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The effect of preliminary processing and period of storage on the quality of frozen *Boletus edulis* (Bull: Fr.) mushrooms

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ABSTRACT

This paper investigates the effect on the quality of frozen *Boletus edulis* (Bull: Fr.) mushrooms of blanching or soaking and blanching in aqueous solutions containing combinations of added substances safe for human consumption, or period of frozen storage. During 12 months of storage, sensory evaluations, instrumental colour measurements and chemical analyses of the frozen products were carried out every four months. Based on the results of the sensory evaluation, a maximum storage period of four months was set for the frozen product obtained from unblanched mushrooms. Frozen products having undergone preliminary processing retained good sensory quality for up to 12 months. Soaking, blanching and freezing resulted in the appearance of colours, such as yellow, honey and pink–violet. As a result of freezing, decreases in the contents of thiamine, riboflavin and vitamin C were noted. Blanching in water, as a method of pre-processing, was sufficient for maintaining acceptable sensory quality.

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1. Introduction

Of all the forest species gathered in the wild, the edible mushrooms from the *Boletus* genus are the most frequently harvested in central-European countries, including Poland. Their popularity is mainly due to their sensory qualities, in particular aroma, taste and texture. Among the many species of fungus belonging to the *Boletus* family, *Boletus edulis* is undoubtedly regarded as having the finest flavour. The *B. edulis* species involves a dozen or so varieties, such as *B. edulis* (Bull: Fr.), *Boletus reticulatus* (Schaeff.) and *Boletus pinophilus* (Pil.: Dermek) and may be classified by their natural habitat, the trees they are mycorrhized with and finally the morphology of their fruiting body. *B. edulis* mushrooms are most commonly found in coniferous forests, usually mycorrhized with *Picea* or *Pinus* trees. The fruiting body of *B. edulis* consists of cap and stipe. The cap, of up to 25 cm in diameter, is a light to dark bronze colour. The solid, barrel-shaped stipe, 5–20 cm long, is off-white or greyish brown in colour and topped with a soft, light-brown or white reticulum (Szweykowska & Szweykowski, 2003).

The availability of *B. edulis* is seasonal and, like other edible mushrooms, it is highly perishable, mainly due to the high water content (approx. 90%), the high level of enzyme activity and the presence of micro-flora (Burton & Noble, 1993; Jolived, Voiland, Pellon, & Arpin, 1995; Nikkarinen & Mertanen, 2004). According to well-documented results obtained for *Agaricus bisporus*, the storage of mushrooms affects their quality in the following ways: darkening of the tissue; elongation of the stems; opening of the caps; hardening of the flesh (Burton & Noble, 1993). Storage also has a negative effect on the level of sugars and 1-octen-3-ol, the main aromatic compound of mushrooms (Mau, Beelman, Ziegler, & Royse, 1991). In investigating the mushroom *Volvariella volvacea*, Yen (1992) also observed a rapid increase in the level of biogenic amino acids during storage.

Although drying is the most common method for preserving mushrooms, freezing is becoming increasingly popular. The main advantage of freezing is that it allows the best retention of nutritional values as well as sensory qualities, such as colour, aroma, taste and texture. Moreover, advances in freezing technology indicate a growing trend toward the production of convenience foods which are "ready to cook" or "ready to eat" (Sloan, 2005).

Blast freezing is the most common method used in mushroom freezing although, recently, the cryogenic method has been gaining in popularity. Cryogenic freezing provides a higher quality product; however, its application in the food industry is rather limited, due to its high cost. In order to assure good quality frozen products, mushroom pilei require preliminary processing, which usually involves blanching in aqueous solutions containing enzyme inhibitors, such as metabisulfites (Czapski & Szudyga, 2000; Prestano & Fuster, 1982), organic acids, versenic acid (EDTA), table salt, and hydrogen peroxide (Coşkuner & Özdemir, 2000). Apart from having a beneficial effect on colour, blanching also leads to significant weight loss in mushrooms. To minimalize this effect, vacuum moistening or soaking is used in pre-processing (Vivar-Quintana, González-San José, & Collado-Fernández, 1999).

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The aim of the present work was to investigate the effects of blanching or soaking and blanching in aqueous solutions containing combinations of added substances safe for human consumption and the period of storage on the quality of *B. edulis* (Bull: Fr.) frozen products.

2. Material and methods

2.1. Material

The experimental material was fresh *B. edulis* (Bull: Fr.), mushrooms having undergone different preliminary treatments (blanching or soaking and blanching) and, finally, frozen products immediately after freezing and after 4, 8, and 12 months of frozen storage.

The mushrooms were collected in *Pinus* forests in Western Poland and, within 12 h of harvesting, were sorted to reject any unsound or wormy specimens, cleaned of any remaining mycelium and forest cover and washed in cold running water. Next, the caps were separated from the stipes and, in the case of pilei 5–7.5 cm in diameter, cut in half; pilei over 7.5 cm diameters were quartered. The following blanching operations were carried out immediately after washing: in water (sample code – BW), in a citric acid (0.5%) and L-ascorbic acid (0.1%) water solution (BCA), and in a lactic acid (1.0%) and L-ascorbic acid (0.1%) water solution (BLA). In addition, two methods of soaking and blanching were applied for these same solutions: in a citric acid (0.5%) and L-ascorbic acid (0.1%) water solution (SBCA), and in a lactic acid (1.0%) and L-ascorbic acid (0.1%) water solution (SBLA). The pilei were soaked for 1 h in a ratio by mass of mushrooms to soaking solution of 1:2. Blanching was carried out at 96–98 °C in a ratio by mass of mushrooms to water or water solution of 1:5. Taking into account the varying texture of caps and stipes, the former were blanched for 3 min and the latter for 1.5 min. Changes in the masses of 1 kg batches of caps ($n = 6$) and stipes ($n = 6$) were determined after both soaking and blanching. Unblanched and blanched mushrooms (the latter also referred to as pre-processed in this study), were then cut into strips approximately 5 mm in thickness, placed in unit packages in a ratio of pilei to stipes of 1:1.4 and frozen at −35 °C. When the temperature at the thermal centre of the products had reached −25 °C, they were placed in a cold storage chamber and stored at that temperature prior to analysis.

The quality of frozen *B. edulis* was established on the basis of the results obtained from sensory evaluation, instrumental colour measurements and analysis of the chemical composition.

2.2. Sensory analysis

The sensory quality of mushroom samples, previously defrosted at 2–4 °C for 12 h, was evaluated directly after freezing and after 4, 8, and 12 months of frozen storage. The analysis of sensory parameters, conducted on a 5-point scale, was additionally supported by a quantitative descriptive analysis of colour (QDA) (ISO 13299, 2003).

Using procedures in accordance with Polish standard PN-ISO 6658 (1998), mushroom quality was scored on a 5–1 scale (5 = excellent, 4 = very good, 3 = good, 2 = bad, 1 = very bad) by a panel of five judges fulfilling the requirements for sensory sensitivity in the Polish standard (PN-ISO 3972, 1998). Samples were evaluated in terms of visual appearance, cell fluid leakage, colour, texture, taste, and aroma. The coefficient of total sensory quality was calculated from weighted average indicator coefficients (coefficients of ponderability). The final value was obtained mathematically by dividing the total score obtained for the examined product (points relating to every indicator multiplied by their coefficients) by the sum of coefficients.

Colour was characterised by means of profile analysis. The evaluation was carried out by a panel of eight panellists fulfilling the requirements of ISO 8586/2 (1994). The discussion was led by a moderator, who had considerable experience of this method of food quality assessment as well as a wide knowledge of mushroom products. In this analysis the following colour descriptors were used: white, cream, yellow, honey yellow, bronze, ashy, grey, and pink–violet.

In establishing the optimal storage time for frozen mushrooms, it was decided that any sample failing to achieve three points on the 5-point scale for any single indicator would be withdrawn from further analysis.

2.3. Colour analysis by the instrumental method

The colour of pileus with gill tissue was determined according to the CIE (1976) system using a Chroma Meter MINOLTA CM-3500d. On the basis of the measurements obtained, the following parameters were set: L^* - lightness ($L^* = 0$ blackness, $L^* = 100$ whiteness), a^* – greenness ($a^* < 0$) or redness ($a^* > 0$), b^* – blueness ($b^* < 0$) or yellowness ($b^* > 0$), C^* – chroma and h^* – hue value. The results were calculated from six replications.

2.4. Chemical evaluation

Fresh *A. bisporus* (sample code NB), blanched or soaked and blanched pilei, as well as frozen products (directly after freezing and during frozen storage), were subjected to chemical analysis, and the frozen products every four months. The material was examined in terms of dry matter content (AOAC, 1995), ash content (AOAC, 1995), total acidity (AOAC, 1995), total nitrogen content, (AOAC, 1995) and vitamin C content (ISO 6557/2, 1984). Additionally, in fresh and pre -processed material, as well as in frozen products at the end of frozen storage, the levels of vitamins B_1 and B_2 were determined by means of the chromatographic (HPLC) methods EN 14122 (2003) and EN 14152 (2003), respectively. The results where calculated from four samples taken from each treatment in a single experiment.

2.5. Statistical analysis

The results were statistically evaluated using the F-Snedecor and *t*-Student tests. In the case of sensory evaluation. The least significant difference (LSD) was $\alpha = 0.01$.

3. Results and discussion

It was found that preliminary processing, mainly blanching, caused weight loss in pilei, resulting in a decrease in yield (Czapski, 1994; Gormley & Walsh, 1982; Prestano & Fuster, 1982; Vivar-Quintana et al., 1999). According to McArdle and Curven (1962), weight loss after blanching may be as much as 30–40% but can be minimalized by vacuum moistening (Czapski, 1994). As Czapski (1994) reports, weight loss due to blanching can be reduced by as much as half when preceded by vacuum moistening.

As a result of blanching or soaking and blanching, considerable changes in pilei weight were noted, depending on the preliminary processing applied (Fig. 1). Compared with the raw material, products from mushrooms which were only blanched, regardless of the solution used, showed a 10–11% decrease in mass. On the other hand, when both soaking and blanching were applied, the masses of the caps and stipes increased by 10–11% and 4–9%, respectively.

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