Food Fragmentation by Human Mastication

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Fragmentation is very complicated phenomena. In this study, we investigate the particle size distribution produced by human mastication. Mastication is in-mouth fragmentation process in which food is broken, ground or crushed by the teeth to prepare for swallowing and digestion. Size reduction and Pulverization of food are the main function of mastication.[1] The object of this study is to show how the function of mastication affect the size distribution of food particles. Experimental procedure is very simple. After chewing of the prefixed number of strokes, the subject expectorate the food bolus onto a sieve (1 mm). Then, we took pictures of the bolus and digitize the snapshots of masticated particles with the suitable resolution.

Figure 1: Digitized particles of raw carrots.

First experiments were performed with raw carrots. Figure 1 shows the snapshot of food particles for the raw carrot (about 2 g) at 10 strokes. Figure 2 shows the log-log plots of the cumulative number of particles vs. their size. Hence we tried to fit a curve to the experimental data calculated by assuming that the size of mastications can be described by a log-normal distribution,

$$n(s) = \frac{1}{\sqrt{2\pi\sigma^2}s} \exp[-\frac{(\log(\frac{s}{T})^2)}{2\sigma^2}]. \qquad (1)$$

The cumulative function is $N(s) \equiv \int_s^\infty n(s')ds'$. Here s is the size, σ and T are the fitting parameters meaning the average and the dispersion, respectively. The reasons are as follows : We suggest that the mastication should be regarded as a sequential fragmentation with randomness. If the type of fragmentation is sequential and random, the size distribution of fragments is a log-normal distribution.[2] The fit of log-normal distribution was partly-good coincidence (see Fig. 2). Moreover we propose the other assumption that the size segregation would occur in the oral cavity. In order to represent this assumption, we employ two log-normal distributions as fitting function. Then the size distributions of masticated particles were well fitted by two log-normal distributions (see Fig. 2). The excellent data fitting for raw carrots by two log-normal distributions implies that two main function of mastication, a sequential fragmentation with randomness and size segregation, affect the size distribution of masticated food particles.

Second experiments were examined with fish gels. At 20 strokes, the cumulative size distribution of masticated particles were well fitted by two log-normal distributions such as raw carrots. Futhermore, in several data at 10 strokes the cumulative distributions showed the power-law behaviour. It is an interesting problem to change the size distribution from log-normal to power-law, depending on the number of strokes.

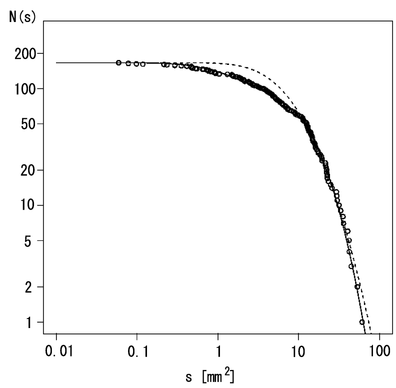

Figure 2: The log-log plots of the cumulative number vs. size for raw carrot. Circle: experiment. Broken line: log-normal. Solid line: two log-normals.

References

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[2] A. N. Kolmogorov: Doklady Akad. Nauk. SSSR **31** (1941) 99; M. Matsushita *et al*: Bull. Facul. Sci. & Eng. Chuo University **31** (1988) 69.