, periodically reinforced by the polyphosphate addition, and eventually discarded. Each processor operates in a differentiated way; some substitute the solutions daily, others every two or three days (Henson & Kowalewski 1992; Lampila 1992; Teicher 1999; Neto & Nakamura 2003).

Shrimp

Shrimp is a highly perishable product and it should be maintained under low temperature to extend its quality and its safety. For those reasons, all the treatments with phosphates should be carried out under inferior temperatures of 4°C or between 0°C and 2°C for long exposure periods. Thus, low temperatures should be maintained during this period and the selected phosphates should be more soluble in low temperatures and kept soluble in them.

Shrimps are processed in different ways, according to the species and consumers demand. The phosphates don’t generally penetrate in the shell of the shrimps and they are only functional before cooking. The adapted use of phosphates in shrimp results in better yield of the product and promotes sensorial benefits for the consumer. For shelled shrimp - or shelled and desveined (visceral removal) - treated with phosphates at 2-4% for 20-120 minutes (4°C) there was an increase of 5 to 8% of the acceptability when compared with the non-treated shrimp; as for the shelled shrimp with added value (butterfly cut) treated with phosphate at 2-4% for 10-25 minutes (<4°C) there was an increase of 8 to 10% of acceptability (Garrido & Otwell 2004; Gonçalves, 2005).

Crab

The primary effects of the phosphates in crab are: larger yield, better quality of the meat and increase of the period of stability in frozen storage. In natura crab pieces can be immerged in a polyphosphate solution (8-10%) for 1 to 2 hours before vapor cooking (Neto & Nakamura, 2003).

Scallops

The use of sodium tripolyphosphates in scallops, in concentrations of 4% (20 minutes), of 10% (1 minute) and of 2.5% until the moisture reaches 82%, 84% and 86%, respectively, added with 1% of NaCl, was shown efficient in the control of the drip loss during defrosting and after cooking, besides decreasing the microbial count. No additional benefit was verified by the long exposure to TPF, while in short exposure it produced desirable functional effects, generally without exceeding 83% of moisture (Rippen *et al.* 1993).

Fish Fillets

The best results for fillets or pieces of raw fish meat are obtained with an immersion or washing in solution of 2 to 6% of phosphates, until the residual contents of phosphates reach approximately 0.5%. Some species need less than 1 minute of treatment to reach that amount, but others don’t exceed that level, even after a long exposure. The phosphate solutions are very effective and controllable when they are used in direct contact with the fish meat and not with the whole fish, as they don’t penetrate the skin or the bones. For a better penetration in the meat, a vacuum tumbling or injection can be used, mainly for species such as tuna, catfish and some shellfishes (Aitken 2001; Schnee 2004).

Sinergic effect of the combination of salt with phosphates

In the fish processing, the solubilization of the sodium tripolyphosphate will suffer interference if the water presents high salt levels. It is recommended to have the phosphates dissolved before the addition of salt, once this salt reduces the solubility of the phosphates, and to use a mixture of compatible phosphates with the presence of salt (Teicher 1999).

For some products, the phosphates are applied with salt, to help the interaction among the proteins and to distribute the flavor better. But the salt increases the osmotic pressure of the solution, and so, the amount of water that is absorbed decreases (Lampila 1992; Teicher 1999; Schnee 2004).

Cares associated to the use of phosphates

Not all the sources of sodium tripolyphosphate exhibit acceptable levels of insoluble substances and characteristics of solubility. Some care should be taken, when using different product sources, with different raw materials and production processes. Among the factors that affect the acting of the sodium tripolyphosphate are the crystalline form, the granulometria and the density (Teicher 1999).

The factors “time of immersion” and “phosphate concentration” should be very well studied, because for the same product or species, the immersion in a solution of phosphate at 5% requests a time of treatment of 24 hours, while in a solution at 25% requests just 2 seconds to reach the same effect, i.e., inhibition of the formation of a superficial proteic clot and reduction of the loss when cooking (Otwell 1992; Lampila 1993).

Care should also be taken when the phosphates are applied to the fish with different thickness, different parts of the muscle, different species and the content of initial moisture. Another aspect that demands attention refers to the treatment of small shrimps without shell and desveined (viscera removal), due to the tendency of occurring excessive treatment, resulting in the formation of a transparent or vitreous appearance and a viscous texture (Lampila 1993; Neto & Nakamura 2003).

When high levels of polyphosphates are used, the processing and the flavor can be affected. An astringent taste has been occurred in superior levels at 0.5%. The polyphosphate solution can also be hydrolyzed for the orthophosphate form in the presence of the fosfatase enzyme, found in the meat. If that happens, the orthophosphates can react with the fatty acid and form soap presenting a specific flavor (Teicher 1999).

Legislation

It is of extreme importance the concern of all the sections acting in the segment of fish with the consumers' health and protection. However, some principals are valid for the additives in general and they should be observed (Marujo 1988):

- ❖ no substance should be used either to disguise any damage or quality inferiority or to make the product look better or with a higher value than it really has;
- ❖ the use of additive is acceptable, as long as they are used for suitable proposals, according to the amount limits established by the legislation and under the specific conditions for such use;
- ❖ to be sure of the quality and safety of the additive and other products in general, care should be taken so that the products follow the specifications of purity according to the appropriate legislation;

Sodium tripolyphosphate is one of the phosphates which belong to the family used in the fish industry that can be used as humectant, i.e., substances that keep the moisture of the product (FDA 2003).

According to Health Ministry (ANVISA) it can be observed in Table 4 that the phosphates can only be used after freezing, in the glazing process, with a maximum concentration of 0.5%.

Table 4. Use of phosphates in fish according to the National Health Surveillance Agency (ANVISA/Brazil)

Product	Additive	INS	Max Level in final product
External coating of frozen fish (Res. CNS/MS no. 4, de 24 de novembro de 1988)	Polyphosphates:		0.5% (0.5g/100g) or (0.5g/100ml)
	Sodium Hexametaphosphate	452 i	
	Sodium metaphosphate	452 i	
	Potassium metaphosphate	452 ii	
	Sodium pyrophosphate	450 iii	
	Potassium pyrophosphate	450 v	
	Sodium tripolyphosphate	451 i	
	Potassium tripolyphosphate	451 ii	
	Calcium polyphosphate	452 iv	

Source: Brazil (1988)

Table 5. Use of phosphates in fish according to the Ministry of Agriculture (Brazil).

Product	Additive	INS	Max Level in final product
External coating of frozen fish (Ofício Circular n° 13/70 e n° 009/2003)	Tripolyphosphates	451 i 451 ii	0.5% (0.5g/100g) or (0.5g/100ml)

Source: Brazil (1970)

According to DIPES/DIPOA/MAPA (Brazil 2003), the additive employment (Table 5), before freezing, can only be approved when provely exists the indispensable technician back-up, on the part of a research institution and, naturally, with the guarantee of the competent authority, ANVISA (Health Ministry).

According to FDA (USDA 2004), there is neither prohibition of the phosphates use in fish nor a limit for their use. They can be used as a multifunctional substance without restrictions for specific alimentary products. The appropriate use will be controlled by the Good Manufacturing Practices (Table 6).

Table 6. Use of phosphates in fish according to the United States.

Purpose use	Additive	INS	Max Level in final product
Multiple purpose	Sodium Acid Pyrophosphate (21 CR 182.1087)	450 i	GRAS (Generally Recognized as Safe) when used in accordance with good manufacturing practice
	Sodium Phosphate (21 CR 182.1778)	339 i	
	Sodium Tripolyphosphate (21 CR 182.1810)	450 iii	
Sequestrants	Disodium Phosphate (21 CR 182.6290)	339 ii	
	Dipotasium Phosphate (21 CR 182.6285)	340 ii	
	Sodium Hexametaphosphate (21 CR 182.6760)	452 i	
	Sodium Metaphosphate (21 CR 182.16769)	452 i	
	Sodium Pyrophosphate (21 CR 182.6787)	450 iii	
	Tetra Sodium Pyrophosphate (21 CR 182.6789)	450 iii	
	Sodium Tripolyphosphate (21 CR 182.6810)	451 i	

Source: US Code of Federal Regulations (2007)

On the other hand, the Canadian Food Inspection Agency (CFIA 2007) liberates the use of phosphates in different fish species, with multiple uses, but it cannot exceed the concentration from 0.1% to 0.5% with some restrictions (see notes below Table 7).

Table 7. Use of phosphates in fish according to Canada

Product (Purpose use)	Additive	INS	Max Level in final product
GLAZE (To prevent cracking)	Sodium monohydrogen phosphate or sodium phosphate-dibasic	339	GMP
FROZEN: CLAMS, CRAB, FILLETS, LOBSTER, SHRIMP AND MINCED FISH (processing loss control and reducing thaw dripping)	Sodium acid pyrophosphate, tetrabasic or tetrasodium pyrophosphate	450 iii	0.5 %
	Sodium tripolyphosphate	451 i	
	Sodium hexametaphosphate	452 i	
	Disodium Pyrophosphate or sodium acid pyrophosphate	450 i	
SURIMI-BASED PRODUCTS - KAMABOKO (texturizer)	Sodium acid pyrophosphate, tetrabasic or tetrasodium pyrophosphate	450 iii	0.1 %
	Sodium tripolyphosphate	451 i	
	Sodium hexametaphosphate	452 i	
CANNED CLAMS (emulsifying, gelling, stabilizing and thickening agents)	Sodium tripolyphosphate	451 i	0.5 %
CANNED SEAFOOD GENERAL (sequestering agent)	Sodium hexametaphosphate	452 i	0.1 %
	Disodium Pyrophosphate or sodium acid pyrophosphate	450 i	0.5 %

Source: Canadian Food Inspection Agency (2007)

Note 1: Used singly or in combination with sodium acid pyrophosphate and sodium tripolyphosphate, not to exceed 0.5 %, calculated as sodium phosphate, dibasic.
Note 2: Crab meats contain naturally occurring phosphates in the average amount of 1.7%. The action level applied to the presence of phosphates in crab meats will be the total amount of the naturally occurring and added phosphates to a level of 2.2%.
Note 3: Clam meats contain naturally occurring phosphates in the average amount of 1.0%: The action level applied to the presence of phosphates in clam meats will be the total amount of the naturally occurring and added phosphates to a level of 1.5%.
Note 4: Lobster meats contain naturally occurring phosphates in the average amount of 1.47%: The action level applied to the presence of phosphates in frozen lobster will be the total amount of the naturally occurring and added phosphates to a level of 1.97%.
Note 5: For minced fish, the flesh of fin fish contains naturally occurring phosphates in the average amount of 1.37%. The action level applied to the presence of phosphates in minced fish will be the total amount of the naturally occurring and added phosphates to a level of 1.87%.
Note 6: Frozen fish fillets contain naturally occurring phosphates in the average amount of 1.37%. The action level applied to the presence of phosphates in fish fillets will be the total amount of the naturally occurring and added phosphates to a level of 1.87%.
Note 7: Shrimp meats contain naturally occurring phosphates in the average amount of 1.6%: The action level applied to the presence of phosphates in shrimp meats will be the total amount of the naturally occurring and added phosphates to a level of 2.1%
Note 8: Lobster meats contain naturally occurring phosphates in the average amount of 1.47%: The action level applied to the presence of phosphates in frozen lobster will be the total amount of the naturally occurring and added phosphates to a level of 1.97%.

Codex Alimentarius (Table 8) is a little more flexible and tolerates a higher percentage of phosphates in the final product (1%). However, the European Community (Table 9) restricts in smaller percentage similar to the other legislations.

Table 8. Use of phosphates in fish according to Codex Alimentarius.

Product (Purpose use)	Additive	INS	Max Level in final product
QUICK FROZEN FILLETS (Codex Stan 190-1995)	Monosodium orthophosphate	339 i	1% 10 g/kg expressed as P_2O_5, singly or in combination (includes natural phosphate)
	Monopotassium orthophosphate	340 i	
	Tetrasodium diphosphate	450 iii	
	Tetrapotassium diphosphate	450 v	
	Pentasodium triphosphate	451 i	
	Pentapotassium triphosphate	451 ii	
	Sodium polyphosphate	452 i	
	Calcium, polyphosphates	452 iv	
QUICK FROZEN BLOCKS OF FISH FILLET, MINCED FISH FLESH AND MIXTURES OF FILLETS AND MINCED FISH FLESH (Codex Stan 165-1989)	Monosodium orthophosphate	339 i	
	Monopotassium orthophosphate	340 i	
	Tetrasodium diphosphate	450 iii	
	Tetrapotassium diphosphate	450 v	
	Pentasodium triphosphate	451 i	
	Pentapotassium triphosphate	451 ii	
	Sodium polyphosphate	452 i	
	Calcium, polyphosphates	452 iv	
QUICK FROZEN FISH STICKS (FISH FINGERS), FISH PORTIONS AND FISH FILLETS - BREADED OR IN BATTER (Codex Stan 166-1989)	Monosodium orthophosphate	339 i	
	Monopotassium orthophosphate	340 i	
	Tetrasodium diphosphate	450 iii	
	Tetrapotassium diphosphate	450 v	
	Pentasodium triphosphate	451 i	
	Pentapotassium triphosphate	451 ii	
	Sodium polyphosphate	452 i	
	Calcium, polyphosphates	452 iv	
QUICK FROZEN SHRIMPS OR PRAWNS (Codex Stan 92-1981)	Tetrasodium diphosphate	450 iii	
	Tetrapotassium diphosphate	450 v	
	Pentasodium triphosphate	451 i	
	Pentapotassium triphosphate	451 ii	
QUICK FROZEN LOBSTERS (Codex Stan 95-1981)	Pentasodium triphosphate	451 i	
	Pentapotassium triphosphate	451 ii	
	Sodium polyphosphate	452 i	
	Calcium polyphosphates	452 iv	

Source: Codex Alimentarius (2007)

Table 9. Use of phosphates in fish according to European Community.

Product (Purpose use)	Additive	INS	Max Level in final product
SURIMI (Directive N° 95/2/EC 20/02/95)	Pentasodium triphosphate Pentapotassium triphosphate	451 i 451 ii	0.1% (1 g/kg)
FISH AND CRUSTACEAN PASTE (Directive N° 95/2/EC 20/02/95)	Pentasodium triphosphate Pentapotassium triphosphate	451 i 451 ii	0.5% (5 g/kg)
FILLETS OF UNPROCESSED FISH, FROZEN AND DEEP-FROZEN (Directive N° 95/2/EC 20/02/95)	Calcium polyphosphates	452 iv	0.5% (5 g/kg)
UNPROCESSED AND PROCESSED MOLLUSCS AND CRUSTACEANS FROZEN AND DEEP-FROZEN (Directive N° 95/2/EC 20/02/95)	Calcium polyphosphates	452 iv	0.5% (5 g/kg)
CANNED CRUSTACEAN PRODUCTS (Directive N° 95/2/EC 20/02/95)	Calcium polyphosphates	452 iv	0.1% (1 g/kg)

Source: European Parliament and Council (1995)

Final considerations about the use of phosphates

The phosphates are an indispensable additive for the maintenance of the functional properties of the seafood myofibrillary proteins which helps the preservation of the muscle integrity, inhibits the drip loss of the fresh fish, and helps to prevent the economic loss during the thawing and the cooking. The phosphates also increase the thermal stability of the proteins of the fish which is usually lower than the one of other animals.

There are possibilities of using phosphates and mixtures in several concentrations and treatment times. However, a deeper study should be carried on in order to demonstrate such possibilities, since the final products obtain sensorial quality, not only being characterized with weight gain.

As a conclusion, the phosphates application in seafood is shown promising, but it has to be used with criterion. The incorrect or abusive use will lead to sensorial failures and besides that, it can characterize economic frauds.

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