Functional pasta enriched with bioactive compounds and fibers in the form of highly stable SC-CO_2 extracted pumpkin oleoresin/α-CD complex

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Pumpkin (*Cucurbita* spp.) is a good source of carotenoids, mainly α- and β-carotene, β-cryptoxanthin, lutein and zeaxanthin [1]. Additionally, pumpkin seed oil is rich in tocochromanols and polyunsaturated fatty acids (PUFA).

Supercritical carbon dioxide (SC-CO_2) represents an effective, non-toxic technology for extracting food-grade

solvent-free oleoresins

from a range of edible plant materials, including pumpkin.

The obtained pumpkin oleoresin is a rich source of carotenoids, tocochromanols and unsaturated fatty acid and can be used for the industrial preparation of **functional foods**.
A ratio of PUFA to SFA above 0.4–0.5 is considered optimal in a balanced diet. The SC-CO_2 obtained oleoresin has a 1.56 PUFA/SFA ratio confirming its high nutritional value.

Carotenoid, tocochromanol and fatty acid composition of pumpkin SC-CO_2 extracted oleoresin

Carotenoids (mg/100 g oleoresin)	
Lutein	16.18±0.42
α-Carotene	70.61±0.48
9, cis β-Carotene	4.64±0.02
β-Carotene	86.48±0.62
13, cis β-Carotene	0.50±0.01
β-cryptoxanthin	1.13±0.03
Totale	**179.54±1.58**
Tocochromanols (mg/100 g oleoresin)	
α-T	21.80±0.84
γ-T	216.27±9.80
α-T3	22.22±1.94
γ-T3	138.74±2.82
Total	**399.03±15.49**
Fatty acid composition (%)	
Myristic (C14:0)	0.3±0.02
Palmitic (C16:0)	17.10±1.92
Stearic (C18:0)	8.98±0.92
Arachidic (C20:0)	0.64±0.03
Palmitoleic (C16:1)	0.30±0.01
Oleic (C18:1 n-9)	30.40±1.11
Linoleic (C18:2n-6)	41.70±1.23
Linolenic (C18:3 n-3)	0.58±0.02
SFA	**27.02**
MUFA	**30.70**
PUFA	**42.28**
PUFA/SFA	***1.56***

The limited stability of oleoresins over time and/or during food processing is one of the main drawbacks that affects the healthy properties of functional products.

Encapsulation into micro or nano particles is a promising technique to increase the stability of such compounds [2, 3].

α-Cyclodextrins (α-CDs) are biocompatible, non-toxic cyclic oligosaccharides, approved in Europe as soluble dietary fiber and novel food ingredient.

Pumpkin oleoresin/α-CD complex has been used as ready-to-mix high-quality ingredient in the preparation of functional pasta enriched with bioactive compounds

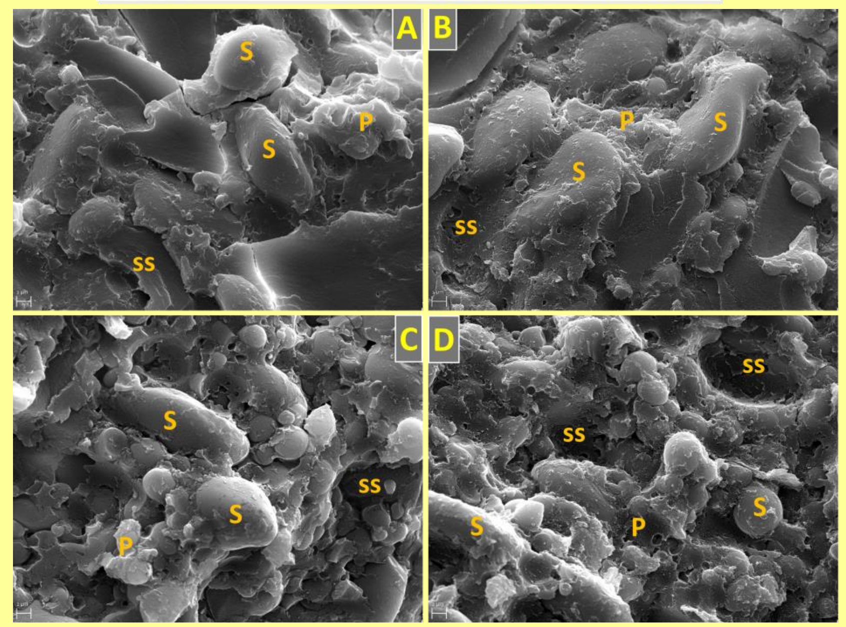
[1] Rodriguez-Amaya et al. (2008). Journal of Food Composition and Analysis, 21, 445–463
[2] Durante et al. (2012). Journal of Agricultural and Food Chemistry, 60, 10689-10695
[3] Durante et al. (2016). Food Chemistry, 199, 684–693.

Durum wheat (cv Vertola) semolina, was used to produce pasta: **A**, control pasta; **B**, pasta supplemented of α-CDs; **C**, pasta supplemented of pumpkin oleoresin; **D**, pasta supplemented of oleoresin/α-CD complexes. Specifically, B, C and D were obtained by adding 130 g α-CDs to 4.87 Kg semolina; 65 g pumpkin oleoresin to 4.935 kg semolina; 65 g and 130 g α-CDs to 4.805 kg semolina, respectively.

Macroscopic image of raw pasta (i) and SEM micrograms of cross sections of cooked pasta (ii). S, starch granules; ss, starch shadows; p, protein network. Magnification 2000x.

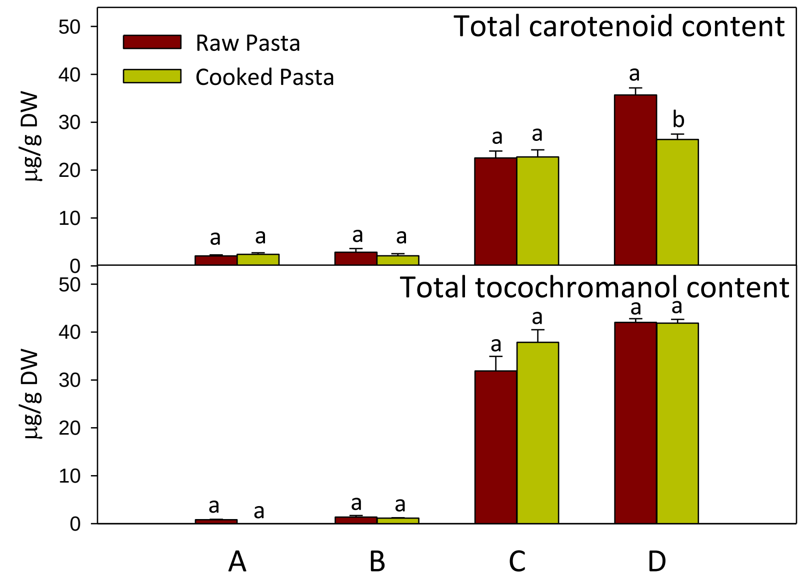
(i)

(ii)



No ultrastructural differences were evidenced between control and supplemented pasta types.

Total content of carotenoids and tocochromanols of control and pumpkin oleoresin supplemented in raw and cooked pasta



The analyses confirmed that pasta was indeed enriched in bioactives: in C and D pasta samples total carotenoids and tocochromanols levels resulted respectively 11.08-, 17.60- and 40.28-, 53.32- times higher than controls .
In C and D cooked pasta samples, the levels of bioactives remained high: total carotenoids and tocochromanols resulted 9.49-, 11.65- and 31.08-, 31.16-times higher than control.

	% RDA				
		Raw pasta			
	Oleoresin	A	B	C	D
Tocochromanols	4.3	0.47	0.81	2.5	3.7
Vitamin A	19	0	0	11.8	17

In conclusion pasta supplemented with pumpkin oleoresin (C) and oleoresin/α-CD complexes (D) can provide 2.5–3.7% and 11.8-17% of recommended dietary allowance of tocochromanols and vitamin A