

# Validation of X-ray computed tomography for the quantification of the eye volume in cheese

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## Introduction

X-ray computed tomography (CT) is widely used in medicine but also more and more in technical applications such as weld verification, structural mechanics or in archaeology. The system allows to distinguish materials of different density as they block the X-ray beam accordingly.

Eye formation is an important quality aspect of Swiss-type cheese and also of many semi-hard cheeses. The existing two-dimensional X-ray system only allows a semi-quantitative determination of the eye-volume. To find differences in the activity of metabolic pathways with gas formation of different microorganisms in cheese for the development of eye forming cultures and to investigate other influences on eye formation, CT was applied to quantitatively determine the eye volume.

## Material and Methods

A Philips X-ray CT system was used in collaboration with the veterinary hospital of Bern University. To quantify the eye volume, a package of commercial image processing software (Disect Systems Ltd., UK) was applied to analyse the data received by the detected density differences between eyes and cheese body. Pre-processing of the acquired data to remove artefacts of the CT-system was followed by the calculation of the total cheese loaf volume and the total eye volume inside the cheese. Eyeless Gruyere type hard cheeses with the inclusion of hollow polypropylene balls of a diameter of 10 and 20 mm respectively were produced: Six cheeses per ball diameter with an increasing number of balls and hollow volumes from 0 to 33.3 mL and 0 to 309.1 mL respectively were ripened for 30 days within a plastic film.

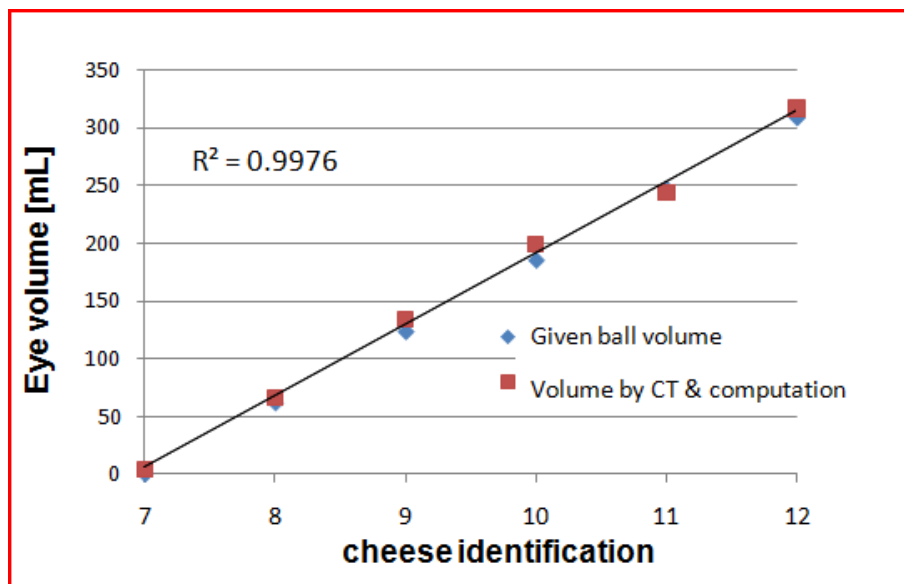


Figure 3: Comparison between the given volume of the embedded balls of 20 mm diameter in eyeless Gruyere type cheese and the calculated volume by CT and image processing

## Results and discussion

Figure 1 shows the produced cheese no. 12 with the embedded balls imaged by the conventional X-ray system. The distribution of the balls can be seen in a 3-dimensional manner. In the binary image of the pre-processed CT-data of layer 94 of the same cheese loaf, the exact area of the eyes in this layer was calculated (Figure 2). Based on that and the integral calculus of all the layers, the exact eye volume is computed. The eye volume measured and calculated

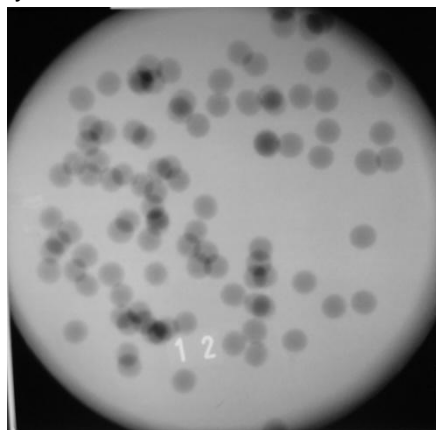


Figure 1: Image by conventional X-ray

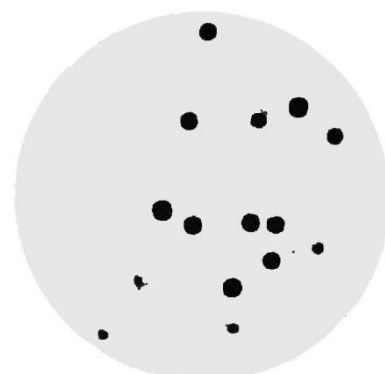


Figure 2: Pre-processed CT-Layer 94 of cheese no. 12 containing 309.1 mL of 20 mm-balls

with the CT-system and image processing software package showed correlation factors of  $R^2 = 0.9912$  and  $R^2 = 0.9976$  respectively in comparison with the given hollow volume of the added balls (figure 3).

## Conclusion

The study showed that X-ray computed tomography with the applied image processing is well suited to measure quantitatively the eye volume of semi-hard and hard cheeses in a non-invasive manner.



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