Contribution of hydrocolloids to gelling properties of blue whiting muscle

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Abstract Several hydrocolloids (locust bean gum, guar gum, xanthan gum, iota-carrageenan, kappa-carrageenan, carboxymethylcellulose and alginate) were added in different concentrations (0.5, 1.0, 2.0, 3.0, and 4.0%) to determine their behaviour as additives in washed blue whiting muscle mince. Higher percentages significantly reduced rheological properties, which in some cases fell to values below that of the control gel, with no added hydrocolloids. Water holding capacity, on the other hand, was lowest at low concentrations. Gel colour was virtually unaffected by the presence of different hydrocolloid concentrations in the formulation. Discriminant analysis differentiated the various hydrocolloids used, chiefly on the basis of hardness; however, the most influential factor affected by the concentration of hydrocolloid was breaking force. In this manner, it was defined what properties can be achieved by addition of these ingredients obtaining a variety of characteristics.

Key words Gelation · Hydrocolloid · Blue whiting (Micromesistius poutassou)

Introduction

The suitability of the fish protein for gel formation differs according to species, season, the place where the fish were caught, and processing and storage conditions. Muscle mince functionality can be altered by the addition of gelling agents or aids, particularly polysaccharides. Many hydrocolloids, commonly known as gums, are extracted from seaweed or seeds; they are selected for enhancement of functional properties such as water holding capacity (WHC) and rheological properties. However, their action as fibre may affect the nutritional properties as well. They are useful in industrial applications because they are effective at low concentrations. The rheological properties are influenced by the type and concentration of the ingredients [1].

These additives alter gel characteristics in different ways depending on the quality of the myofibrillar protein [2–4]. When the minced muscle is of high quality, addition of gelling agents or aids can reduce the rheological properties of the product, which is useful for attenuating excessive elasticity and hardness. When quality is low, these additives modify the product’s characteristics, enhancing protein functionality, particularly gel-forming ability and WHC [5].

A number of studies have been reported on the interaction of these hydrocolloids with the proteins in model systems [6–9]; however, only a few studies have been published on the comparative effect of hydrocolloids within the myosystem, and referring to the use of a few hydrocolloids like starches, carrageenans and alginates [4, 10–13], and scarcely anything has been published about locust bean gum, guar gum, carboxymethylcellulose (CMC) or xanthan gum in fish products.

This study provides basic information on functional properties of blue whiting washed mince gels with different hydrocolloids added in various concentrations. It also seeks to determine which act in similar ways and which exhibit unique characteristics.

Materials and methods

Blue whiting (Micromesistius poutassou Risso) used in this study was caught off the Cantabrian coast in November. Their average size was 22.2 ± 1.8 cm and average weight 101.1 ± 22.3 g. The fish were headed, gutted and washed, and the skin and bones were removed with a deboning machine (Baader 694, Lübeck, Germany). The resulting mince was washed in a solution of NaCl (0.2%) at 0–3°C, in a 3:1 proportion (solution:minced muscle (w/w)), first with constant stirring for 10 min then without stirring for another 10 min. After draining, excess water was removed using a screw press (Baader 523). Sorbitol (4%) and tripolyphosphate (0.2%) were added as cryoprotectants. The mince was immediately vacuum-packed in bags (Cryovac BB-1, Grace, Spain) and froz-
en in a plate-freezer (Sabroe, Denmark). The bags were stored at -80°C in a freezer cabinet (Revo ULT, Revco, Asheville, N.C., USA) in order to minimize alteration during frozen storage until gel preparation.

**Proximate analysis.** The proximate analysis of mince was performed according to AOAC procedures [14] and crude fat by Bligh and Dyer [15]. The proximate composition was: crude protein, 13.25±0.31%, moisture, 81.75±0.71%, crude fat, 0.16±0.03% and ash 0.40±0.05% (analyses do not show added 4.2% cryoprotectant).

**Colour.** The colours of mince and gels were determined on a HunterLab MiniScan MS/S-40005 (Hunter, USA) using the CIE Lab scale (D65/10°) where L*, a* and b* are the parameters that measure lightness, redness and yellowness. The results were the average of six measurements taken at ambient temperature at different points on the sample.

**Gel preparation.** Washed white whiting mince was tempered in a chilled room and placed in a refrigerated vacuum homogenizer (Stephan UMS, Stephan, Germany). It was ground for 1 min at high speed. Sodium chloride (1% w/w) in gel (Panreac, Montpellet & Esteban, Barcelona, Spain) was added and homogenized for 3 min at slow speed. Then the hydrocolloid (locust bean gum as Viscogum BE, guar gum as FFH-200, xanthan gum as Satiaxane CX90, iota-carrageenan as Satiagel RPT25, kappa-carrageenan as Satiagel RPT18, sodium CMC as Tylopora C10/00 or sodium alginate as Satialgine SI100 (all from SKW Biosystems, Rubi, Spain)) was added at different final levels (0.5, 1.0, 2.0, 3.0, or 4.0%), with crushed ice to give the required final gel moisture (80%). The homogenate was beaten slowly for 6 min under vacuum, keeping the sample temperature below 10°C. Batters were stuffed into flexible plastic casings (Krehalon Soplaril, Barcelona, Spain) of 40 mm thickness and 3.5 cm diameter and subjected to heat treatment at 37°C for 30 min followed by 90°C for 50 min. All the casings were immediately cooled with water at 0°C and stored in a cold room at 4°C for 24 h before analysis.

**Water holding capacity.** About 1.5 g of sample was placed in a centrifuge tube with two Gilson Pipetman dried pipette filters. A centrifuge (Sorval RT6000B, Du Pont, Delaware, USA) was used at 4000 g for 15 min at ambient temperature. WHC was expressed as water retained per 100 g of water present in the sample prior to centrifuging. All determinations were carried out at least in triplicate.

**Folding test.** A slice 3.5 cm in diameter and 3 mm high is folded over twice. If it does not break, a score of 5 is awarded. If it breaks on the second fold, it scores 4. If a crack shows only on part of the folded edge, it scores 3. If the crack runs the length of the folded edge, it scores 2. If the slice breaks apart completely, it scores 1 [16].

**Puncture test.** Samples were removed from their casings, cut (3.5 cm diameter, 3 mm height) and tempered at 20°C. Gels were penetrated to breaking-point using a texture meter (Intron 4501, Intron, Canton, Mass., USA) with a round-ended stainless steel plunger (Ø=5 mm). Cross-head speed was 10 mm/min and a 100 N load-cell was used. Breaking force (newtons), breaking deformation (millimetres) and work of penetration (newton millimetres) were determined in the force-deformation curve. All determinations were carried out at least in quadruplicate.

**Compression test.** The compression test was carried out with Texture profile analysis (TPA) [17]. Samples (3.5 cm diameter, 3 cm height) were tempered at 20°C and placed on the flat plate of the texture meter. Compression was applied by a cylindrical plunger (Ø=58 mm) adapted to a 5 kN load cell at a deformation rate of 50 mm/min. On the basis of previous trials to establish a compression limit that would ensure no cracking and recoverability of most samples, it was decided to compress samples to 60% of their height. In the test, each sample was compressed twice. The parameters determined were hardness (newtons), adhesiveness (joules) and cohesiveness (adimensional). Elasticity (%) was determined by stress-relaxation test after 1 min of relaxation. The percentage of relaxation was calculated as YT = 100 (F1−F0)/F0, where F0 is the force registered at the onset of relaxation immediately after sample compression and F1 is the force registered after 1 min of relaxation. Thus, 100-YT is taken as an index of elasticity and is expressed as percentage elasticity of the gel. At least four replications of all determinations were performed.

**Results and discussion.**

In the folding test (Table 1) for gels made with different proportions of the seven target hydrocolloids, there was a significant decrease in the score in the formulations with added CMC and guar gum. These additives do not themselves gel, but at low concentrations they can reinforce weak areas of the protein network; at higher concentrations, on the other hand, they can interfere in the network formed by the myofibrillar protein, producing brittle gels [3]. It is also important to remember that the hydrocolloid and the myofibrillar protein compete for water, to the extent that this may actually prevent proper gelation [12, 13]. Folding test scores of gels with the other gums (carrageenans, sodium alginate and locust bean gum) remained high, as did those gels containing myofibrillar protein but no hydrocolloid, which scored the maximum.

According to Llanto et al. [11] the cause of the increased gel-forming ability of Alaska pollack surimi when carrageenans are added is the interaction of the sulphate groups of the carrageenan with the myofibrillar protein. On the other hand, other authors [18] have failed to improve the low gel-forming ability of sardine (Sardina pilchardus) muscle by adding increasing concentrations from 1–4% of kappa-carrageenan or up to 2% alginate. It was only when 2% alginate plus 8% starch was added that folding test scores improved.

In general, breaking deformation (Table 2) decreased significantly as hydrocolloid concentration increased, falling below that of gel without additive (10.5±0.6 mm). Breaking deformation was particularly high in gels containing 1% locust bean gum. Decreases in breaking deformation values when hydrocolloids are...