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PII: S0308-8146(97)00032-0

*Food Chemistry*, Vol. 60, No. 4, pp. 559-562, 1997
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0308-8146/97 $17.00+0.00

# Effects of canning processes on the elements content of cultivated mushrooms (*Agaricus bisporus*)

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(Received 4 October 1996; revised version received 3 December 1996; accepted 3 December 1996)

Mushroom (*Agaricus bisporus*) was studied for chemical characteristics after blanching and different chemical preservations (acidification and control process). Losses of Mn, Cu, Zn and Fe during blanching treatment were 45, 3.9, 23.48 and 35.3%, respectively. On the other hand, losses of drained weight values were only 37.5%. During storage for four months, and using different chemical preservation treatments, the differences of the means of the elements and drained weights were not significant ($P < 0.05$). © 1997 Elsevier Science Ltd

## INTRODUCTION

*Agaricus bisporus* is the world's most widely grown culture mushroom species; it contains more protein than many other foodstuffs. The protein levels of the mushroom samples are within the range 19–35% of the dry weight of mushroom. In addition to the protein, lipids (1.1–8.2%) and carbohydrates (4–8.1%), mushrooms appear to be good sources of vitamins of the B complex and vitamin C, but a great deal of species-specificity exists and mineral values of the mushrooms show important differences due to their growth substrates. Fresh mushrooms contain 3–28% carbohydrate and 3–32% fibre on a dry basis (Breene, 1990).

The economical importance of mushroom quality, influencing sales and price, creates a need for greater knowledge of the biochemistry and physiology determining quality (Burton *et al.*, 1993). After harvesting, mushrooms lose their whiteness and become increasingly brown in appearance. This change in colour, causing a deterioration in quality, is a result of enzymatic oxidation of polyphenols in the cap tissue by polyphenol oxidase into quinones that ultimately condense to form melanin (Smith *et al.*, 1993). Other major indicators of quality include freshness, cleanliness, uniformity and flavour.

The main factors that contribute loss in quality after harvest are mushroom discoloration and development, losses in weight and changes in texture. Most recent research on mushroom quality has examined post-harvest technologies for maintaining quality, by modified-atmosphere packaging, cooling, $\gamma$-irradiation and chemical washing. Burton and Noble (1993) have reported which mushrooms were storagable for seven days at 5°C or two days at 18°C without bruising.

Mushrooms should be consumed or processed promptly after harvest; most mushroom crops are preserved by canning and only a small portion treated by other methods such as freeze-drying (Fang *et al.*, 1971).

Many processes used for mushroom canning operations cause constituent levels to be decreased or increased (both during blanching treatment and storage time). Some leachates (e.g. acids, nitrogenous compounds, carbohydrates and ash) accumulate in the blanch water during the canning operation (Nelson & Hsu, 1985).

Our objective was to examine the effects of blanching, different chemical preservations (with and without addition of L-ascorbic acid) on the concentrations of elements and drained weight in mushroom (*Agaricus bisporus*).

## MATERIALS AND METHODS

### Raw material and processing procedures

Mushroom (*Agaricus bisporus*) samples were obtained from MÜPA Horticulture and Food Industry (MÜPA), a commercial grower in Kocaeli, Turkey. The mushrooms were transported on the day of harvest to our laboratory and placed in refrigerator at 5°C.

After selecting and washing (by tap water), mushroom samples were blanched by blanching water (0.5 g $l^{-1}$ $NaHSO_3$, 0.5 g $l^{-1}$ citric acid and 1.0 g $l^{-1}$ NaCl) at 95–100°C for 15 min, and cooled by continuously washing at room temperature.

Two canning processes were tested with and without addition of L-Ascorbic acid. For treatment 'a'; the brine was prepared by adding 0.5 g $l^{-1}$ L-Ascorbic acid, 0.5 g $l^{-1}$ citric acid and 1.0 g $l^{-1}$ NaCl. For treatment 'b'; the brine was prepared by adding 0.5 g $l^{-1}$ citric acid and 1.0 g $l^{-1}$ NaCl.

A batch of 100 g blanched mushrooms was weighed and placed into 170 ml glass-jar then hot brine was added. After being exhausted and closed, the cans were retorted in an autoclave for 25 min at 112°C and cooled for 10-15 min at room temperature (20-25°C).

### Determination of drained weight, brine volume and pH of can

The cans were opened and mushrooms placed onto a tared fine-mesh sieve. The amount of brine volume was measured by cylinder. The pH of filtrate was determined by pH meter (Hanna Instruments, Singapore, HI 8521Model). The mushrooms were washed with de-ionized water until free of adhering substances. After washing the mushrooms and draining for 5 min they were weighed by electronic balance (CHYO, Model MP-300, 310 g capacity and readability 0.001g) (Luh & Woodroof, 1982). (Table 1)

### Determination of polyphenols in brine

The Folin-Denis Spectrophotometric method was employed for total polyphenol in brine using tannins as the basis (Horwitz, 1980).

5.0 ml brine (was placed into a 25 ml) flask and the diluted with 2.5 ml of filtered brine. 1.25 ml of Folin-Denis reagent and 2.5 ml of saturated $Na_2CO_3$ were added and diluted to the volume of 25 ml with de-ionized water. The absorbance of the mixture was determined by spectrophotometer (Shimadzu, UV-160 A Model, Japan) at 760 nm.

### Determination of elements in mushroom samples

Fresh and canned mushroom samples were dried at 105°C and ground. A batch of 2.00 g of mushroom sample was placed into a high-form porcelain crucible. The furnace (Electromag, Model 3, adjustable, 1000–1200°C, Turkey) temperature was adjusted to 500°C, and then the samples were ashed for 4 h at 500°C and allowed to cool.

The ash was wetted with 10 drops of distilled water and then 5 ml of concentrated nitric acid was added. Excess nitric acid was evaporated on a hot plate set at 100–120°C. The crucibles were returned to the furnace and ashed again for 1 h at 500°C. The crucibles were cooled and ash was dissolved in 2 N nitric acid, transferred quantitatively to a 25 ml volumetric flask and diluted to 25 ml with 2 N nitric acid (Özdemir, 1996).

The Flame Atomic Absorption Spectrophotometer (Perkin Elmer, 3100 Model, Germany) was used for determining Cu, Mn, Fe and Zn levels in the solution at the wavelength 324.5, 279.5, 243.5 and 213 nm, respectively.

## RESULTS AND DISCUSSION

The concentrations of the Copper, Manganese, Zinc and Iron of fresh mushrooms with blanching and during storage are shown Table 2.

The concentrations of the Fe, Cu, Mn and Zn in fresh mushroom samples were found; 74.37 ± 7.19, 48.75 ± 2.50, 8.53 ± 1.29 and 113.7 ± 8.75 ppm, respectively. Breene, (1990) reported that the mineral contents of the edible mushrooms were changed as follows; Fe levels 3.5 to 27; Cu levels 0.4 to 26.6; Mn levels 0.8 to 7.4; and Zn levels 3.3 to 19.5 $\mu g\ g^{-1}$. Özdemir, (1996) studied Cu, Zn, Mn and Fe in *Agaricus bisporus*. Values for Cu, Zn, Mn and Fe were 56.3, 77.1, 144 and 325 $\mu g\ g^{-1}$, respectively, dry weight basis. It is shown that the levels of the elements in various *Agaricus bisporus* samples and other edible mushrooms were different. It is reported that different element values in these mushrooms depend primarily on climate and

**Table 1. The changing of drained weight, brine volume and pH in canned mushroom**

| Time | Drained weight (g) | | Brine volume (ml) | | pH of brine | |
|---|---|---|---|---|---|---|
| Day | a | b | a | b | a | b |
| * | 160.0 ± 0.50 | 160.0 ± 0.50 | | | | |
| ** | 100.0 ± 0.50 | 100.0 ± 0.50 | | | 5.30 ± 0.11 | 5.69 ± 0.07 |
| 7 | 99.50 ± 2.99 | 96.80 ± 2.59 | 70.00 ± 8.66 | 68.10 ± 8.86 | 4.72 ± 0.11 | 5.11 ± 0.04 |
| 14 | 99.30 ± 4.14 | 97.10 ± 1.59 | 70.33 ± 6.81 | 68.77 ± 7.34 | 4.66 ± 0.14 | 5.11 ± 0.05 |
| 21 | 99.20 ± 6.35 | 100.1 ± 0.65 | 68.00 ± 6.00 | 68.62 ± 7.49 | 4.61 ± 0.01 | 5.11 ± 0.02 |
| 28 | 97.10 ± 1.24 | 98.50 ± 1.12 | 71.33 ± 2.31 | 72.36 ± 2.65 | 4.55 ± 0.10 | 5.11 ± 0.01 |
| 43 | 102.6 ± 1.46 | 96.00 ± 1.80 | 67.33 ± 1.53 | 63.00 ± 2.06 | 4.77 ± 0.09 | 5.04 ± 0.05 |
| 58 | 103.9 ± 3.09 | 95.90 ± 0.38 | 67.50 ± 0.71 | 62.30 ± 1.98 | 4.56 ± 0.23 | 5.00 ± 0.06 |
| 89 | 99.50 ± 3.18 | 97.30 ± 2.43 | 73.67 ± 4.04 | 72.04 ± 4.91 | 4.59 ± 0.08 | 5.03 ± 0.06 |
| 120 | 97.20 ± 2.58 | 97.40 ± 1.65 | 74.00 ± 5.00 | 74.15 ± 5.53 | 4.45 ± 0.02 | 4.95 ± 0.03 |

(*) Fresh Mushrooms, (**) Blanched Mushrooms.

**Table 2. Changing of Fe, Cu, Mn and Zn levels (ppm) of canned mushrooms**

| Time | Iron | | Copper | | Manganese | | Zinc | |
|---|---|---|---|---|---|---|---|---|
| Day | a | b | a | b | a | b | a | b |
| * | 74.4±7.19 | 74.4±7.19 | 48.8±2.50 | 48.8±2.50 | 8.53±1.29 | 8.53±1.29 | 114.0±8.75 | 114.0±8.75 |
| (**) | 48.1±6.25 | 48.1±6.25 | 46.9±2.68 | 46.9±2.68 | 4.68±0.62 | 4.68±0.62 | 87.0±1.12 | 87.0±1.12 |
| 7 | 43.8±5.30 | 45.0±5.45 | 47.3±0.35 | 48.8±0.14 | 4.38±0.88 | 4.17±0.72 | 92.5±8.84 | 85.0±1.25 |
| 14 | 40.4±5.91 | 43.3±0.72 | 45.8±2.89 | 52.1±5.05 | 4.58±0.72 | 5.00±1.25 | 94.6±3.61 | 97.9±2.89 |
| 21 | 37.5±2.17 | 39.4±4.42 | 45.8±1.44 | 46.7±3.82 | 4.58±0.72 | 4.17±0.72 | 94.2±2.89 | 95.8±0.72 |
| 28 | 36.3±2.50 | 42.1±1.91 | 42.9±1.44 | 45.0±1.25 | 3.75±0.05 | 4.58±0.72 | 94.2±2.89 | 94.2±1.91 |
| 43 | 38.3±2.60 | 41.7±2.89 | 43.8±2.50 | 50.8±0.72 | 4.17±0.72 | 4.17±0.72 | 85.4±3.15 | 87.9±1.91 |
| 58 | 39.2±4.39 | 38.8±1.77 | 45.9±0.76 | 49.6±2.89 | 4.58±0.72 | 4.17±0.72 | 90.0±2.50 | 88.8±2.50 |
| 89 | 42.5±5.45 | 38.8±1.77 | 47.5±1.29 | 49.2±3.15 | 4.58±0.72 | 4.58±0.72 | 88.8±9.44 | 87.9±3.82 |
| 120 | 37.5±2.50 | 40.4±0.72 | 42.9±3.61 | 49.6±1.91 | 4.17±1.44 | 4.92±0.08 | 92.5±5.45 | 87.1±1.91 |
| A1 | 36.3±2.17 | | 44.2±1.91 | | 5.83±0.72 | | 76.7±1.44 | |
| A3 | 34.6±1.44 | | 45.4±0.72 | | 5.42±0.72 | | 79.4±4.42 | |
| A5 | 31.3±2.50 | | 47.5±2.17 | | 4.17±0.72 | | 72.1±0.72 | |

(*) Fresh Mushroom, (**) Blanched Mushroom, (A1): 1.0 g $l^{-1}$ Ascorbic acid, (A3): 3.0 g $l^{-1}$ Ascorbic acid, (A5): 5.0 g $l^{-1}$ Ascorbic acid.

soil (Loughton & Frank, 1974; Tyler, 1980; Breene, 1990).

When the fresh mushroom was blanched by blanching water, the amounts of Fe, Cu, Mn and Zn were 48.12±6.25, 46.88±2.68, 4.68±0.62 and 87.0±1.12 ppm, respectively. Except for Cu, all the element contents in the fresh mushroom were decreased significantly in blanched mushrooms. The drained weight values of the blanched mushrooms were less than fresh mushrooms Table 1. During the blanching treatment, drained weight values decreased by about 37.5%. Similar results have been reported by Parrish *et al.* (1974) showing those weight losses as high as 40%.

Lanos *et al.* (1993) have reported that fresh mushrooms contained higher concentrations of P, Fe, Mg, K and lower concentrations of Ca and Na than canned samples.

The changes in brine volume, drained weight, pH and element values of canned mushrooms are shown in Tables 1 and 2. During the blanching treatment, drained weight values decreased. Statistical analysis showed no significant differences ($P < 0.05$) between the results of drained weight by different treatments (a and b) on storage period for four months.

Changing of brine volume or pH values did not seem to be important during storage or between different treatments. Amounts of Cu, Zn, Mn and Fe were not changed between different treatments during the storage period. Statistical analysis showed no significant differences ($P < 0.05$) between the mineral levels (Cu, Zn, Mn and Fe).

When concentrations of L-ascorbic acid were increased to 1.0, 3.0 and 5.0 g $l^{-1}$ respectively, the amounts of Mn, Cu, Zn and Fe were decreased.

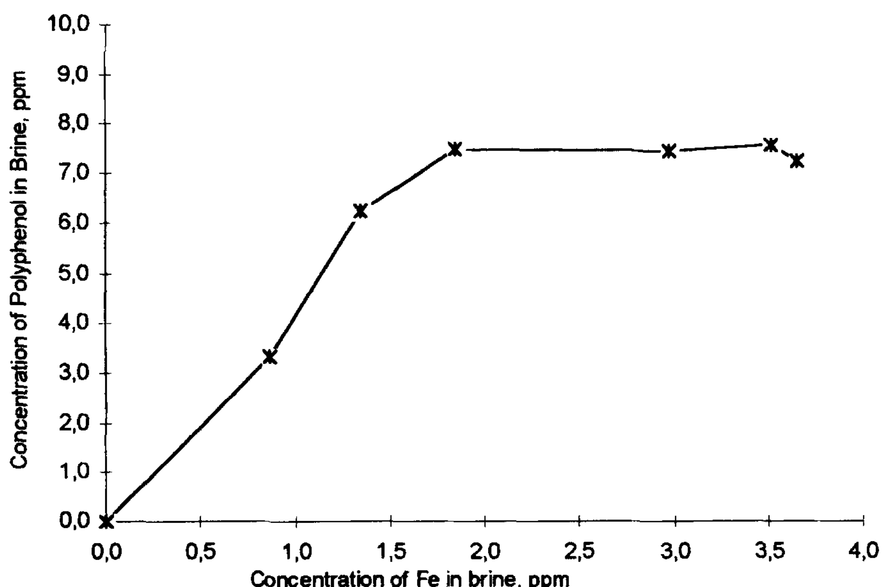


**Fig. 1.** Correlation between Fe Concentration and Total Polyphenol Concentration in Brine.

Respective decreases of Cu levels - 9.39, 6.83 and 2.56%; Mn levels - 31.7, 36.5 and 51.1%; Zn levels - 32.6, 30.2 and 36.7% and Fe levels - 51.3, 53.5 and 58.0% were found. (Table 2)

Amounts of total polyphenols were decreased with ascorbic acid added to brine. Statistical analysis showed a significant difference ($P < 0.05$) for polyphenols between treatments 'a' and 'b'.

These decreases were probably caused by the elements being extracted out during blanching of the mushrooms prior to canning and/or during the actual thermal processing where elements were extracted into the liquid. Rizley and Sistrunk (1979) have reported that acidification with citrate complexed trace elements such as copper and iron, making them unavailable for reactions with phenolic compounds and sulfides, causing reduced flavour production. Water-soluble minerals are lost during processing due to leaching, even though elements may remain tied up in the tissues by binding with naturally-occurring chelating agents (Fang, 1971).

As can be seen from Fig. 1. When the Fe levels were compared with the concentrations of polyphenol in 'b' brine, the Fe levels increased in the polyphenol. Thus the remaining Fe was in polyphenolic form.

## CONCLUSION

The amounts of elements (Mn, Cu, Zn and Fe) and drained weights were decreased by blanching treatment. The levels of the Mn, Cu, Zn and Fe and drained weights were not significantly different at the 95% confidence level during the storage time (four months) or through different chemical preservation treatments (with or without L- ascorbic acid) .

When concentrations of L-ascorbic acid were increased in brine (e.g. 1.0, 3.0 and 5.0 g $l^{-1}$), the amounts of Mn, Cu, Zn and Fe were decreased.

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