On the integral valorization of shrimp by-products: development of chitosan edible films incorporated with functional compounds recovered from the chitin demineralization process

Gómez-Estaca, J., López-Caballero, M.E.*, Alemán, A., Montero, P. & Gómez-Guillén, M.C.
Instituto de Ciencia y Tecnología de Alimentos y Nutrición (ICTAN-CSIC). c/ José Antonio Nováis 10, Madrid
E-mail: elvira.lopez@ictan.csic.es*

Introduction

Chitosan is a natural cationic linear aminopolysaccharide majorly obtained from chitin that, due to its natural origin, biocompatibility, biodegradability and film forming ability, has been extensively employed in the development of edible films and coatings. Furthermore, it possesses fat binding properties, antimicrobial and antioxidant activity, and is an excellent carrier for the sustained release and delivery of active compounds, thus being a very interesting matrix in the development of functional edible films. However, the chitosan obtaining process from crustacean shells involves sequential demineralization, deproteinization and deacetylation, in which a considerable amount of waste containing proteins, lipids, calcium and pigments is produced.

In the present work this biomass has been collected and characterized, with the **objective** of developing functional chitosan-based edible films through the addition of this biomass. The performance of the edible film developed was studied, with special emphasis on its antimicrobial activity and the bioaccessibility of key functional components. The edible film developed was used as wrapping for salmon sashimi, which was selected as an attractive, nutritive, and highly perishable food product.

Composition of the SME (shrimp mineral extract)

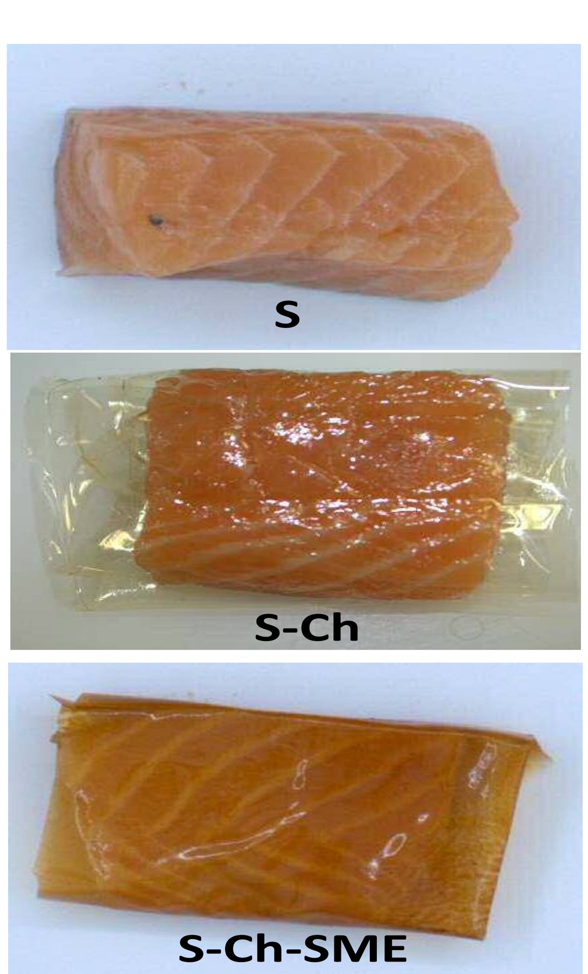
Calcium content of SME
≈2 g/100 g SME

Magnesium content of SME
≈ 0,11g/ 100g SME

Fatty acid	% of lipids
C14:0	1.16 ± 0.01
C15:0	1.24 ± 0.01
C16:0	19.56 ± 0.05
C17:0	1.81 ± 0.01
C18:0	8.90 ± 0.02
Σ SFA[1]	34.05 ± 0.2
C16:1n7	2.08 ± 0.01
C18:1n9c	19.98 ± 0.03
C18:1n7c	3.55 ± 0.02
C20:1n9	1.16 ± 0.00
Σ MUFA	27.32 ± 0.09
C18:2n6c	14.08 ± 0.03
C18:3n3	1.08 ± 0.00
C20:2n6	1.71 ± 0.00
C20:4n6	3.96 ± 0.01
C20:5n3 EPA	6.74 ± 0.03
C22:6n3 DHA	8.91 ± 0.07
Σ PUFA	38.63 ± 0.21

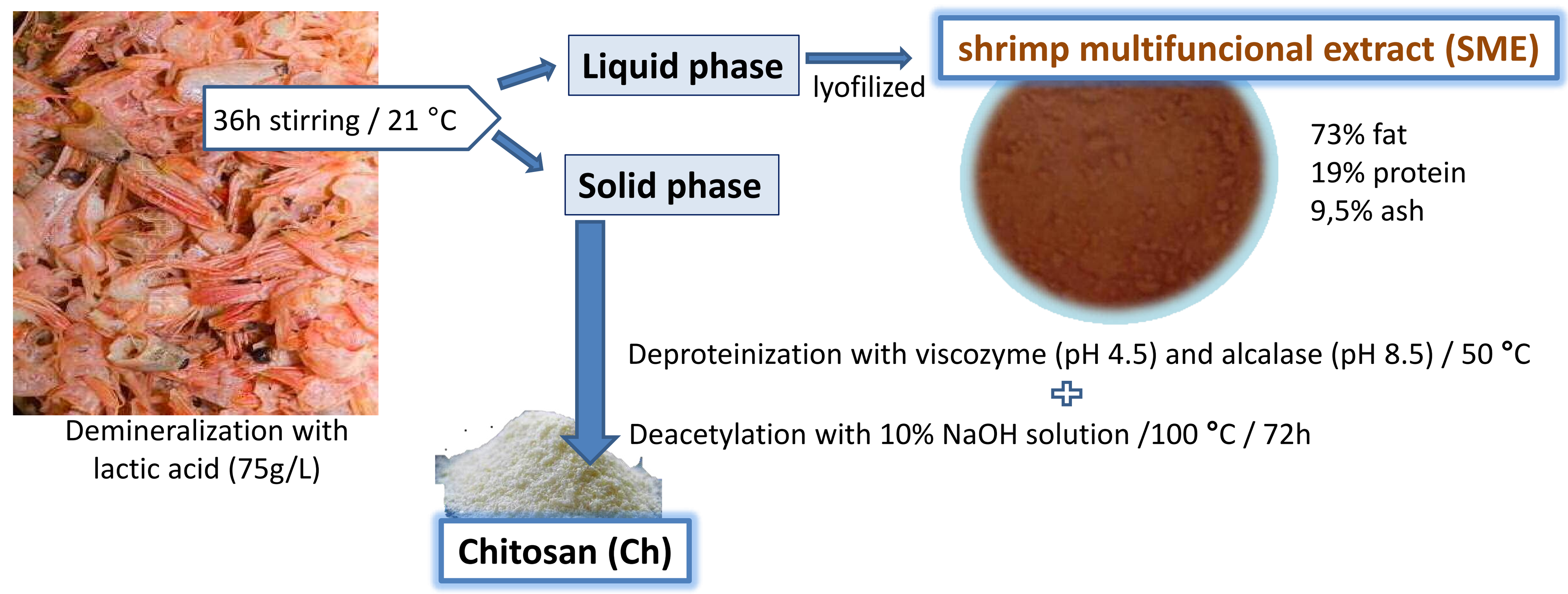
65%

Σ SFA: total amount of saturated fatty acids.
Σ MUFA: total amount of monounsaturated fatty acids.
Σ PUFA: total amount of polyunsaturated fatty acids.



Salmon samples. S: uncoated salmon; S-Ch: chitosan film-coated salmon; S-Ch-SME: shrimp mineral extract-chitosan film-coated salmon.

Materials & Methods

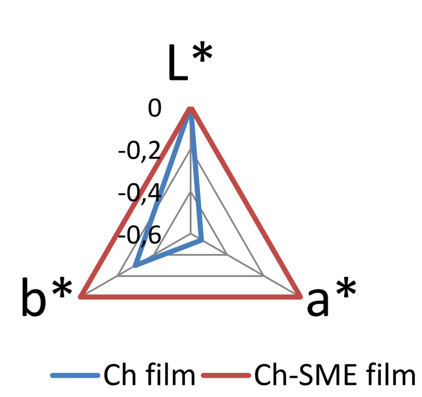


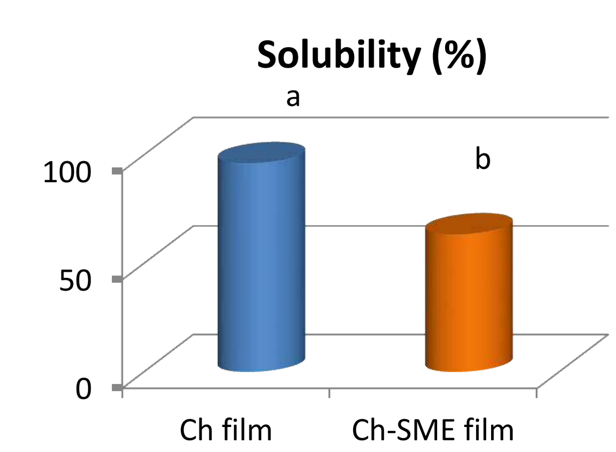
Film forming solutions was prepared at final concentration of 1% (w/v) of chitosan and 3% (w/v) of mineral concentrate. Ch was dissolved in 0.15M lactic acid. SME was suspended in distilled water.

Films were prepared by casting, drying the film formimg solutions for 21h at 45°C (**Ch-SME film**). A control film without SME addition was prepared for comparative purposes (**Ch film**).

Results

Physico-chemical properties of films





SME caused a reduction of film water solubility

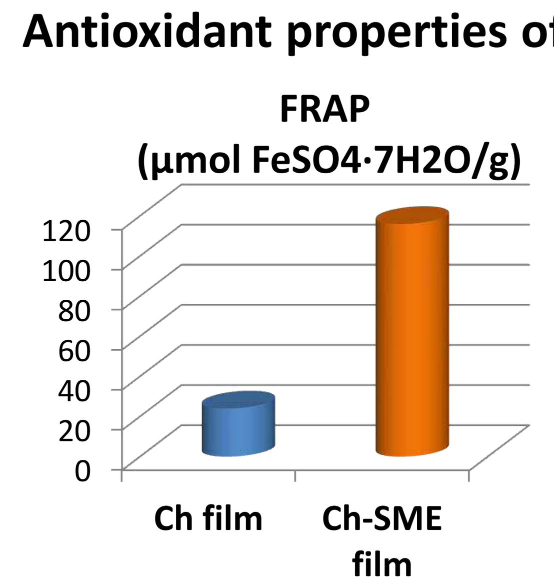
Antimicrobial activity of films against selected microorganisms

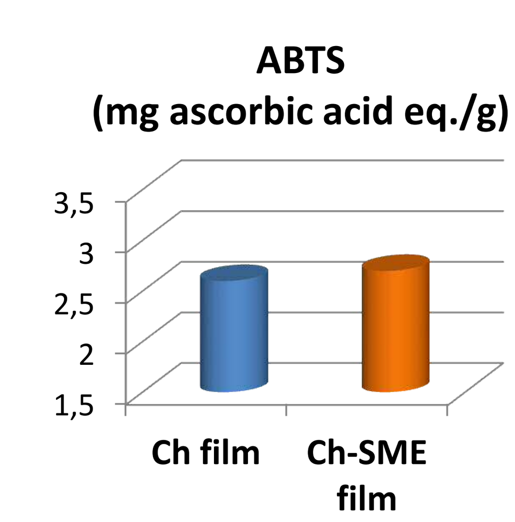
	Ch film	Ch-SME film
Listeria monocytogenes	+	+
Enterococcus faecium	++	+
Bacillus cereus	+	+
Yersinia enterocolitica	++	+
Staphylococcus aureus	+	+
Shigella sonnei	++	+
Salmonella cholerasuis	+	+
Vibrio parahaemolyticus	+	+

+++: totally inhibited; ++: inhibited; +: partially inhibited

Biological properties of films

Antioxidant properties of films





Regarding **antioxidant activity**, incorporation of SME caused a significant increase of FRAP, whereas ABTS was not modified, as compared with Ch film.

The **antimicrobial activity** of the films showed different sensibility depending on the microorganism tested.

Inhibition halos were larger for Ch film, owing to its higher solubility; however, Ch-SME film exerted inhibition in the film-agar interface for all microorganisms.

Bioaccessibility of wrapped salmon samples

Calcium and magnesium contents (mg/100 g salmon), fatty acid composition (mg/100 g lipid extract) and bioaccessibility (%).

	Uncoated salmon		S-Ch: chitosan film-coated salmon		SME-chitosan film-coated salmon	
	Content	Bioaccessibility	Content	Bioaccessibility	Content	Bioaccessibility
Ca^{2+}	8.5 ± 0.2	79.2 ± 16.5	8.2 ± 0.3	74.9 ± 1.2	60.9 ± 0.8	36.4 ± 7.3
Mg^{2}	42.2 ± 0.8	60.9 ± 13.8	42.4 ± 1.0	56.7 ± 7.8	47.1 ± 0.8	64.2 ± 1.9
Σ SFA	119.8±0.5	90.8 ± 2.1	117.8±4.5	76.8 ±1.9	124.6±0.9	82.1 ± 2.8
Σ MFA	474.7±3.2	91.2 ±2.5	445.3±20.8	79.8 ± 1.8	476.7±5.6	83.8 ±1.4
Σ PUFA	288.0±3.9	84.6 ± 3.1	279.0±10.0	72.9 ± 1.9	300.1±4.6	77.2 ± 2.2

Σ SFA: total amount of saturated fatty acids. Σ MUFA: total amount of monounsaturated fatty acids. Σ PUFA: total amount of polyunsaturated fatty acids

It is worth noting that Ch-SME film gave rise to an increase of total **SFA and PUFA**, as expected due to the high fat content of the film. Bioaccessibility was ≥70% for all samples and fatty acid group.

Magnessium and specially **calcium** content of samples were significantly improved by the Ch-SME film.

CONCLUSION

A waste commonly produced during chitosan obtaining process was recovered and characterized, showing potential as a functional food ingredient mainly thanks to its calcium content and fatty acid composition. Multifunctional edible films were prepared with chitosan and this shrimp mineral extract (SME), showing good performance as wrapping materials for salmon *sashimi*. The Ch-SME film improved the mineral content, whereas the fatty acid composition were slightly affected.

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