Comparison of nutritional properties and in-vitro antioxidant activity of organically grown garlic and its fermented product

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Introduction

Over the past few years, fermented (black) garlic and its extracts have been increasingly used in cooking and in the daily diet due to their specific taste, nutritional composition and health benefits. The fermentation process is performed by heat treatment of garlic with controlled humidity for a longer period of time. During fermentation, chemical reactions and transformations such as Maillard reactions and caramelization reactions cause the changes in taste, nutritional composition, content of macro- and microelements as well as the content of phenolic compounds and antioxidant activity of garlic.

Methods

- Physico-chemical profile (GC-FID – fatty acid methyl-esters, HPAE-PAD – Dionex™ ICS-5000+, Soxhlet - multiple fat extraction - Soxtherm instrument, Kjeldahl – digestion - Foss Tecator)
- Elemental composition (Microwave digestion - SpeedWave EXPERT instrument, manufactured by Berghof, Purified nitric acid and hydrogen peroxide were added to the samples, after digestion samples were recorded on instruments ICP-OES and ICP-MS)
- Total phenolics and antioxidant activity (DPPH and Ferrous ion chelating (FIC) assay, methanol extracts were recorded on spectrophotometer Cintra 6)

Conclusion

From the obtained results it can be concluded that fermented garlic has a higher content of phenolic compounds and more pronounced antioxidant activity compared to fresh garlic, as well as that various chemical changes occur during fermentation, which can be confirmed by insight into differences in nutritional and elemental composition, before and after fermentation. As the benefits of fermented garlic are positively correlated with the content of phenolic compounds, further research is needed to gain insight into the structures and groups of phenolic compounds that contribute most to the positive effects of fermented garlic.

Results and Discussion

Figure 1. Appearance and shape of fresh garlic and black garlic bulbs and cloves

- The values of the measured samples are expressed as the mean value of the four repeated measurements.

Table 1. Comparison of the nutritional value between fresh garlic and black garlic

Parameter	Fresh garlic	Black garlic
Humidity (g/100g)	66.8 ± 3.3	33.4 ± 0.8
Ash (g/100g)	1.29 ± 0.06	2.32 ± 0.06
Protein (g/100 g)	4.80 ± 0.19	11.05 ± 0.47
Fat (g/100g)	0.57 ± 0.16	0.52 ± 0.19
Saturated fatty acids (g/100g)	0.13 ± 0.02	0.15 ± 0.08
Salt (g/100g)	0.03 ± 0.02	0.05 ± 0.03
Carbohydrate (g/100g)	23.8 ± 3.3	48.0 ± 1.1
Sugars (g/100g)	1.82 ± 0.10	32.80 ± 5.41
Dietary fiber (g/100g)	2.71 ± 0.03	4.76 ± 0.08
Energy (KJ)	529 ± 59	1061 ± 14
Energy (Kcal)	125 ± 14	250 ± 4

- The water content decreased during the fermentation process, while the sugar and carbohydrate content increased significantly as a result of thermal decomposition of the poly- and oligosaccharides (fructan, glucan and other complex polysaccharides). Accordingly, the energy value of fermented garlic (BG) is higher than that of fresh garlic (FG).

Table 2. Content of macro- and microelements in analysed samples

Element	Fresh garlic (mg/kg)	Black garlic (mg/kg)
Ca	147 ± 11	174 ± 38
Fe	27 ± 13	24 ± 4
K	5292 ± 741	8432 ± 585
Mg	221 ± 67	373 ± 46
Na	78 ± 11	136 ± 12
Li	< 0.01	< 0.01
Al	19.4 ± 3.9	16.6 ± 5.4
V	0.014 ± 0.003	0.012 ± 0.007
Cr	0.32 ± 0.09	0.19 ± 0.03
Mn	6.3 ± 1.4	12.7 ± 1.5
Co	0.034 ± 0.002	0.039 ± 0.016
Ni	1.34 ± 0.08	1.0 ± 0.4
Cu	5.3 ± 0.8	9.0 ± 0.8
Zn	14.7 ± 1.8	20.1 ± 0.6
As	0.027 ± 0.005	0.032 ± 0.006
Se	< 0.01	< 0.01
Mo	1.2 ± 0.4	0.41 ± 0.06
Cd	0.018 ± 0.005	0.015 ± 0.003
W	1.6 ± 0.6	2.4 ± 0.9
Hg	0.0036 ± 0.0011	0.0017 ± 0.0006
Pb	< 0.01	< 0.01

- The content of Ca, K, Mg, Na, Mn, Cu, Zn, and W increased, while the content of Fe, Al, Cr, Ni, Mo and Hg decreased during fermentation. The content of V and Cd decreased slightly, while the content of Co and As slightly increased after fermentation.

- The content of total phenolic compounds is higher in the fermented sample (904 ± 282 mg EKG/g) compared to fresh one (39 ± 5 mg EKG/g), indicating different chemical transformations of secondary metabolites during the fermentation process.
- As a measure of antioxidant activity, two assays were performed: DPPH (BG: 0.324 ± 0.059; FG: 0.014 ± 0.007 mmol/L TE/g]) and FIC (BG: 365 ± 52; FG: 255 ± 52 mmol/L TE/g]) and both showed higher activity of fermented garlic, which is positively correlated with the higher content of phenolic compounds in the sample.

Table 3. Extended nutritional composition parameters of fresh garlic and black garlic

	Parameter	Fresh garlic	Black garlic
Sugars (g/100g)	Sucrose	1.07	< 0.10
	Glucose	< 0.10	3.52
	Fructose	0.74	29.28
	Lactose	< 0.10	< 0.10
Fatty acids (g/100g)	C16	0.085	0.099
	C18	0.048	0.056
	C18:1 (cis - 9)	0.112	0.092
	C18:2 (cis - 9, 12)	0.171	0.159
	C18:2 (trans - 9, 12)	< 0.01	0.057
	C18:3 (cis - 6, 9, 12)	0.052	< 0.01
	C20:3 (cis - 11, 14, 17)	0.132	0.038
	Monounsaturated	0.112	0.092
	Polyunsaturated	0.355	0.254
	Trans	< 0.01	0.057

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