# COMPARISON OF NUTRITIONAL PROPERTIES AND ANTIOXIDANT ACTIVITY OF 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 was performed in Soxtherm instrument, Kjeldahl - digestion was performed on instrument Foss Tecator,…)
- Elemental composition (Microwave digestion was performed in the 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 (Folin-Ciocalteu assay, methanol extracts were recorded on spectrophotometer Cintra 6)
- Total antioxidant activity (DPPH and *Ferrous ion chelating* (FIC) assay, methanol extracts were recorded on spectrophotometer Cintra 6)
- The values of the measured samples are expressed as the mean value of the four repeated measurements.

## 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

**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 |

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

**Table 2.** 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) | $C_{16}$ | 0.085 | 0.099 |
| | $C_{18}$ | 0.048 | 0.056 |
| | $C_{18:1}$ (*cis* - 9) | 0.112 | 0.092 |
| | $C_{18:2}$ (*cis* - 9, 12) | 0.171 | 0.159 |
| | $C_{18:2}$ (*trans* - 9, 12) | < 0.01 | 0.057 |
| | $C_{18:3}$ (*cis* - 6, 9, 12) | 0.052 | < 0.01 |
| | $C_{20:3}$ (*cis* - 11, 14, 17) | 0.132 | 0.038 |
| | Monounsaturated | 0.112 | 0.092 |
| | Polyunsaturated | 0.355 | 0.254 |
| | *Trans* | < 0.01 | 0.057 |

- 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).

- 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.

**Table 3.** 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 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.

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