

Comparison of the dietary fiber content of carob (*Ceratonia siliqua L.*) flour as related to seed presence and roasting effects

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Introduction

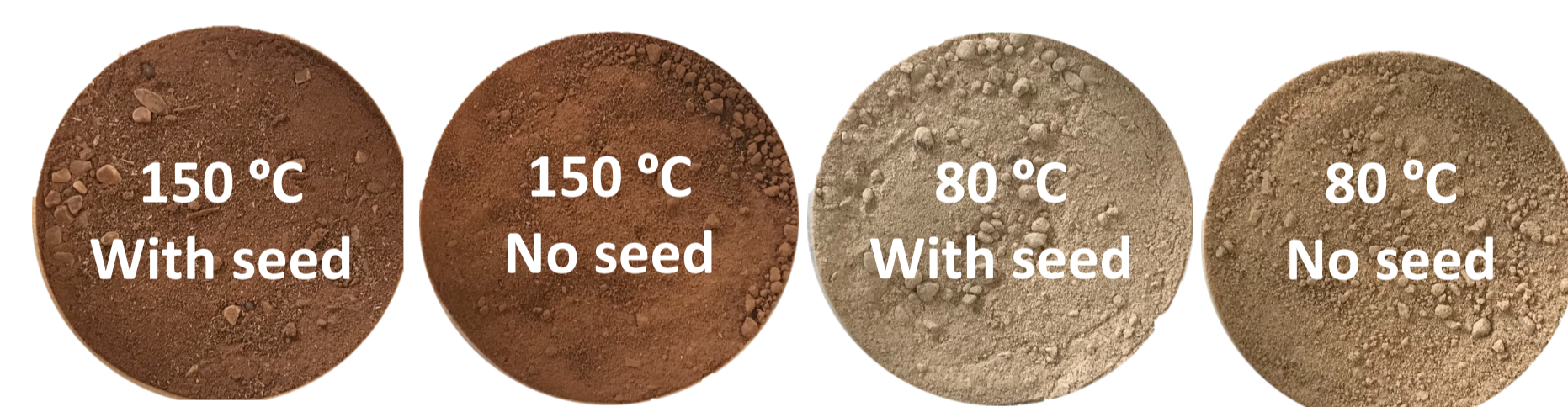
Carob fruit originates from the carob tree, a leguminous evergreen tree (*Ceratonia siliqua L.*) cultivated in the Mediterranean area, namely in Portugal, with high relevance in production and low price. Carob pods contain various relevant nutrients that include proteins, carbohydrates and fiber, as well as phytochemicals such as polyphenols, conferring great potential for carob pods to be used as a functional ingredient.

Objectives

This study focused on extracting, by a thermal-enzymatic process and characterizing, by HPLC, the dietary fiber (DF) content for carob powders with and without seed at different roasting temperatures.

Methods

Carob pods were obtained from a local manufacturer from Algarve, Portugal. The pods were collected in September 2019 and identified. They were a blend of three varieties: Canela, Mulata da Parra and Dolores. The pods were cleaned and crushed into little pieces with a hammer. The pods pieces were separated into two groups: with seeds and without seeds. The two separated groups were roasted in an air forced draft oven at two different temperatures/times, 80 °C/ON and 150 °C/60 min. These roasting temperatures were selected for being used in conventional roasting. Then, they were milled with a hammer mil. Four samples were obtained:



All carob powder (CP) samples were characterized for nutritional composition and antioxidant activity.

Results and Discussion

An initial nutritional evaluation on carob powders (CPs) indicated that seed presence led to higher content in macronutrients (Table 1).

Table 1 – Macronutrients content of carob powders at two roasting temperatures and seed presence. DW – dry weight; Suceq – sucrose equivalents

Content [g/100 g DW]	Sample			
	CP with seed		CP without seed	
	80 °C	150 °C	80 °C	150 °C
Moisture	4.03 ± 0.14 ^b	3.53 ± 0.78 ^{a,b}	3.93 ± 0.22 ^b	2.77 ± 0.26 ^a
Ash	3.09 ± 0.13 ^{a,b}	3.55 ± 0.30 ^a	2.66 ± 0.41 ^b	3.28 ± 0.27 ^{a,b}
Total Carbohydrate	88.06 ± 0.54 ^a	88.83 ± 0.32 ^a	89.39 ± 0.87 ^a	90.44 ± 0.20 ^a
Total Protein	4.52 ± 0.63 ^b	3.79 ± 0.37 ^{a,b}	3.92 ± 0.32 ^{a,b}	3.30 ± 0.06 ^a
Total Fat	0.3 ± 0.00	0.3 ± 0.00	0.1 ± 0.00	0.2 ± 0.00
Suceq [g/100 g DW]	37.02	22.61	40.27	27.40
Energy [kcal/100 g]	373.02 ± 0.77 ^a	373.18 ± 1.95 ^a	374.17 ± 2.23 ^a	376.8 ± 1.04 ^a

The different superscripts in the same row were significant different ($p < 0.05$).

The CPs with seed processed at 150 °C (table 2) showed significantly higher content in neutral sugars (NS). As for the determination of DF content, results indicated that the main fiber fraction present in all samples was insoluble dietary fiber (IDF) corresponding to 98.4 % of total fiber content (Table 2).

Table 2 – Dietary fiber content in carob powders with two roasting temperatures and seed presence. DW – dry weight

Dietary Fiber (g/100g DW)	Carob flour with seed		Carob flour without seed		
	80 °C	150 °C	80 °C	150 °C	
IDF	Glucose	2.70 ± 0.31	3.19 ± 0.44	2.56 ± 0.04	2.94 ± 0.29
	Xylose	0.92 ± 0.15	1.39 ± 0.21	0.81 ± 0.06	1.16 ± 0.03
	Galactose	1.05 ± 0.18	1.96 ± 0.30	0.47 ± 0.04	0.57 ± 0.03
	Arabinose	1.04 ± 0.20	1.91 ± 0.34	0.47 ± 0.07	0.64 ± 0.06
	Mannose	2.99 ± 0.32	11.14 ± 0.36	0.26 ± 0.05	0.74 ± 0.22
	NS _{IDF}	8.70 ± 1.30	19.59 ± 1.66	4.57 ± 0.24	6.05 ± 0.41
	UA _{IDF}	0.17 ± 0.03 ^{a,b}	0.19 ± 0.04 ^a	0.13 ± 0.02 ^b	0.15 ± 0.01 ^a
	NS _{IDF} + UA _{IDF}	8.87 ± 1.84	19.78 ± 4.83	4.70 ± 0.26	6.20 ± 0.95
	KL	10.74 ± 0.90	16.76 ± 1.34	8.14 ± 0.00	17.46 ± 0.50
	IDF	19.61 ± 1.04	36.54 ± 3.62	12.84 ± 0.26	23.66 ± 1.27
	SDF	Glucose	0.06 ± 0.01	0.05 ± 0.01	0.05 ± 0.00
Xylose		0.03 ± 0.00	0.02 ± 0.01	0.02 ± 0.01	0.02 ± 0.00
Galactose		0.20 ± 0.03	0.24 ± 0.07	0.13 ± 0.03	0.09 ± 0.02
Arabinose		0.09 ± 0.03	0.14 ± 0.09	0.10 ± 0.01	0.07 ± 0.01
Mannose		0.47 ± 0.07	0.78 ± 0.31	0.13 ± 0.04	0.11 ± 0.03
NS _{SDF}		0.86 ± 0.09	1.23 ± 0.48	0.42 ± 0.01	0.34 ± 0.10
UA _{SDF}		0.07 ± 0.03 ^{a,b}	0.05 ± 0.01 ^a	0.06 ± 0.02 ^b	0.05 ± 0.01 ^a
SDF		0.93 ± 0.08	1.28 ± 0.48	0.48 ± 0.00	0.39 ± 0.10
(NS _{IDF} + NS _{SDF})		9.56 ± 1.89	20.82 ± 4.66	4.99 ± 0.24	6.39 ± 0.85
(UA _{IDF} + UA _{SDF})		0.24 ± 0.02	0.24 ± 0.05	0.19 ± 0.02	0.20 ± 0.01

KL, Klason lignin; NS, neutral sugar; UA, uronic acid, expressed as g galacturonic acid equivalents (GUA)/g DW; IDF, insoluble dietary fiber; SDF, soluble dietary fiber. IDF=NSIDF+UAIDF+KL; SDF=NSSDF+UASDF. Data were expressed as mean ± SD (n=3). The different superscripts in the same row were significant different ($p < 0.05$).

The uronic acid content was significantly higher in IDF, for both roasting temperatures. The Klason lignin (KL) was higher for CPs processed at 150 °C and represented, in all cases, 50 % of total IDF. The DF were also evaluated for antioxidant activity and phenolic content.

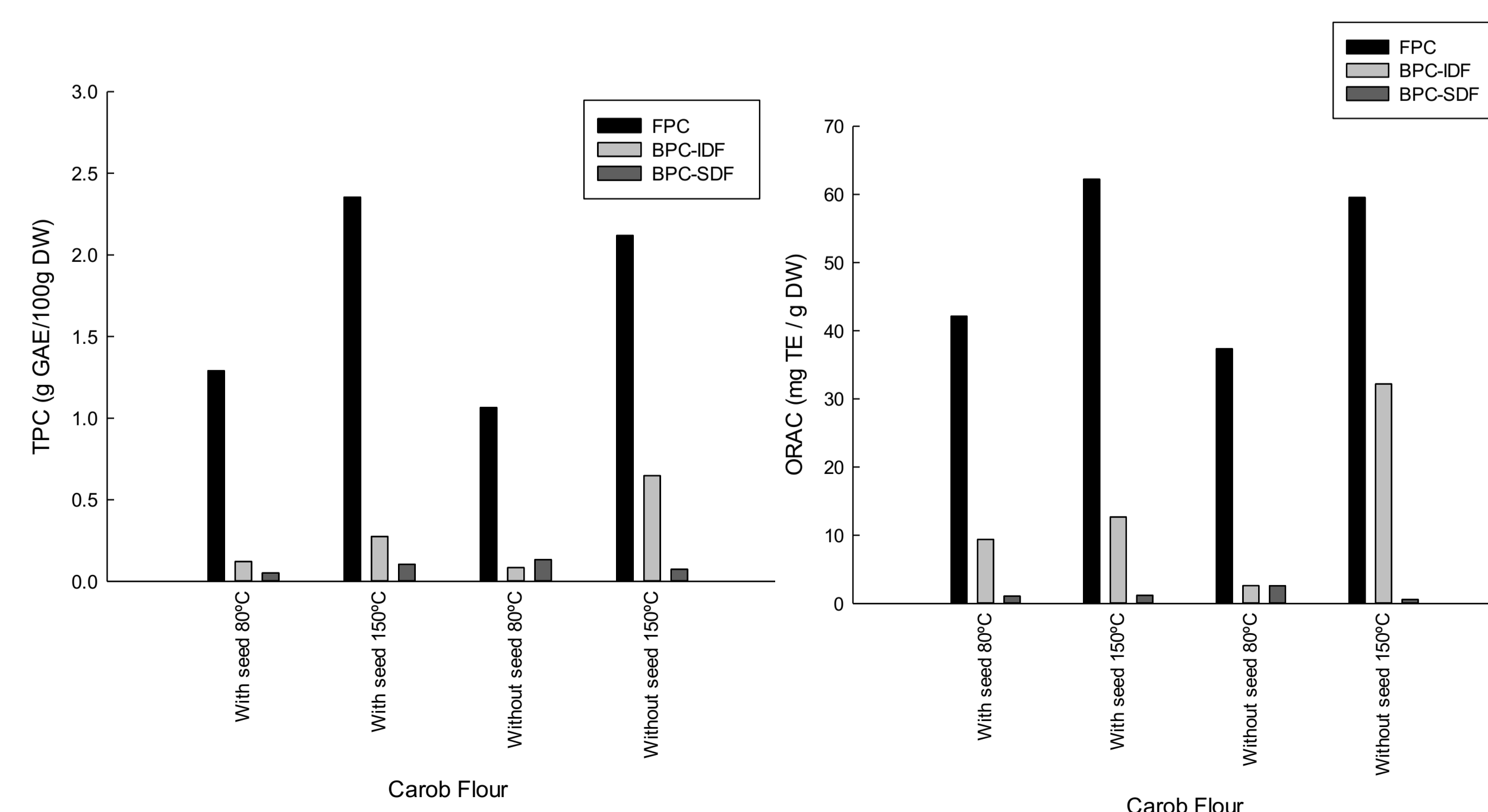


Figure 1 – Total phenolic content and antioxidant activity, determined by ORAC, obtained for CPs at two roasting temperatures and seed presence. DW– dry weight

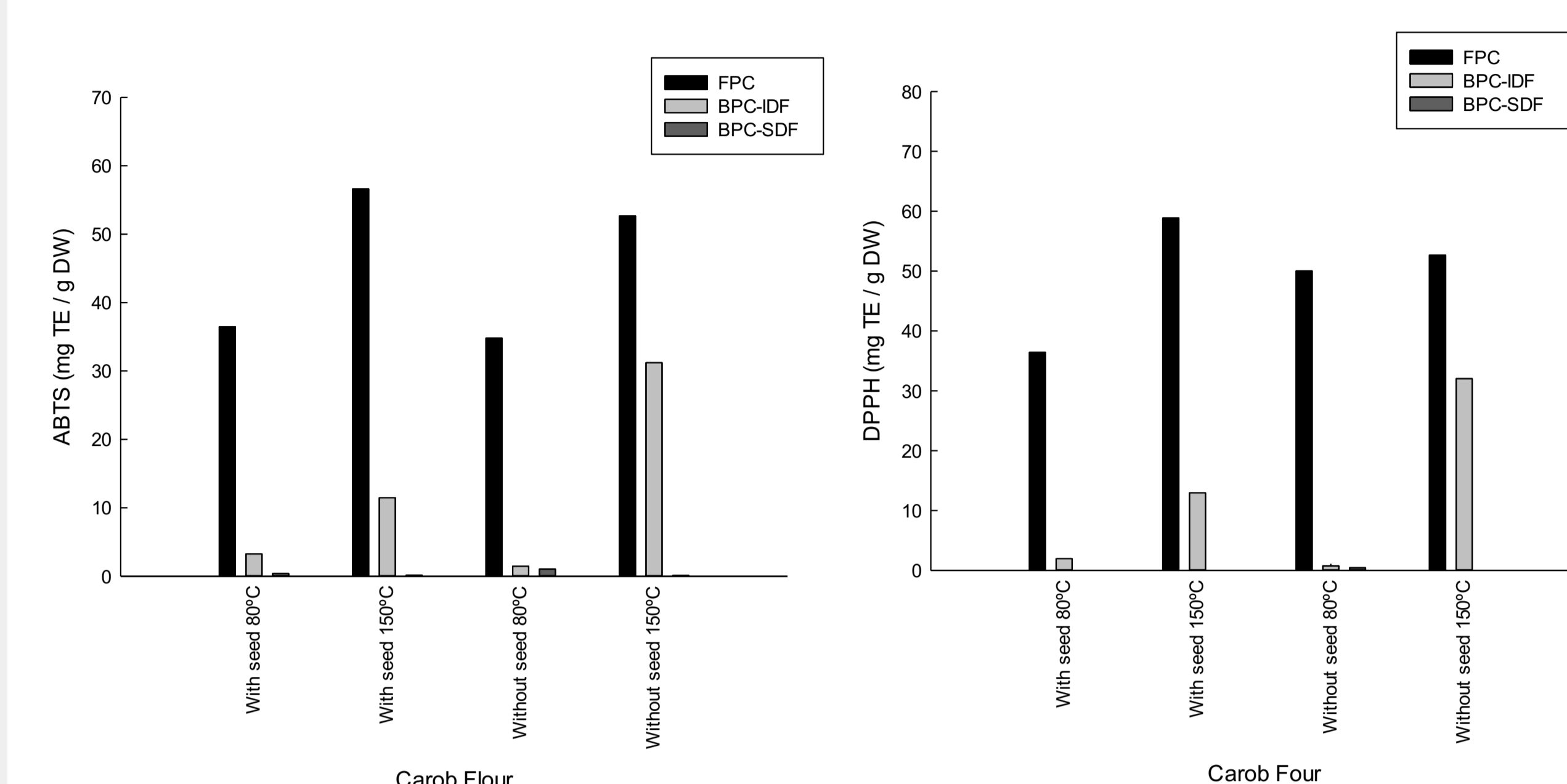


Figure 2 – Antioxidant activity, determined by ABTS and DPPH, obtained for CPs at two roasting temperatures and seed presence. DW – dry weight

The total phenolic content (TPC), determined by Folin-Ciocalteu, was twice on IDF as high at 150 °C than 80 °C, probably due to the formation of certain Maillard reaction products (MRPs), or certain phenolics that may degrade during roasting. The free phenolic content was significantly affected by the roasting temperatures and seed presence. The antioxidant activity is correlated with TPC, increasing in IDF when the flour was roasted at 150 °C.

Conclusions

These findings could promote the utilization of carob flours in food industry to develop new sustainable food products and to induce the consumers towards the undervalued resources.

References

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