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# Effect of maturity stages on the content of ash components in raw, frozen and canned broad beans

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**Abstract**

The aim of the present work was to determine the level of ash, potassium, phosphorus, calcium, magnesium, iron, zinc, manganese, and copper in fresh and preserved broad bean seeds at the stage of milk-wax maturity. The experiments included two broad bean cultivars, four stages of seed maturity being differentiated in each. With the higher maturity stages, the contents of ash, potassium, phosphorus, calcium, and magnesium gradually increased in fresh matter of the two cultivars. The contents of zinc and copper showed a slight decreasing tendency, while the levels of iron and manganese varied. Frozen and canned broad bean seeds of milk-wax maturity, prepared for consumption, were a valuable source of mineral compounds. The more mature the seeds, the greater were the contents of potassium, phosphorus, calcium, magnesium, and manganese, and smaller less so for copper, while the levels of iron and zinc varied. Boiled frozen seeds contained more potassium, phosphorus, magnesium, zinc, manganese, and copper than canned products, no differences being found in the contents of calcium and iron. The dehulled seeds contained more phosphorus but less calcium than the intact ones. 

## 1. Introduction

In European countries broad beans are consumed after their seeds have reached the stage of milk maturity. Achundov, Gurevic and Ismailov (1981) used this term for seeds with a dry matter content of 7% but Duckworth (1966) for that of 35%. The wide limits of this maturity stage are reflected in the pronounced variability of the chemical composition of the raw material. The harvest of broad bean seeds at the higher maturity stages is economically beneficial, owing to the greater yields of seeds and of protein per area unit (Kmiecik & Lisiewska, 1990). Moreover, Gebczynski (1995) showed that, in the maturity range corresponding to a dry matter content of 25–40%, the raw material possessed a high organoleptic quality, though at the highest maturity stage preserved seeds had fairly tough hulls.

The attention of research workers has chiefly concentrated upon protein compounds and to a smaller degree, on vitamins in the broad bean. Only a few works have focussed on the content of ash constituents, none of them with reference to seeds that had not yet reached physiological maturity.

The aim of the present work was to determine the levels of ash, potassium, phosphorus, calcium, magnesium, iron, zinc, manganese, and copper in fresh and preserved broad bean seeds at the stage of milk-wax maturity. The experiments included two broad bean cultivars, four stages of seed maturity being differentiated in each.

## 2. Materials and methods

### 2.1. Materials

Broad beans of Comprimo RS and Threefoldwhite cultivars were harvested from the experimental field of the department situated in southern Poland (the Krakow region). The seeds were picked at four maturity stages. The first stage (I) corresponded to a dry matter content at the level of 25%, the second (II) — 30%, third (III) — 35%, and fourth (IV) to 40%.

Analyses of the raw material were carried out within 3 h of pod harvest and 1 h after shelling. Freezing and

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canning procedures were preceded by blanching, carried out 1 h after shelling. The seeds were blanched in water at 96–98°C and a seed-water ratio of 1:5. The blanching time necessary for peroxidase inactivation to a level of about 5% of its initial activity ranged from 2.5 to 4 min, depending upon the size of the seeds.

Freezing was conducted in a Feutron model 3101-01 blast freezer with a forced air current at −35°C. The seeds were frozen on trays in layers of about 3 cm. The time of freezing to −20°C was 30 min. Frozen products packed in polyethylene bags were stored in a laboratory chest freezer, at −20°C.

Preservation in cans was carried out in an experimental autoclave. The 0.9 l containers were filled with 550 g of blanched seeds and salt brine. The brine at a concentration of 2.5% NaCl was prepared using tap water of 13 German degrees hardness. The following times and thermal conditions of sterilization were applied: 10 min for reaching the sterilization temperature, sterilization during 15–23 min (depending on the size and maturity of the seeds), time of cooling to 40°C 15 min sterilization temperature 118–120°C. The time of actual sterilization was longer for more mature seeds and for Comprimo RS with its larger seeds. After sterilization, the canned preserves were stored in a dark air-conditioned chamber at about 10°C until the time of analysis.

### 2.2. Methods

Ash was determined by incinerating weighed portions of homogenized seeds in a Nabertherm model L 9/S 27 furnace oven at 550°C. For the determination of individual mineral constituents, except P, the mineralization of seeds was carried out in a 3:1 mixture of $HNO_3$/$HClO_4$. A 50 g portion of the material and 30 ml of the acid mixture were placed in 250 ml test tubes of the Tecator Kjeltec Auto Plus II mineralization set. The treated samples were left until the next day. Mineralization was carried out at 120°C. The mineralized samples were diluted with double-distilled water to a volume of 100 ml and filtered into dry flasks. The contents of K, Ca, Mg, Fe, Zn, Cu, and Mn in the solutions were determined using the flame method in a Philips PU 9100X AA spectrophotometer. Phosphorus was determined according to Method 3.098 (AOAC, 1984).

Analyses included raw broad beans, blanched seeds, frozen seeds after 6-month storage, and final products, i.e. frozen seeds after 6-month storage then cooked to consumption consistency with a ratio of brine to seeds similar to that in the sterilized product, and sterilized canned seeds after 6-months storage. In the final products, both intact seeds and dehulled ones (cotyledons) were analysed. The results were calculated on a dry matter basis because of the varied weight of 1000 seeds due to the absorption or release of water, and also of the leaching of constituents from the seeds. The range of changes is listed.

| Cultivar | Stage of maturity | Weight of 1000 seeds of raw broad bean, g | Percentage of increase (+) or decrease (−) of 1000 seed weight as the effect of: | | |
|---|---|---|---|---|---|
| | | | Blanching | Cooking of frozen seeds | Canning |
| Comprimo RS | I | 3097 | 0 | −3 | +4 |
| | II | 3327 | +2 | 0 | +8 |
| | III | 3454 | +3 | +5 | +12 |
| | IV | 3571 | +4 | +9 | +16 |
| Threefoldwhite | I | 1940 | 0 | −1 | +1 |
| | II | 2033 | 0 | +3 | +4 |
| | II | 2166 | +3 | +5 | +10 |
| | IV | 2312 | +4 | +12 | +14 |

The level of the analysed components in 100 g of the product is given in synthetic form in Fig. 1. This presentation of results allows the consumer to estimate the amount of various compounds contained in a 100 g portion of broad bean resulting from a particular form of preservation. The amount of sodium chloride added to the brine in canned preserves or to the water in which frozen products were cooked was subtracted from the total content of ash components. Analysis of intact seeds and, separately, of dehulled ones, is associated with diverse preferences of consumers who eat the seeds with or without the hull. In statistical analysis the Snedecor $F$- and Student $t$-tests were applied and the least significant difference (LSD) was computed at a probability level of $p=0.01$.

## 3. Results and discussion

With the higher maturity stages, the contents of ash, potassium, phosphorus, calcium, and magnesium gradually increased in the fresh matter of the two cultivars. The contents of zinc and copper showed a slight decreasing tendency while the levels of iron and manganese varied (Fig. 1). A different pattern of changes in the contents of the analysed components was observed after its calculation on a dry matter basis (Tables 1–9). In the content of ash a decreasing tendency appeared, no statistically significant differences being determined between the maturity stages. The levels of potassium, calcium, magnesium, zinc, and copper fell while those of phosphorus, iron, and manganese varied. In numerous cases, significant differences were assessed in the levels of the investigated elements between the successive stages of maturity. In analyses of broad bean composition carried out by Ziena, El-Tabey Shehata, Youssef and Abd El-Bary (1987) at regular intervals up to the stage of physiological maturity of the seeds, the contents of ash, potassium, calcium, magnesium, iron, copper, and zinc increased. According to Islam and Lea (1979) the levels of magnesium and copper increased, potassium

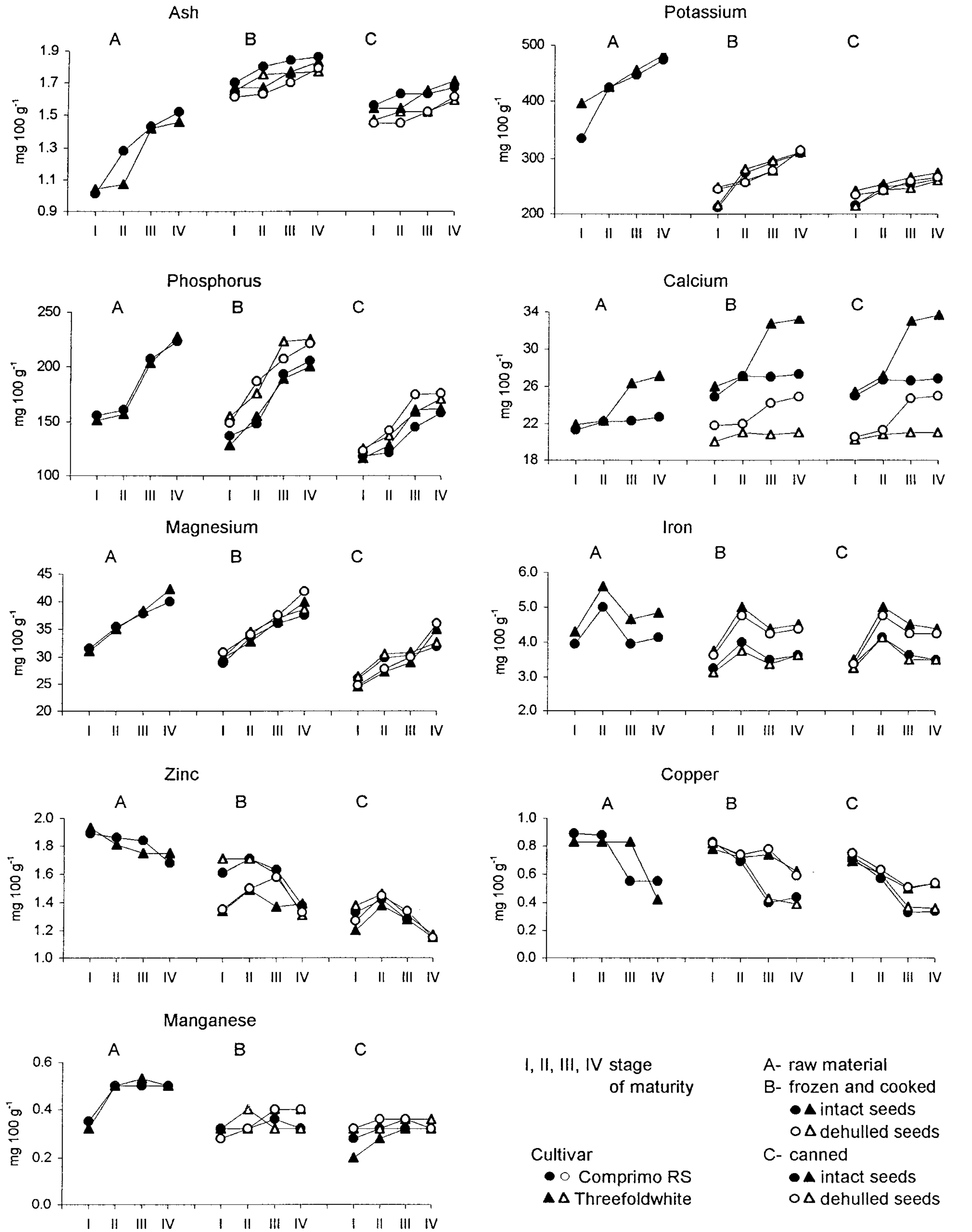


Fig. 1. Content of ash and some mineral components in raw and perserved broad bean seeds, in fresh matter.

Table 1
Content of ash[a] in raw and preserved seeds of broad bean, g 100 $g^{-1}$ dry matter

| Cultivar | Stage of maturity[b] | Raw material | Blanched material | Frozen broad bean: Before cooking | Frozen broad bean: After cooking: Intact seeds | Frozen broad bean: After cooking: Dehulled seeds | Canned broad bean: Intact seeds | Canned broad bean: Dehulled seed | LSD p = 0.01 |
|---|---|---|---|---|---|---|---|---|---|
| Comprimo RS | I | 3.94 | 3.68 | 3.51 | 6.78 | 6.25 | 7.24 | 6.48 | 0.246 |
| | II | 4.17 | 3.89 | 3.66 | 5.99 | 5.73 | 6.67 | 5.90 | 0.217 |
| | III | 4.05 | 3.80 | 3.80 | 5.41 | 5.19 | 6.00 | 5.32 | 0.194 |
| | IV | 3.90 | 3.76 | 3.66 | 5.16 | 4.99 | 5.83 | 5.31 | 0.184 |
| Threefoldwhite | I | 4.08 | 3.81 | 3.71 | 6.74 | 6.32 | 6.97 | 6.14 | 0.312 |
| | II | 4.00 | 3.64 | 3.58 | 5.85 | 5.53 | 6.08 | 5.29 | 0.206 |
| | III | 3.99 | 3.59 | 3.43 | 5.29 | 4.93 | 5.90 | 5.12 | 0.139 |
| | IV | 3.67 | 3.50 | 3.39 | 5.12 | 5.10 | 5.64 | 5.01 | 0.248 |
| LSD = $p = 0.01$ | | 0.270 | 0.166 | 0.146 | 0.229 | 0.269 | 0.242 | 0.210 | |

[a] From four determinations.
[b] Stage of maturity, see text for stage of maturity.

Table 2
Content of potassium[a] in raw and preserved seeds of broad bean, mg 100 $g^{-1}$ dry matter

| Cultivar | Stage of maturity[b] | Raw material | Blanched material | Frozen broad bean: Before cooking | Frozen broad bean: After cooking: Intact seeds | Frozen broad bean: After cooking: Dehulled seed | Canned broad bean: Intact seeds | Canned broad bean: Dehulled seed | LSD $p = 0.01$ |
|---|---|---|---|---|---|---|---|---|---|
| Comprimo RS | I | 1312 | 1131 | 1069 | 847 | 822 | 999 | 945 | 51.8 |
| | II | 1385 | 1187 | 1122 | 913 | 918 | 1017 | 944 | 68.8 |
| | III | 1264 | 1048 | 1034 | 860 | 872 | 930 | 862 | 55.2 |
| | IV | 1211 | 1082 | 1057 | 857 | 879 | 868 | 808 | 58.0 |
| Threefoldwhite | I | 1536 | 1301 | 1226 | 997 | 956 | 1090 | 992 | 51.6 |
| | II | 1407 | 1131 | 1131 | 912 | 971 | 987 | 883 | 60.2 |
| | III | 1274 | 1080 | 1041 | 828 | 806 | 955 | 871 | 58.9 |
| | IV | 1214 | 1048 | 1025 | 882 | 894 | 905 | 835 | 51.2 |
| LSD $p = 0.01$ | | 49.7 | 45.2 | 61.1 | 57.8 | 45.9 | 68.7 | 70.6 | |

[a] From four determinations.
[b] Stage of maturity, see text for stage of maturity.

Table 3
Content of phosphorus[a] in raw and preserved seeds of broad bean, mg 100 $g^{-1}$ dry matter

| Cultivar | Stage of maturity[b] | Raw material | Blanched material | Frozen broad bean: Before cooking | Frozen broad bean: After cooking: Intact seeds | Frozen broad bean: After cooking: Dehulled seed | Canned broad bean: Intact seeds | Canned broad bean: Dehulled seed | LSD $p = 0.01$ |
|---|---|---|---|---|---|---|---|---|---|
| Comprimo RS | I | 611 | 608 | 610 | 546 | 589 | 548 | 550 | 41.6 |
| | II | 528 | 511 | 525 | 493 | 579 | 497 | 534 | 43.6 |
| | III | 587 | 588 | 600 | 568 | 656 | 534 | 5555 | 39.4 |
| | IV | 570 | 596 | 603 | 568 | 636 | 550 | 569 | 45.2 |
| Threefoldwhite | I | 596 | 602 | 593 | 513 | 583 | 524 | 520 | 48.7 |
| | II | 556 | 535 | 551 | 530 | 635 | 500 | 521 | 40.4 |
| | III | 602 | 598 | 601 | 564 | 593 | 579 | 589 | 47.4 |
| | IV | 589 | 593 | 598 | 560 | 629 | 536 | 551 | 42.5 |
| LSD $p = 0.01$ | | 40.4 | 39.3 | 46.8 | 38.1 | 42.2 | 40.2 | 42.5 | |

[a] From four determinations.
[b] Stage of maturity, see text for stage of maturity.

Table 4
Content of calcium[a] in raw and preserved seeds of broad bean, mg 100 $g^{-1}$ dry matter

| Cultivar | Stage of maturity[b] | Raw material | Blanched material | Frozen broad bean: Before cooking | Frozen broad bean: After cooking, Intact seeds | Frozen broad bean: After cooking, Dehulled seed | Canned broad bean: Intact seeds | Canned broad bean: Dehulled seed | LSD $p=0.01$ |
|---|---|---|---|---|---|---|---|---|---|
| Comprimo RS | I | 83.3 | 97.5 | 92.1 | 99.0 | 76.0 | 116 | 91.8 | 8.33 |
| | II | 72.3 | 87.3 | 83.9 | 90.2 | 68.5 | 109 | 80.8 | 6.93 |
| | III | 63.2 | 74.3 | 74.5 | 82.3 | 61.3 | 97.8 | 73.5 | 4.35 |
| | IV | 58.2 | 68.4 | 67.6 | 75.8 | 59.3 | 88.6 | 70.1 | 6.61 |
| Threefoldwhite | I | 86.5 | 99.3 | 95.7 | 104.8 | 85.3 | 115 | 87.0 | 6.73 |
| | II | 74.0 | 84.1 | 83.1 | 94.6 | 74.8 | 106 | 77.8 | 6.63 |
| | III | 73.7 | 88.5 | 87.4 | 97.6 | 70.3 | 117 | 82.9 | 4.70 |
| | IV | 68.3 | 79.6 | 78.2 | 92.9 | 71.2 | 111 | 78.4 | 6.50 |
| LSD $p=0.01$ | | 5.41 | 4.31 | 6.84 | 6.99 | 6.78 | 7.18 | 7.00 | |

[a] From four determinations.
[b] Stage of maturity, see text for stage of maturity.

Table 5
Content of magnesium[a] in raw and preserved seeds of broad bean, mg 100 $g^{-1}$ dry matter

| Cultivar | Stage of maturity[b] | Raw material | Blanched material | Frozen broad bean: Before cooking | Frozen broad bean: After cooking, Intact seeds | Frozen broad bean: After cooking, Dehulled seed | Canned broad bean: Intact seeds | Canned broad bean: Dehulled seed | LSD $p=0.01$ |
|---|---|---|---|---|---|---|---|---|---|
| Comprimo RS | I | 124 | 123 | 116 | 115 | 114 | 122 | 117 | $F_e < F_t$ |
| | II | 116 | 119 | 113 | 112 | 113 | 122 | 119 | 7.7 |
| | III | 107 | 106 | 105 | 106 | 109 | 111 | 108 | $F_e < F_t$ |
| | IV | 102 | 106 | 104 | 104 | 106 | 111 | 109 | $F_e < F_t$ |
| Threefoldwhite | I | 123 | 124 | 120 | 120 | 121 | 121 | 105 | 6.7 |
| | II | 116 | 117 | 113 | 114 | 116 | 106 | 101 | 11.2 |
| | III | 107 | 109 | 106 | 109 | 109 | 104 | 101 | 5.8 |
| | IV | 106 | 108 | 106 | 112 | 119 | 116 | 113 | 9.2 |
| LSD $=p=0.01$ | | 6.0 | 4.3 | 5.6 | 5.3 | 7.5 | $F_e < F_t$ | 5.7 | |

[a] From four determinations.
[b] Stage of maturity, see text for stage of maturity.

Table 6
Content of iron[a] in raw and preserved seeds of broad bean, mg 100 $g^{-1}$ dry matter

| Cultivar | Stage of maturity[b] | Raw material | Blanched material | Frozen broad bean: Before cooking | Frozen broad bean: After cooking, Intact seeds | Frozen broad bean: After cooking, Dehulled seed | Canned broad bean: Intact seed | Canned broad bean: Dehulled seed | LSD $p=0.01$ |
|---|---|---|---|---|---|---|---|---|---|
| Comprimo RS | I | 15.5 | 13.3 | 12.7 | 13.0 | 11.9 | 15.7 | 14.9 | 1.01 |
| | II | 16.4 | 14.0 | 13.5 | 13.3 | 12.2 | 16.9 | 16.1 | 0.86 |
| | III | 11.2 | 10.5 | 10.4 | 10.3 | 9.9 | 13.4 | 12.3 | 0.74 |
| | IV | 10.6 | 9.9 | 9.8 | 10.1 | 10.2 | 12.2 | 11.7 | 0.57 |
| Threefoldwhite | I | 17.0 | 15.5 | 14.8 | 15.1 | 14.2 | 15.8 | 14.3 | 0.86 |
| | II | 18.6 | 17.1 | 17.0 | 17.5 | 16.2 | 19.5 | 17.4 | 0.63 |
| | III | 13.0 | 12.7 | 12.9 | 13.1 | 12.3 | 16.2 | 14.3 | 0.89 |
| | IV | 12.2 | 11.7 | 11.6 | 12.6 | 12.5 | 14.5 | 13.3 | 0.80 |
| LSD $p=0.01$ | | 1.29 | 1.26 | 1.12 | 0.73 | 0.72 | 0.91 | 0.79 | |

[a] From four determinations.
[b] Stage of maturity, see text for stage of maturity.

Table 7
Content of zinc[a] in raw and preserved seeds of broad bean, mg 100 $g^{-1}$ dry matter

| | | | | Frozen broad bean | | | Canned broad bean | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Before cooking | After cooking | | | | |
| Cultivar | Stage of maturity[b] | Raw material | Blanched material | | Intact seeds | Dehulled seed | Intact seeds | Dehulled seed | LSD $p=0.01$ |
| Comprimo RS | I | 7.4 | 6.5 | 6.4 | 6.4 | 6.5 | 6.2 | 6.1 | 0.36 |
| | II | 6.1 | 5.8 | 5.8 | 5.7 | 5.6 | 5.8 | 5.7 | 0.27 |
| | III | 5.2 | 4.8 | 4.8 | 4.8 | 4.7 | 4.7 | 4.6 | 0.25 |
| | IV | 4.3 | 4.0 | 4.0 | 3.8 | 3.7 | 4.0 | 3.9 | 0.28 |
| Threefoldwhite | I | 6.4 | 5.6 | 5.6 | 5.4 | 5.3 | 5.4 | 5.4 | 0.39 |
| | II | 6.0 | 5.6 | 5.5 | 5.2 | 5.1 | 5.4 | 5.3 | 0.31 |
| | III | 4.9 | 4.8 | 4.9 | 4.8 | 4.6 | 4.6 | 4.5 | 0.41 |
| | IV | 4.4 | 4.2 | 4.1 | 3.9 | 3.8 | 3.8 | 3.6 | 0.38 |
| LSD $p=0.01$ | | 0.37 | 0.36 | 0.29 | 0.31 | 0.23 | 0.22 | 0.22 | |

[a] From four determinations.
[b] Stage of maturity, see text for stage of maturity.

Table 8
Content of manganese[a] in raw and preserved seeds of broad bean, mg 100 $g^{-1}$ dry matter

| | | | | Frozen broad bean | | | Canned broad bean | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Before cooking | After cooking | | | | |
| Cultivar | Stage of maturity[b] | Raw material | Blanched material | | Intact seeds | Dehulled seed | Intact seeds | Dehulled seed | LSD $p=0.01$ |
| Comprimo RS | I | 1.38 | 1.32 | 1.25 | 1.27 | 1.22 | 1.25 | 1.32 | 0.165 |
| | II | 1.62 | 1.38 | 1.31 | 1.27 | 1.11 | 1.31 | 1.25 | 0.161 |
| | III | 1.41 | 1.20 | 1.08 | 1.06 | 0.94 | 1.18 | 1.26 | 0.124 |
| | IV | 1.27 | 1.26 | 1.17 | 1.04 | 0.90 | 1.20 | 1.21 | 0.135 |
| Threefoldwhite | I | 1.22 | 1.19 | 1.11 | 1.10 | 1.10 | 1.11 | 1.20 | 0.107 |
| | II | 1.64 | 1.43 | 1.30 | 1.12 | 1.10 | 1.27 | 1.32 | 0.194 |
| | III | 1.48 | 1.20 | 1.24 | 1.21 | 1.20 | 1.19 | 1.20 | 0.084 |
| | IV | 1.25 | 1.10 | 1.08 | 1.10 | 1.10 | 1.10 | 1.09 | 0.090 |
| LSD $p=0.01$ | | 0.110 | 0.095 | 0.100 | 0.074 | 0.078 | 0.086 | 0.101 | |

[a] From four determinations.
[b] Stage of maturity, see text for stage of maturity.

Table 9
Content of copper[a] in raw and preserved seeds of broad bean, mg 100 $g^{-1}$ dry matter

| | | | | Frozen broad bean | | | Canned broad bean | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Before cooking | After cooking | | | | |
| Cultivar | Stage of maturity[b] | Raw material | Blanched material | | Intact seeds | Dehulled seed | Intact seeds | Dehulled seed | LSD $p=0.01$ |
| Comprimo RS | I | 3.50 | 3.47 | 3.41 | 3.31 | 3.11 | 3.29 | 3.19 | 0.244 |
| | II | 2.88 | 2.498 | 2.42 | 2.31 | 2.38 | 2.31 | 2.33 | 0.272 |
| | III | 1.56 | 1.34 | 1.28 | 1.20 | 1.27 | 1.20 | 1.29 | 0.148 |
| | IV | 1.40 | 1.29 | 1.28 | 1.21 | 1.10 | 1.19 | 1.20 | 0.129 |
| Threefoldwhite | I | 3.29 | 3.18 | 3.29 | 3.15 | 3.21 | 3.10 | 3.20 | $F_e < F_t$ |
| | II | 2.74 | 2.68 | 2.65 | 2.53 | 2.53 | 2.36 | 2.31 | 0.322 |
| | III | 2.30 | 2.09 | 2.26 | 2.22 | 2.25 | 1.78 | 1.70 | 0.262 |
| | IV | 1.92 | 1.83 | 1.83 | 1.73 | 1.69 | 1.78 | 1.68 | 0.149 |
| LSD $p=0.01$ | | 0.167 | 0.220 | 0.200 | 0.169 | 0.176 | 0.175 | 0.189 | |

[a] From four determinations.
[b] Stage of maturity, see text for stage of maturity.

and zinc decreased, and calcium was at a uniform level, while manganese and iron varied. Also Reddy and Kumari (1988) recorded an increase in iron content up to a certain stage, followed by a decrease.

The blanching applied before seed preservation caused a decrease in the levels of ash by 4–10%, potassium by 11–20%, iron by 2–14%, zinc by 2–12%, copper by 1–14%, and manganese by 1–19%, while the content of calcium increased by 14–21%, depending on the sample. The contents of phosphorus and magnesium did not change. No dependence was found between the level of losses of the particular elements and the degree of maturity.

Great losses in mineral components, during the blanching and other procedures involving water concerned elements which are dissolved in cell sap and easily washed out (Scheffeldt, Blumenthal, Meier & Von Kanel, 1982). On the other hand, an increase in calcium content is usually observed since the tap water contains this element. Moreover, it is not so easily washed out, being structurally connected with plant tissues (Lee, Parsons & Downing, 1982; Lopez & Williams, 1988).

Contrary to boiling, the freezing and storage of frozen products for 6 months did not induce changes in the level of the analysed elements (Tables 1–9). Owing to the addition of sodium chloride to the water during cooking, the total content of ash increased by 60%, on average, compared with that in frozen seeds before boiling (Table 1). When the total content of ash components in boiled seeds was reduced by the amount of chlorides added in table salt to the boiling water, the level of ash in boiled broad beans was 14–27% lower than before cooking, the greater losses being associated with more mature seeds. Boiling significantly reduced the content of potassium and, in the last mature seeds, of phosphorus. The content of calcium significantly increased, though not in all cases. Changes in the levels of magnesium, iron, zinc, manganese, and copper were statistically non-significant.

Maskova, Rysova, Fiedlerova, Halasova and Verveinova (1996) observed that the effect of boiling seeds on the preservation of mineral components to a great degree depended upon the species. According to Tanusi, Suzuki and Nishiyama (1992) boiling induced a decrease in most mineral components of broad bean.

The content of ash components in the dry matter of canned seeds was 70% greater than in the blanched raw material. This was due to the addition of sodium chloride to the brine used in the canning process. The content of salt was identical in the fresh weight of broad bean products of both types, i.e. in boiled frozen seeds and canned preserves. Compared with boiled frozen seeds, the canned ones showed a greater weight, in spite of the use of identical raw materials (see the Table in Methods); therefore, the content of dry matter in canned seeds was on average 16% smaller. Hence the level of sodium chloride in the dry matter of canned broad bean was higher than in boiled frozen seeds, varying from 4.05 to 4.10 g 100 $g^{-1}$. After subtracting the amount of added salt from the total content of ash components, the level of ash was reduced by 27–37% in relation to the content in blanched seeds, greater losses occurring in more mature seeds, as was the case with boiled frozen products. The canning and 6-month storage brought a significant reduction of potassium and also of phosphorus in samples prepared from the least and the more mature seeds. An increase in iron, but no significant changes in the level of calcium, magnesium, zinc, manganese, and copper, were recorded.

Lee et al. (1982) reported that, during the autoclaving of peas which contained 30% dry weight in the raw material, the losses in potassium content reached 14%, in phosphorus 9%, in magnesium 12%, and in iron 12%, while the content of calcium did not change. According to Khalil and Mansour (1995), the autoclaving of broad beans in the stage of physiological maturity reduced their phosphorus content by 40% but did not change the levels of calcium, magnesium, iron, zinc, or manganese. However, according to Lopez and Williams (1988), the content of potassium was 38%, of magnesium 37%, and of iron 30% smaller in canned than in blanched beans, the content of phosphorus being unchanged and that of calcium 18% greater.

The comparison of the investigated types of products shows that 100 g of frozen seeds, after cooking, contained 1–17% more potassium, 10–33% more phosphorus, 11–26% more magnesium, 7–27% more zinc, 1–29% more manganese, and 13–48% more copper, while the contents of calcium and iron were practically the same (Fig. 1). It should be stressed that, the more mature the seeds, the greater were the differences in the contents of potassium, phosphorus, magnesium, and copper in favour of frozen products. With regard to the results calculated on a dry weight basis, a similar comparison showed that canned seeds contained significantly more calcium, iron, and potassium than the boiled frozen products, with the exception of samples prepared from the most mature broad bean.

As noted in materials and methods, depending on the preference of consumer, the edible parts of broad bean are either intact or dehulled seeds. Clearly in the two kinds of product, the content of phosphorus alone was 10% greater while that of calcium smaller in dehulled seeds than in intact ones (Fig. 1).

Analyses of the individual ash components (in dry weight) of the two types of product (Tables 2–9) show non-significant differences in zinc, manganese and copper, while the level of iron cannot be so unequivocally estimated. On the other hand, in the two kinds of product, dehulled seeds contained less calcium while boiled frozen broad beans contained significantly more phosphorus and the canned product more potassium. No dependence was found between the content of mineral components in intact and dehulled seeds and the degree of their maturity. Moveover the investigated cultivars behaved fairly similarly in respect to changes in the content of components caused by the technological process and cooking. Divergent data are found in the literature concerning the levels of constituents in intact and dehulled seeds. According to Youssef (1990), the dehulled raw material contained less magnesium and manganese, almost the same level of iron, and more calcium, phosphorus, and copper than intact seeds. In experiments with 10 cultivars of broad bean, El-Tabey Shehata, Abu-Bakr and El-Shimi (1983) demonstrated a greater content of iron and a smaller one of calcium in dehulled than in intact seeds while Udayasekhara-Rao and Deosthale (1983) postulated that the dehulling of seeds of various pod plants did not significantly change the levels of mineral constituents.

## 4. Conclusion

Frozen and canned broad bean seeds of milk-wax maturity, prepared for consumption are a valuable source of mineral compounds. The more mature the seeds, the greater are the contents of potassium, phosphorus, calcium, magnesium, and manganese and the smaller that of copper, while the levels of iron and zinc varied. Boiled frozen seeds contained more potassium, phosphorus, magnesium, zinc, manganese, and copper than canned products, no differences being observed in the contents of calcium and iron. The dehulled seeds contained more phosphorus but less calcium than the intact ones.

## References


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