Mushroom Biology and Mushroom Products, Royse (ed.) © 1996 Penn State Univ. ISBN 1-883956-01-3

The Density of Common Mushroom (*Agaricus bisporus*) Tissue Related to the Shrinkage at Heating

Eugène Schijvens, Hans Ruisch, Wijnand van Deelen, Elvis Biekman and Harry Wichers
Agrotechnological Research Institute (ATO-DLO), P.O. Box 17, NL-6700 AA Wageningen, The Netherlands (E-mail address: h.j. wichers@ato.dlo.nl; Fax: +31.317.412260)

1 INTRODUCTION

A considerable portion of the production of the common mushroom (*Agaricus bisporus*) in the European Union, United States and China is processed into cans. As a result of canning of mushrooms, 30 to 40% of their original weight and 50% of their original volume is lost. The weight and volume losses vary with strain, growing conditions, stage and flush. In addition, the post harvest treatments and processing conditions influence the quantity of weight and volume loss.

Factors, possibly of importance for influencing the shrinkage rate of mushrooms were studied. In this framework, a study was made of the differences in shrink capacity within the tissue of *A. bisporus*. This analysis is related with measurements of the density of the mushroom tissue. The effect of the tissue density on the mass yield after sterilization is demonstrated by using individual mushrooms as experimental samples.

2 MATERIALS AND METHODS

Common mushrooms (*A. bisporus*) with closed veils and with cap diameters ranging from 30 to 40 mm were purchased at a local market.

For the measurements of the density distribution within a mushroom, the tissue of cap and stipe were fractionated as shown in Fig. 1. The fractions were collected from ten halved mushrooms, resulting in two groups of nine fractions. The gills were removed and were not taken into account for these measurements. The density of all nine fractions from both groups of the halved mushrooms were measured. The density was determined by means of the under water weight of the mushrooms. The weight of the fraction collected in a basket hanging under a balance, was read immediately after it was brought under water. No coating was necessary (Konanayakam 1987) with these mushrooms, because no noticeable absorption of water took place within the five seconds of recording the under-water weight. The density (g/cm^3) is the quotient of the weight of the fractions and its under-water weight. The specific volume (cm^3/g) is the reciprocal of the density. The mass yield (m/m) is the quotient of the weight after the relevant treatment (vacuum soaking, cooking and sterilization) and the fresh weight of the particular mushroom or mushroom fraction. The volume yield (v/v) is the quotient of the volume after cooking and the volume of the particular raw mushroom or mushroom fraction. The volume after cooking is assumed to be equal to the weight, with the density of cooked mushroom predefined as 1.0 (g/cm^3). After the density measurements the fractions of one group of 10 halves was cooked immediately and the other group was vacuum soaked before cooking. The vacuum soaking was performed by keeping the mushroom tissue under water in a desiccator, which is under vacuum during 10 minutes. Thereafter the vacuum was released and the water replaced the air between the hyphae. The fractions were cooked in water during 10 minutes and cooled during 5 minutes in water of about 15°C. After cooling the fractions were weighed again. In total these determinations were repeated four times. Individual mushrooms of two batches were sterilized, during 25 minutes at 116°C in cans of 212.5 ml, after a blanch treatment of 10 minutes at 100°C.

3 RESULTS AND DISCUSSION

From the measurements there appeared to be a systematic distribution of densities within the mushroom, as can be seen in Table 1 and Fig. 1. The outer parts of the mushroom stalk (a and b), have a significantly higher density than the central part of the stalk (c and d). This is in accordance with the findings of Wood *et al.* (1985) showing more loosely packed hyphae in the inner than in the outer regions. In the stalk the densities of the upper parts (a and c) are significantly higher than the density of the tissue of the lower parts (b and d). The difference in these two parts of the stalk read by Wood *et al.* (1985) is caused by a vertical orientation of the hyphae in the upper part of the stalk and an irregular orientation of the hyphae in the lower part of the stalk.

In the cap, the tissue of the central part (I) is more dense than the tissue in the other parts of the cap. Between the two parts situated between the center and the outside of the cap (e and f) there was no significant difference in density. The outside of the cap, a sort of skin which can be removed, has an extremely low density. From the figures of the inner and outer side of the mushroom, shown in the study of Jasinski (1984), it was observed that the structures of these tissues are completely different.

Table 1. The density, specific volume, yield after vacuum hydratation and cooking plain- and vacuum-soaked mushrooms.

Part	Density (g/cm^3)	Specific volume (cm^3/m)	Yield after: vacuum soak (m/m)	Cooking without soaking (m/m)	Cooking without soaking (v/v)	Cooking after vacuum soaking (m/m)	Cooking after vacuum soaking (v/v)
a	.87	1.15	1.15	.69	.60	.72	.63
b	.78	1.27	1.26	.76	.59	.78	.61
c	.68	1.47	1.27	.67	.45	.70	.48
d	.56	1.79	1.44	.74	.41	.76	.43
e	.75	1.33	1.43	.56	.42	.61	.46
f	.75	1.33	1.36	.69	.52	.70	.53
g	.62	1.61	1.50	1.09	.68	1.20	.74
h	.54	1.85	2.16	1.30	.70	1.38	.75
i	.80	1.25	1.28	.60	.48	.61	.49

LSD=0.03 ($P<0.05$)

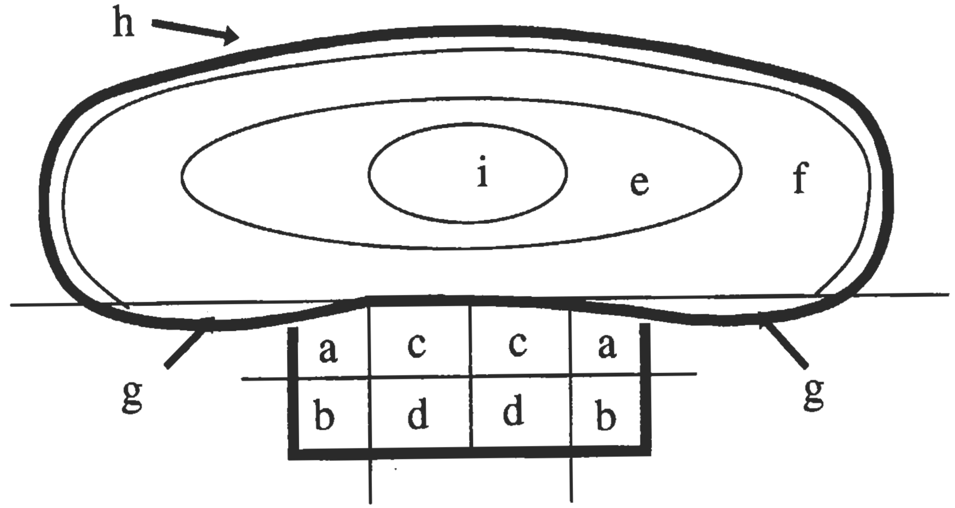

Fig. 1. Fractions of tissue in mushrooms, as it was isolated.

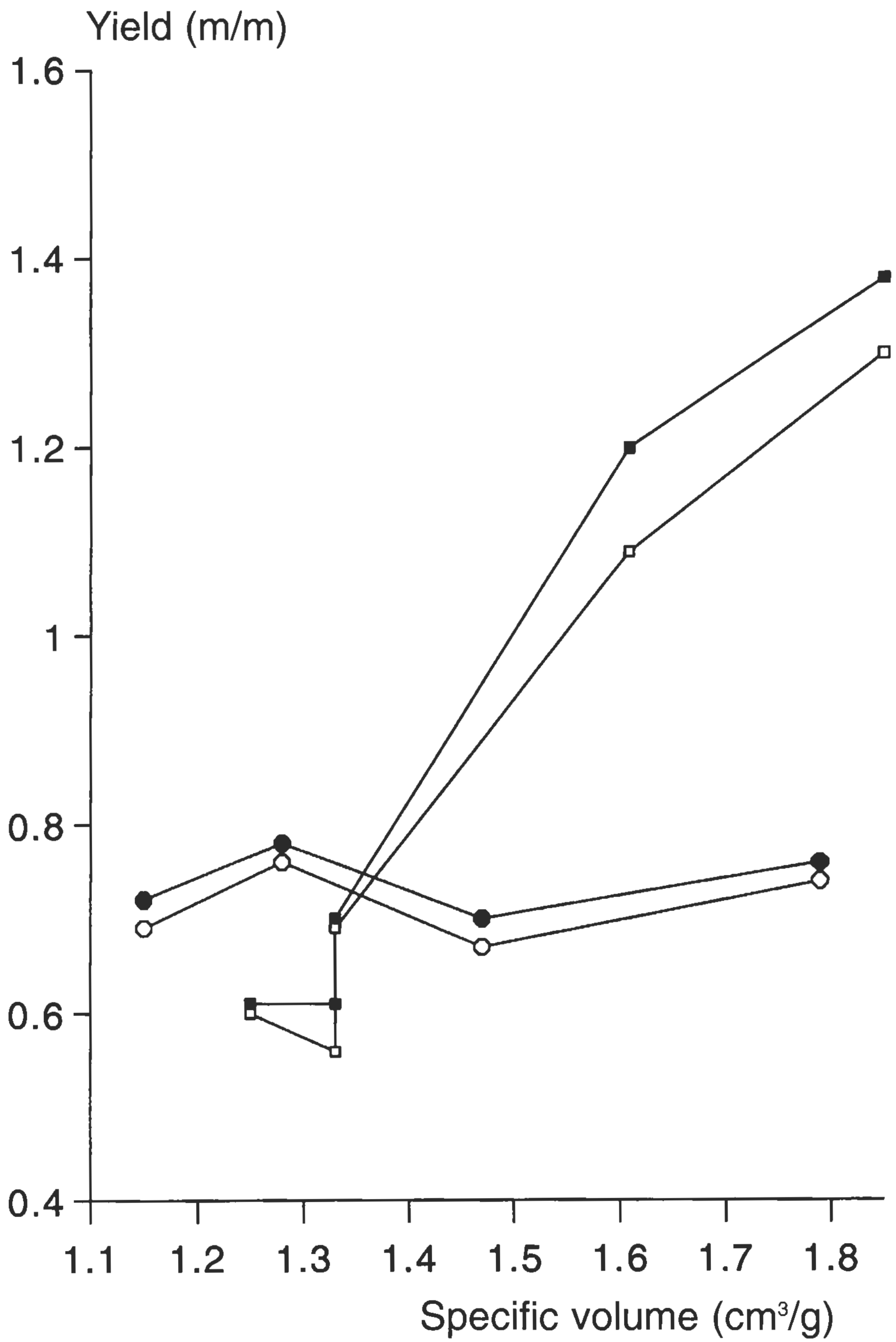

Fig. 2. Mass yield (m/m) after cooking of cap tissue without (□) and with vacuum soaking (■) and the stipe without (○) and after vacuum soaking (●).

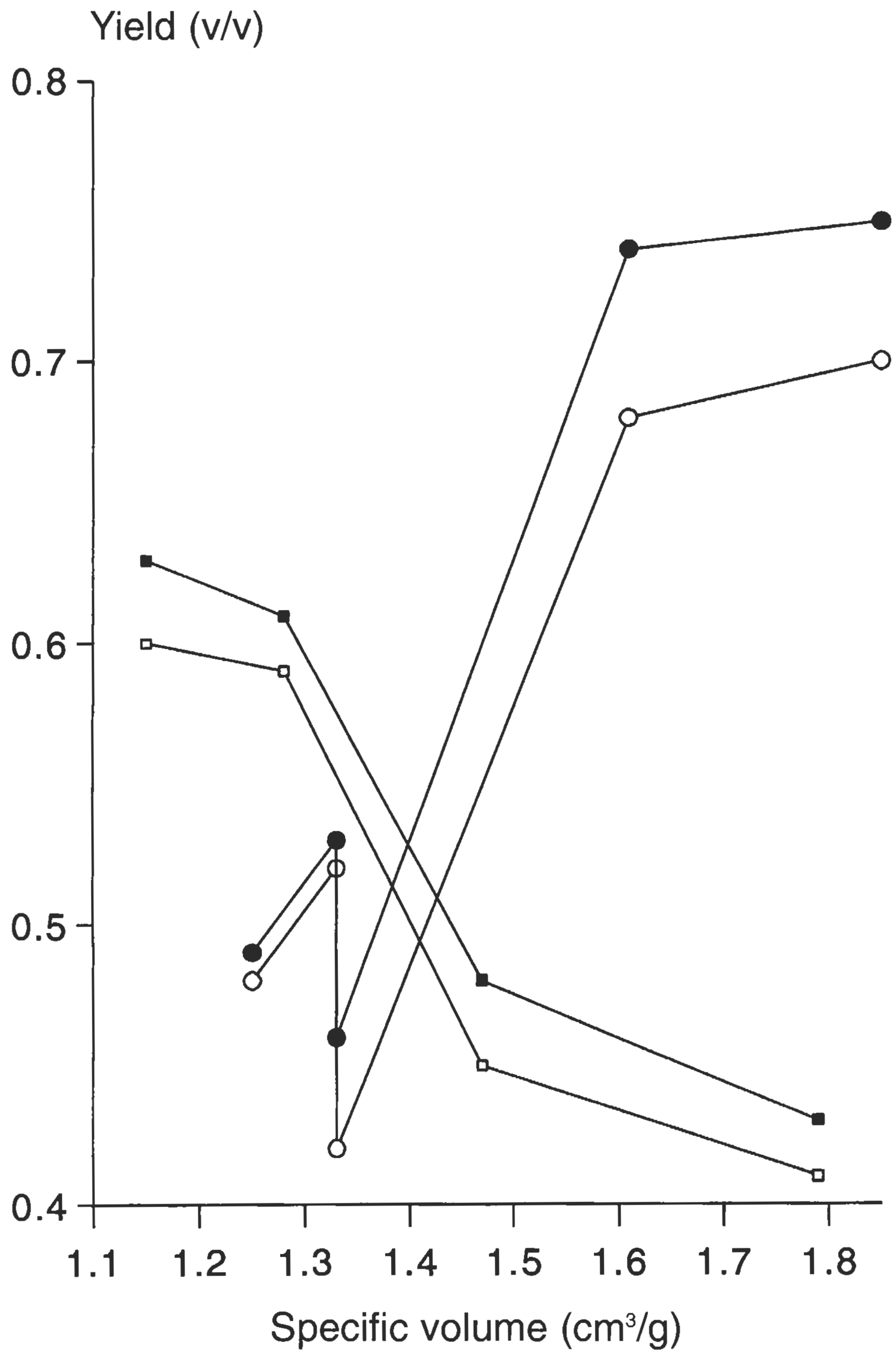

Fig. 3. Volume yield (v/v) after cooking of cap tissue without (□) and with vacuum soaking (■) and the stipe without (○) and after vacuum soaking (●).

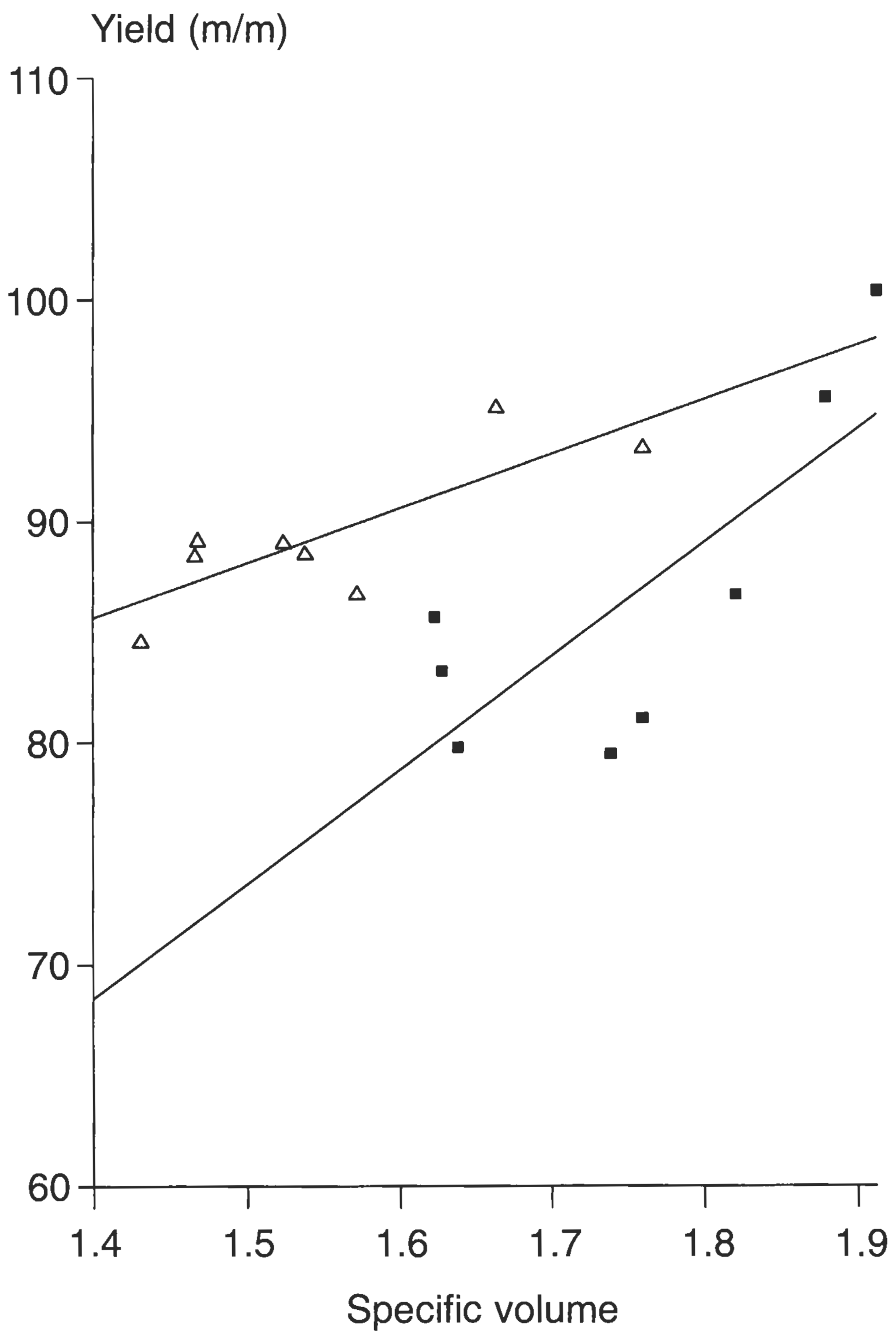

Fig. 4. The mass yield (m/m) after blanching and sterilization of individual mushrooms of two separate lots (△ and ■).

This differentiation in tissue density may explain the increase of the mannitol concentration in the mushroom in blanching treatments as noticed by Biekman *et al.* (1966). Because of a lower tissue density of the outer part of the mushroom, there is relatively more water from the vacuum soaking and less cell substance in the outer part than in the center of the mushroom. When a mushroom shrinks, the content of the outer part of a mushroom will be extracted first, with the result of an initial increase of substances of the cell.

As can be expected, the yield of vacuum soaking correlates with the specific volume of the mushrooms. Only the specific volumes of the inner side of the stalk and the specific volume of the veil do not correlate well with the yield of the vacuum soaking.

Unexpected was the negative relation between mass yield after cooking and density of the tissue. As can be seen in Fig. 2, the center of the mushroom cap with a relative high density shows a low may yield after cooking. The surrounding tissue, with somewhat lower density, shows a higher mass yield after cooking. The outside of the mushroom cap, including the veil, both with low densities showed even an increase in weight after the blanching treatment.

The mass yield of the stipe appeared to be independent of the specific volume of the tissue. Apparently, the reaction of the stipe tissue in relative to the density is, upon processing, different from the cap tissue. In addition, there appeared to be a negative relation between the specific volume of the stipe tissue and the volume yield after cooking as can be seen in Fig. 3. For the cap tissue a positive relation of the specific volume and the volume yield can be seen. The increase of the volume yield with the specific density is however, less strong then the increase of the mass yield. As revealed in both Fig. 2 and Fig. 3 there appeared to be no difference in the relation of the density of the tissue and the mass and volume yield after cooking for the mushrooms which were not vacuum soaked.

As similar relationship between tissue density and mass yield within the mushroom tissue can also be seen between individual mushrooms. In Fig. 4, the mass yield of two batches of mushrooms are shown, where each point is the specific volume and mass yield of one mushroom. Within each lot, the specific volume has a reasonable relation (R=0.77 and 0.80) with the mass yield. When the data of these two lots are combined, the relation of specific volume and mass yield becomes poor (R=0.34).

4 CONCLUSIONS

Within a mushroom there is a significant differentiation in the density of the tissue. For mushroom cap tissue, there is a significant relation between the mass yield after heat treatment and the density of the tissue. The mass yield after heat treatment of the tissue of the mushroom stipe, appeared to be independent from the density. The density of mushroom tissue has a predictive value for the mass yield within a batch.

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