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Application News

Microfocus X-ray CT System inspeXio™ SMX™-225CT FPD HR Plus

Example Observation of Voids in White Bread Using Microfocus X-ray CT System

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User Benefits

- Microfocus X-ray CT system enables the observation of complex three-dimensional shapes inside food in a non-destructive and simple manner.
- The distribution of voids in food can be visualized through three-dimensional representations, and the size of each void can be calculated.

Introduction

Texture is one of the important factors influencing the taste of food. For example, the texture of bread is described using various words, such as "moist," "fluffy," and "crispy." The difference in the texture of bread is caused not only by the elasticity and strength of wheat itself, but also by the size and distribution of voids. In addition, the size and distribution of the voids in the bread change depending on its type, ingredients, and manufacturing method. Because changes in texture occur in various foods including bread owing to the presence of voids, it is important to study the void structure to develop and produce foods that are preferred by many different consumers.

An effective tool for studying the void structure of foods is a microfocus X-ray CT system. This X-ray CT system can visualize an internal three-dimensional structure without destroying the object. Therefore, it is a useful tool for observing the interior of foods with complex porous structures, such as bread.

Herein, an example of an observation and an analysis of the internal structure of two types of bread using a Shimadzu inspeXio SMX-225 CT FPD HR Plus micro focus X-ray CT system (Fig. 1) is described.

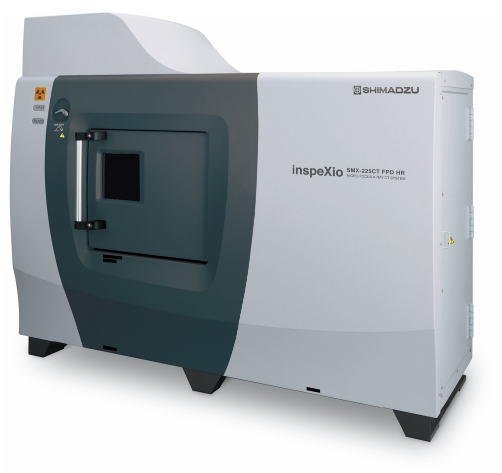

Fig. 1 Microfocus X-ray CT System inspeXio™ SMX™-225CT FPD HR Plus

Observation of White Bread

Fig. 2 shows fluoroscopic images of two slices of bread, which are products with the same name sold by a manufacturer. Although the ingredients and thickness are the same, the manufacturing method is categorized into two types, square and round top shapes. In the fluoroscopic images, higher density or thicker areas appear blacker, because fewer X-rays penetrate the areas. For both types, the fluoroscopic images of the crust are black and appear denser than the crumbs. Compared to the square bread, the round top shape has larger white areas (red frame). These are the areas wherein more of the X-rays are easily penetrated, indicating that the manufacturing method have an influence on the internal structure.

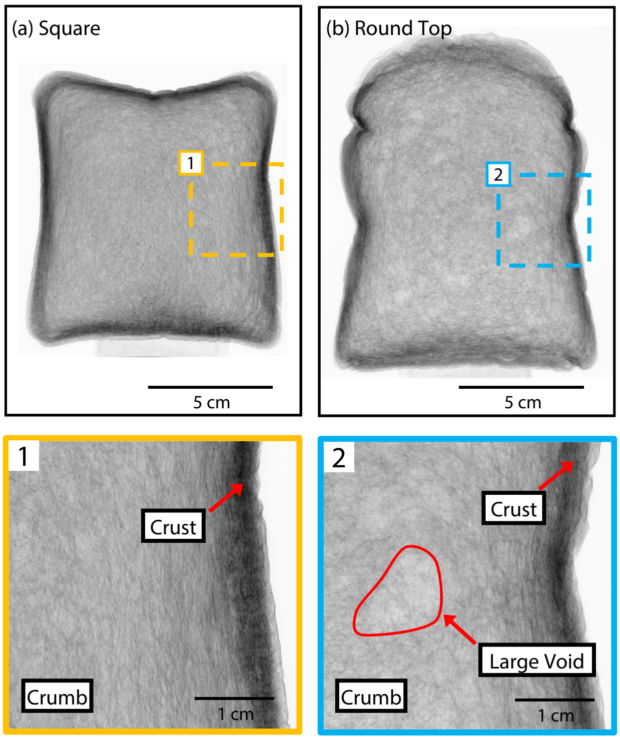

Fig. 2 Fluoroscopic images of bread: (a) square and (b) round top

Fig. 3 shows cross-sectional images of two types of bread acquired using a CT scan. Images[1]and[2]are of the two types of bread. There are differences in the size and expansion of internal voids depending on the manufacturing method applied. The baking mold of the square bread has four sides, whereas the mold of the round top bread has three sides excluding the upper side. Therefore, for the round top type, the dough of the bread rises upward without being suppressed and many large voids are observed in the crumbs close to the upper side crust. Images[3]and[4]show enlarged scans focusing on the upper side crust, and images[5] and [6] show scans focusing on the center of the bread. In Images[3]and[4], there are many flat voids near the crust. This is because the dough does not rise after it reaches the baking mold, even if pressure is applied from the inside. As indicated above, with the cross-sectional images acquired by a CT scan, the position and distribution of voids can be examined in more detail than those in the fluoroscopic images.

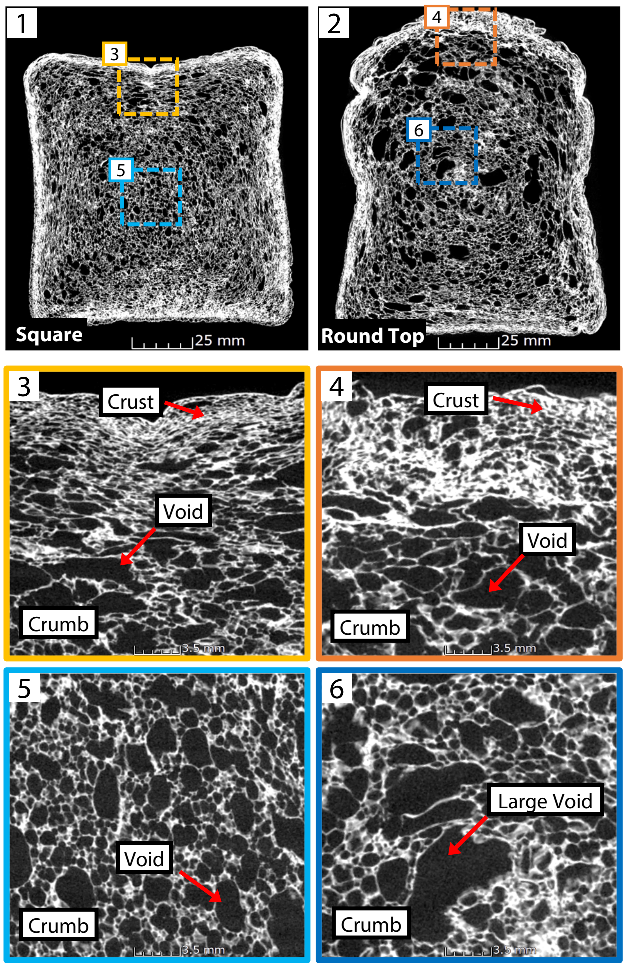

Fig. 3 Cross-sectional images of white bread

Three-dimensional representations of cross-sectional images visualize the voids in the bread three-dimensionally and are used to calculate the volume. Fig. 4 shows three-dimensional representations of an enlarged scan image of a part of the round top. In Fig. 4, each void is colored according to the size. To observe voids outside and inside, a part of the three-dimensional representation is clipped. In addition, in Fig. 5, the number and size of the voids are shown as a histogram.

Table 1 shows the minimum and maximum volume, mean, and standard deviation of the voids in two types of bread. The voids of the round top bread are at least twice the maximum volume and approximately 1.5 times the mean volume of the square bread. The standard deviation of the round top bread is larger than that of the square bread. Thus, the size and deviation of the voids differ even if both types of bread are in the same series. The texture of the square, which has uniform and smaller voids, is moist, whereas that of the round top bread, which has various and larger voids, is fluffy. The analysis using CT enables not only visualizing the size and deviation of voids but also providing them in figures.

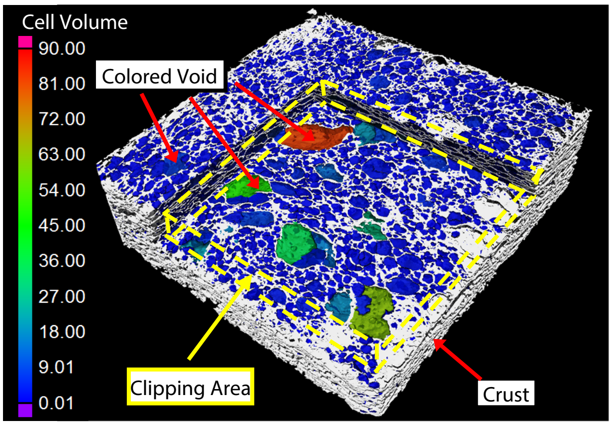

Fig. 4 Example of porosity analysis: Three-dimensional representation of round top white bread

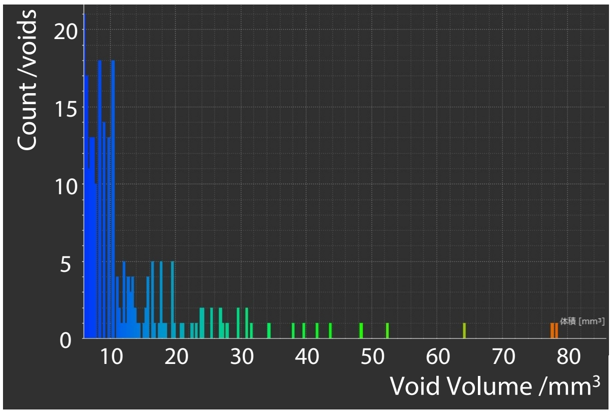

Fig. 5 Example of porosity analysis: Histogram of void volume of round top white bread

Table 1 Min, max, average, and standard deviation of void volume of both types of white bread

	Min /mm^3	Max /mm^3	Avg. /mm^3	S.D. /mm^3
Square	0.01	34.4	0.41	0.88
Round top	0.01	86.0	0.60	1.77

■ Conclusion

As demonstrated in this experiment, an inspeXio SMX -225 CT FPD HR Plus enables an easy examination of the three-dimensional shape, size, and distribution of the bread voids through an observation and analysis of the porous structure. The results can be used for the research and development of popular textures.

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