

BLACK SEA AREA TRADITIONAL FOODS AS A NEW, VALUABLE SOURCE OF ANTIOXIDANT POLYPHENOLS



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RATIONALE AND OBJECTIVES. The antioxidant capacity of many commonly consumed fruits and vegetables is well-documented. Many **traditional foods of the Black Sea area (BSA)** have plant components as main ingredients; nevertheless their antioxidant properties are not yet well characterized. In the BaSeFood project, we have tested the **antioxidant capacity** and evaluated the **total phenolic content** of more than 30 traditional foods of the BSA, generally not yet known by western European consumers. The present work is part of the 7FP BASEFOOD, which aims to revalue traditional BSA foods, representing a potential under-utilised source of putative health promoting dietary components, still neglected by scientific literature.

MATERIALS AND METHODS. Traditional dishes were prepared in different Countries of the BSA (Bulgaria, Georgia, Romania, Russia, Turkey, and Ukraine) by local Partners, according to the typical recipes and the seasonal availability of plant ingredients. After preparation, foods were sent to the University of Bologna for analysis. The samples were prepared using a ethanol/water (70:30) extraction procedure [1]. The extracts were evaluated for their antioxidant capacity and phenolic compound content.

The **total antioxidant capacity (TAC)** was measured using **ABTS** [2] and **DPPH** methods [3]. The values obtained for both methods were compared to the concentration-response curve of a standard Trolox solution and expressed as micromoles of Trolox equivalent (TE).

The **total phenolic compounds (TPC)** were determined at 750 nm using the Folin-Ciocalteu spectrophotometric method according to the guidelines of Singleton *et al.* [4]. The **hydroxycinnamic index (HI)** was carried out at 320 nm according to

Maillard *et al.* [5]. The spectrophotometric determination of **o-diphenols index (ODI)** was carried out as reported in bibliography by Mateos *et al.* [6]. TPC and ODI were assessed through a gallic acid calibration curve, whereas a ferulic acid calibration curve was used to quantify HI.

As the moisture content significantly varied among different samples, the bioactivity was calculated on the basis of **fresh weight** of the original sample.

Statistic analysis. The differences between individual BSA traditional foods, for both the antioxidant capacity and phenolic content, were analysed by means of Analysis of variance and protected LSD. For the differences between the food categories, the Tukey's honest significant difference (HSD) test was applied.

A multiple regression/path coefficient analysis was carried out to investigate the relations between the two antioxidant capacity methods and phenolic compound content.

Table 1. Average values of antioxidant capacity and phenolic compounds evaluated by spectrophotometric analysis in the 39 traditional foods.

BSA traditional foods	Country	TPC ¹	ODI ¹	HI ²	DPPH ³	ABTS ³
Cereals						
Doli bread	Georgia	0.99	0.75	0.35	9.59	6.47
Cornmeal mush (mamaliga)	Romania	0.17	0.22	0.01	2.15	1.00
Buckwheat porridge crumby	Russia	0.82	0.32	0.09	18.27	6.04
Bulgur pilaf	Turkey	0.47	0.46	0.07	5.98	3.23
Sour rye bread	Ukraine	0.60	0.39	0.43	7.26	5.10
Tikvenik	Bulgaria	0.40	0.24	0.07	18.87	4.08
Vegetables						
Nettles with walnut sauce	Georgia	1.27	3.92	0.48	37.01	7.35
Nettle sour soup (ciorba)	Romania	0.88	3.15	0.33	16.84	5.12
Vegetable okroshka (soup)	Russia	0.38	0.65	0.13	3.07	1.69
Kale soup	Turkey	0.37	0.82	0.16	4.89	1.88
Transcarpathian green borshch	Ukraine	0.22	0.42	0.06	4.17	1.58
Ukrainian borshch	Ukraine	0.27	0.31	0.06	4.11	1.31
Bean soup with Rodopski fasul	Bulgaria	0.42	0.42	0.07	10.21	3.65
Fruits						
Rose jam	Bulgaria	0.86	1.75	0.03	41.68	10.11
Churchkela	Georgia	3.13	3.43	0.20	124.30	23.73
Plum jam (magiun)	Romania	3.58	9.00	1.44	56.52	22.08
Fruit of the evergreen cherry laurel	Turkey	0.54	0.36	0.06	3.07	1.77
Compote (uzvar)	Ukraine	0.28	0.36	0.05	3.39	1.68
Blueberry	Ukraine	6.94	8.19	0.65	129.12	60.88
Seeds						
Sunflower seeds	Bulgaria	12.00	13.62	7.82	485.73	66.86
Roast sunflower seeds	Ukraine	11.60	13.23	8.91	474.65	64.95
Herbs & Spices						
Wild plum sauce (tkemali)	Georgia	1.42	2.58	0.43	15.91	10.09
Herbal dish	Romania	0.62	2.16	0.39	11.44	3.60
Dill	Ukraine	1.68	6.87	0.70	26.22	13.81
Nettle	Ukraine	3.67	5.65	0.67	119.14	21.58
Parsley	Ukraine	2.98	6.19	1.25	7.19	18.84
Sorrel	Ukraine	2.40	6.60	1.06	24.38	16.76
Pomazanka	Ukraine	0.38	0.38	0.15	3.43	3.09
Fermented foods						
Sautéed pickled green beans (dible)	Turkey	0.23	0.26	0.06	2.41	1.59
Sauerkraut	Ukraine	0.60	0.44	0.12	5.08	2.35
Boza	Bulgaria	0.52	0.34	0.15	6.03	5.06
Beverages - Oils						
Watermelon juice	Russia	0.15	0.06	0.02	-0.01	0.75
Flax oil	Georgia	0.00	0.00	-0.01	0.02	0.96
Mustard oil	Russia	0.01	0.03	0.00	0.43	1.17
Mursal tea	Bulgaria	0.70	0.73	0.15	0.86	2.18
Green tea	Georgia	0.69	0.59	0.01	3.34	9.78
Black tea	Turkey	0.55	0.43	0.07	2.33	7.25
Kvass southern	Russia	0.12	0.14	0.16	-0.18	1.31
Elderberry soft drink (socata)	Romania	0.19	0.40	0.06	0.27	1.36
Significance⁴						
LSD (P = 0.05)		0.26	0.45	0.19	15.60	2.32

Means differing more than the corresponding least significant difference (LSD) value are significantly different (P ≤ 0.05)

ODI, o-diphenols index; HI, hydroxycinnamic index; TPC, total phenolic compounds (by Folin-Ciocalteu)

¹ mg gallic acid/g f.w. (except for beverages and oils: mg gallic acid/ml)

² mg ferulic acid/g f.w. (except for beverages and oils: mg ferulic acid/ml)

³ μmol Trolox Eq./g f.w. (except for beverages and oils: μmol Trolox Eq./ml)

⁴ ns, non significant; *, significant at P ≤ 0.05

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CONCLUSIONS. For the first time, the antioxidant properties and the phenolic compounds of traditional foods of the BSA were studied. Although many of these foods are largely consumed with the daily diet in individual Black Sea area countries, less is known about their potential health benefits. Our data, evidencing foods with the highest antioxidant capacity, represent the first step for further researches on their health effects. The nutritional reevaluation of traditional foods will be interesting for both consumers, that can discover or rediscover typical dishes, and food processors, that could exploit these data to implement and optimise production schemes.

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RESULTS. Table 1 reports the average values for all the BSA traditional foods analysed. Significant differences among samples were detected for all the considered analyses; some foods showed a considerably strong antioxidant response and contained high concentrations of phenolic compounds.

Figure 1. Average values of antioxidant capacity of food categories. Bars with different letters are significantly different (P ≤ 0.05) within the same character.

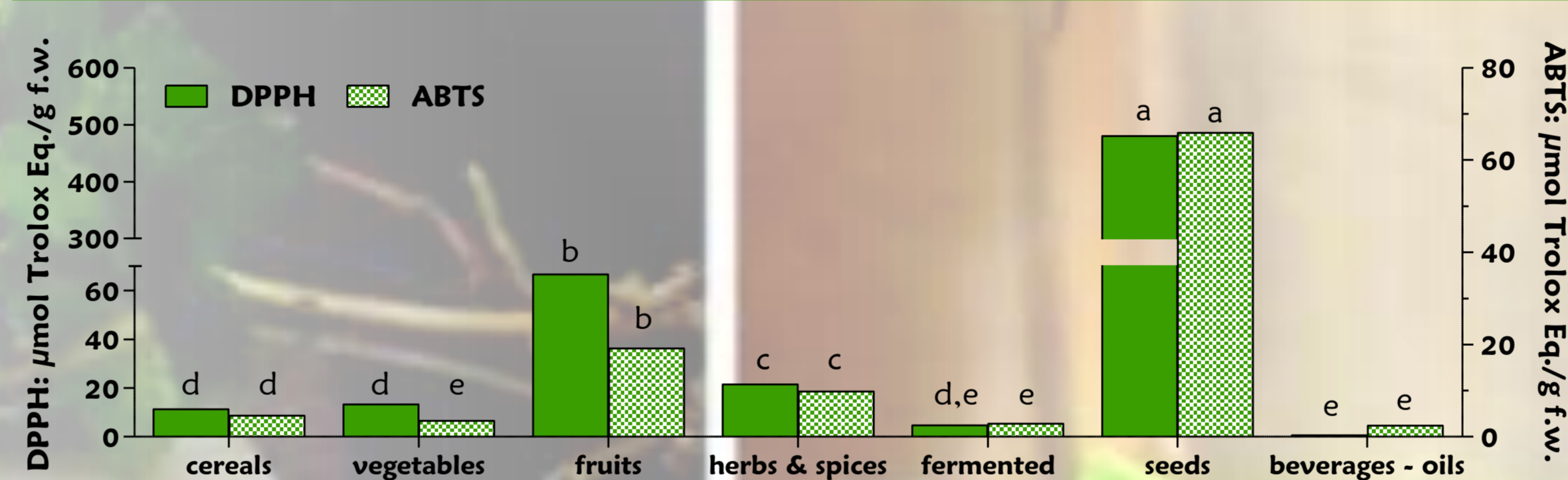
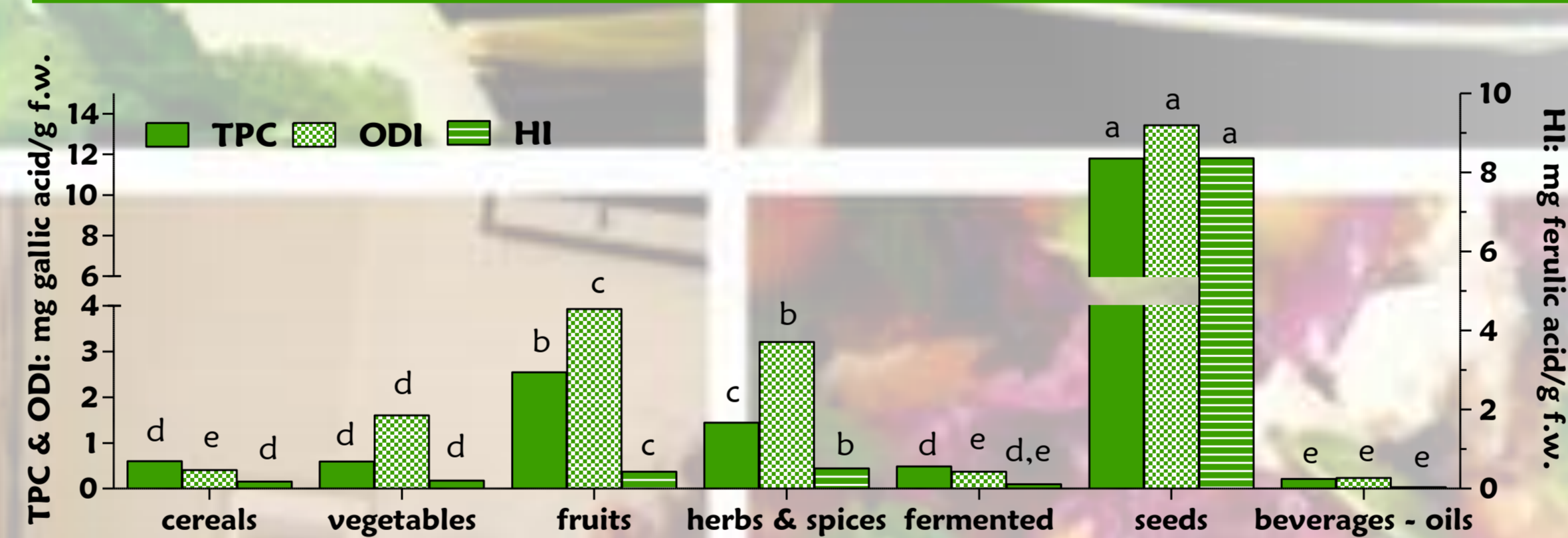


Figure 2. Average values of phenolic compounds of food categories. Bars with different letters are significantly different (P ≤ 0.05) within the same character.



However, the contribution in multiple regression (β coefficient: direct effect) was significant only for TPC and HI. The HI direct effect on TAC was negative, so also in this case its significant correlation coefficient was due mainly to an indirect effect, via its high positive correlation with TPC. ODI had no direct positive effect on TAC and its positive correlation coefficient seems to be due to an indirect effect, via its association with the other two indices. To summarise, the two TAC analyses (DPPH and ABTS) seem to be mainly related to the TPC. In particular the ODI does not seem to positively affect TAC. HI showed a significant contribution on TAC by DPPH method and a negative effect on ABTS method, in which HI also decreased the TPC effect.

Phenolic compounds ^a	r (to DPPH) ^b	Effects (on DPPH) direct (β) / indirect ^b			cross correlations		
		ODI	HI	TPC	ODI	HI	TPC
ODI	0.826*	-0.307*	0.366	0.767	1.00	0.821*	0.922*
HI	0.955*	-0.252	0.446*	0.761	0.821*	1.00	0.915*
TPC	0.957*	-0.283	0.408	0.832*	0.922*	0.915*	1.00

Phenolic compounds ^a	r (to ABTS) ^b	Effects (on ABTS) direct (β) / indirect ^b			cross correlations		
		ODI	HI	TPC	ODI	HI	TPC
ODI	0.905*	-0.033ns	-0.365	1.302	1.00	0.821*	0.922*
HI	0.822*	-0.027	-0.444*	1.293	0.821*	1.00	0.915*
TPC	0.976*	-0.030	-0.406	1.41*	0.922*	0.915*	1.00

^b Multiple regression $r^2 = 0.81$; β (italic), standardised multiple regression coefficient (path coefficient). * Significant at P ≤ 0.05

Table 2. Correlation coefficients (r) and path analysis between DPPH (dependent variable) and phenolic compounds content (independent variables).

Table 3. Correlation coefficients (r) and path analysis between ABTS (dependent variable) and phenolic compounds content (independent variables).