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Control of phosphate levels in seafood products from the Portuguese market: Is there a need for concern?

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ABSTRACT

High consumption of phosphates, particularly added inorganic phosphates, may be associated with several health problems and so comprehensive data on their content in food, especially seafood, is of utmost importance. This work aimed to characterize phosphates contents in seafood products from the Portuguese market. Almost 900 samples of unprocessed and processed species of crustaceans, molluscs, and fish were analyzed at the Portuguese Institute for the Sea and Atmosphere over a 15 years' time period. Considering processed products, crab sticks presented the lowest average values of total phosphates, while salted and dry cod, hake and shrimp evidenced the highest variations. Phosphates contents in unprocessed samples varied among species, being the lowest and highest average values observed for octopus and sardine, respectively. New reference phosphate limits were defined which permits verifying if the legislation is followed with respect to phosphates added to seafood. Moreover, the reference conversion factor is not adequate for seafood, and thus new factors were proposed. Overall, the addition of phosphates has not been a current practice. Nevertheless, for an easier control and to avoid the need of laborious sampling to establish natural phosphates levels, it would be more appropriate to define limits with respect to total phosphates contents.

1. Introduction

Phosphoric acid (E338), monophosphates (E339, E340, E341, and E343), diphosphates (E450), triphosphates (E451), and polyphosphates (E452) are food additives used in a large number of food items (*e.g.* meat, seafood and dairy products) for several technological processes, including to retain natural moisture, inhibit flavours and lipid oxidation, aid emulsification, and for cryoprotection (SEAFISH, 2012). These additives can be added individually or in combination until now to a maximum permitted level that depends on the specific food item (EC, 1995). Although additives are allowed in a large number of food items, their safety has been revised regularly. Recently, a review article of Ritz et al. (2012) has raised several human health concerns, due to the association suggested between high dietary intake of phosphate, particularly added inorganic phosphates, and the effects on health, including cardiovascular risk, for the general population. In reaction, the European Food Safety Authority (EFSA) undertook a scientific assessment about those problems, having however concluded that the information available is inconsistent and in some cases contradictory, which difficults the interpretation of the data (EFSA, 2013).

As such and on account of the inconclusive scientific evaluation of phosphates safety, these are included in the EC programme for the re-evaluation of food additives set up under Regulation No 257 (EC, 2010). EFSA scheduled the assessment of this specific group of food additives with high priority by the end of 2018 and requested further data on phosphate safety and also on phosphate levels in seafood products for a thorough estimation of the human exposure to phosphates and correspondent risk analysis (EFSA, 2013).

Nowadays, more consumers seek for a healthy diet and try to eat seafood more often due to its well known benefits. Seafood is recognized by its high nutritional quality, and its consumption is known to prevent coronary heart disease, hypertension, and cancer (Simopolpoulos, 1997). These factors have been used as motivation to increase seafood consumption. However, there are several constituents in seafood that may cause hazards. Information regarding the phosphates contents lacks attention and needs to be investigated. As phosphate additives are also applied in seafood, it is of major concern that consumers trying to eat seafood more frequently became also

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exposed to considerably higher levels of inorganic phosphates. Thus, it is important to control the levels of phosphates in seafood.

Generally, the control of added phosphate levels in seafood is based on measures of total phosphorus, which are then converted to phosphates. Though, the estimation of added phosphates is not straight-forward because it is necessary to distinguish between naturally occurring phosphates and added inorganic phosphates (SEAFISH, 2012). The quantification of the levels and clear distinction between both types of phosphates in seafood has not yet been achieved. Reference values assumed as natural phosphates content are used for comparison, but still the estimation of added phosphates is uncertain. Another approach for the estimation of added phosphates is based in the difference between total phosphates and protein bound phosphates, which is calculated based on the reference ratio of 10.6 mg of phosphorus per g of protein (Dušek et al., 2003). However, previously it was demonstrated that this reference ratio is not adequate for all food products (Dušek et al., 2003).

In the frame of quality control services for the seafood stakeholders a considerable amount of commercial seafood samples were analyzed for the quantification of phosphorus/phosphates in the Portuguese Institute for the Sea and Atmosphere (IPMA). Moreover, samples not subjected to any kind of industrial processing were also analyzed during the development of research projects at IPMA, and these data can be used for the characterization of natural phosphates levels in seafood. The unpublished information obtained consistently at IPMA over the last 15 years can help to improve the existing data in food composition tables, and also be used for the estimation of the human exposure to phosphates. A thorough search of the relevant literature showed that such a data collection on phosphates content in seafood or other food items was never reported. The knowledge about the content of phosphates is of utmost importance for those who have to take precautions with phosphates ingestion, and also for those who give recommendations about food intake or formulate diets.

In this context, the main objective of this work was to determine the phosphates content in seafood covering a wide group of species, which can be included in food composition databases and be used to estimate phosphates ingestion. Data for both unprocessed and processed fish species and seafood products are reported. It was also aimed to establish limits of variation of natural phosphate and phosphate:protein ratio, as well as the factors responsible for such variations (*e.g.* origin, season), for a correct evaluation of the added phosphates, in order to verify if the legislated values are being followed.

2. Material and methods

2.1. Processed seafood samples

The commercial samples were obtained in the frame of quality control services for the seafood stakeholders. Commercial samples of mussels, clams, cockles, octopus, squid, cuttlefish, shrimp, hake, cod (salted and desalted), angler, flounder, ling, pollock, salmon, sole, and crab sticks, available in supermarkets in Portugal in the period from 1999 until 2014, were used for the quantification of phosphates. A total of 411 samples (90 samples of molluscs, 86 of crustaceans, and 235 of fish) were considered for this study. Detailed information of the number of samples analyzed for each species is indicated in Table 1.

2.2. Unprocessed seafood samples

The unprocessed samples, not subjected to any kind of industrial processing, were obtained during the development of research projects at IPMA.

Samples of octopus (*Octopus vulgaris*) were purchased at the Peniche (central-western Portuguese coast) auction (first sale) and in Cascais (central-western Portuguese coast). Squid (*Loligo vulgaris*) and cuttlefish (*Sepia officinalis*) were also purchased at the Peniche auction. Collected

Table 1
Description of processed seafood samples (common name, number and presentation form) from the Portuguese market used for the quantification of total phosphates.

Sample (common names)	Number of samples	Presentation of samples
Molluscs		
Mussels	10	Meat, frozen
Clams	10	Whole, meat, frozen
Cockles	4	Meat, frozen
Octopus	42	Whole, frozen
Squid	17	Whole, rings, frozen
Cuttlefish	7	Whole, frozen
Crustaceans		
Shrimp	86	Whole, peeled, frozen
Fish		
Hake	121	Whole fish, fillets, portions, loins, steaks, frozen
Cod (salted)	42	Whole fish (butterfly cut), fillets, shredded, dried
Cod (desalted)	19	Fillets, loins, shredded, frozen
Angler	11	Cubes, tails, loins, fillets, frozen
Flounder	6	Fillets, cubes, frozen
Ling	6	Fillets, steaks, frozen
Pollock	6	Whole fish, fillets, frozen
Salmon	5	Loins, steaks, cubes, frozen
Sole	4	Fillets, steaks, frozen
Surimi		
Crab sticks	15	frozen

specimens were immediately stored in plastic bags, which were placed in ice and taken to the laboratory.

Norway lobster (*Nephrops norvegicus)* specimens were caught off the south-western Portuguese coast (Portimão and Sagres) by the trawler R/V *Noruega* from IPMA in 2004. Collected specimens were packed in plastic bags, frozen on board and kept frozen (−20 ± 2 °C) until analysis.

Farmed species were supplied by several commercial farms located in Portugal: sea bass (*Dicentrarchus labrax)* from Sines (western Portuguese coast); gilthead sea bream (*Sparus aurata)* from Vila Nova de Milfontes (western Portuguese coast); rainbow trout (*Oncorhynchus mykiss)* from Montalegre (northern Portugal); and turbot (*Psetta maxima)* from Tocha (north-western Portuguese coast). The rearing systems were all intensive. Due to confidential policy, there was no information available about feeds. Fish specimens were slaughtered in a water-ice slurry and immediately stored in ice inside insulated boxes and transferred to the laboratory.

Wild specimens of sea bass and gilthead sea bream were from Peniche, while wild individuals of rainbow trout were from Serra da Estrela (central Portugal). Hake (*Merluccius merluccius*), sardine (*Sardina pilchardus*), Atlantic horse mackerel (*Trachurus trachurus*), and chub mackerel (*Scomber japonicus*) were acquired in supermarkets in Vila Real de Santo António (south-eastern Portuguese coast), Peniche, Sesimbra/Sines (western Portuguese coast), and Lisboa/Sines (western Portuguese coast), respectively.

A total of 468 samples were considered in this study for the determination of natural levels of phosphates. A compilation of the species studied, their scientific name and the number of samples analyzed is summarized in Table 2.

2.3. Sample preparation

Considering the preparation of processed and non-processed samples, all edible parts (mantle and arms in the case of molluscs; muscle in the case of crustaceans; white and red muscle tissues in the case of fish species) were minced and homogenized in a food blender, following the specifications described in the European Standard 13804:2013 (CEN, 2013). Each individual was homogenized alone constituting one