

Morphological and Histological Changes of Sweet potato and Mino (wall of cattle stomach) during Low Temperature Steam Cooking.

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The objective of cooking is to prepare nutritionally balanced, hygienically safe and tasty food and naturally it depends on how the material is cooked. Cooking can be classified to heating and non-heating methods, however they are not mutually independent but employed in combination and/or in parallel during preliminary steps, mid processes and final completion. Every step influences the final products in many ways and the variation of components of food and their physical nature also should be considered for the best results. Thus, the proper choice of cooking is indispensable.

The majority of heating uses the transfer of energy from heat source in various methods but heating by microwave is also available. External heating can be achieved through moist heat or dry heat or electro magnetic heat¹⁾. Dry heat uses radiation, metal plate and/or oil, but not water for heat conductance, and uses higher temperature than moist heat, through baking, roasting and frying. Moist heat can produce steady heating using water or steam for heat conductance by boiling and steaming.

Steaming heats a food by the latent heat (539 cal/gm) of high temperature steam derived from boiling water which gives a moist heat between 85-100°C under the normal air pressure. It covers the foods to transfer heat by contact. The transfer of heat is faster and more effective than using hot water. Steam heat has been widely used in tradi-

tional "Seiro" cooking together with modification and improvement in Japan. From a study of the application of steam cooking, it has become clear that steaming has been treated as an outdated technology, despite its' sophisticated cooking method. Re-evaluating "Seiro" steam cooking and developing it into a new system called steam cooking, which is capable of maintaining any temperature between 45-95°C as one wishes, has occurred and this has been recognized as one cooking method and has begun to be accepted in society.

Improper heating spoils the nature of the food material and thus the texture and taste of servings will be unsatisfactory. Thus, the heat treatment of food is quite important in cooking. Is today's general heating for food preparation satisfactory? Our concern is an unavoidable reduction of taste and nutritional value in prepared food, especially the safety of servings in large amounts like school lunches and side dishes, and the over stated measure for PL. and HACCP.

The preparation of safe and high quality food depends on how they are cooked and processed, bringing out their original nature and components. We see some problems in many current cooking and processing methods of foods with respect to their heating methods.

At the beginning of steaming, the surface of food material will be covered by a thin layer of water and temperature will rise through heat

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transfer. The water in the material remains but the volatile fatty acids will evaporate and the fats, water-soluble proteins and free water will drip off the material. These are the positive characteristics of this heat transfer²⁾ which are not available in other methods, and this technique should be employed more in cooking and food processing.

The second function of food is to give people taste satisfaction. No matter how nutritious food is, it will not be used as food for man unless it is tasty. The components that one senses are relatively low molecular weight, volatile water soluble molecules. In contrast, high molecular weight substances in a food material stimulate oral tactile sense and produce a good sensation in the mouth. The taste of food also depends on such physical senses. A change of softness after heating relates to the alteration of the nature of the cell wall^{3),4)} and it is an important element for persons with swallowing difficulties. The observation of food material under microscope will supply important information for a study of food texture.

In Europe and the United States, the application of low temperature steam cooking has started and is actively incorporated into cooking and processing of foods as a new food technology. This technique has been widely used in hospital and restaurant kitchens; however, biochemical and histological studies on food materials and cooking are rarely reported. In this paper we would like to report the structural changes of sweet potato, as a plant-food, and stomach wall of cattle, as an animal food, during low temperature steam cooking by means of microscopic evaluation and softness measurement.

Material and methods:

A. Sweet potato

A sweet potato subjected to low temperature cooking was sliced transversely at 3-5mm thickness at various times of cooking or at various

cooking temperatures. The samples were soaked in a 30 times volume of FAA (95 per cent preparation of ethanol: glacial acetic acid=3:1) fixative for one hour. They were carried out to prepare the sections for microscopic observation was carried out after staining with iodine solution.

Samples heated at 85°C were taken at 0, 30, 45, 60 and 75 minutes and compared with boiled samples.

B. Mino (the first stomach of cattle)

The tissue was cut into 3x2x1 cm. Sections with a weight of approximately 7gm. and fixed with Bouin solution for 3 hours and processed into microscopic sections followed by Hematoxylin-Eosin staining for nuclei and cytoplasm or Sudan III staining for lipids.

Uncooked samples, those with low temperature steaming at 70°C for 3, 5 and 15 hours, boiling for 5 and 60 minutes, and baking on a frying pan for 5 minutes were compared for texture and histology.

For low temperature steam cooking, Soft Steamer Ai musu type: ATS-10A (Fig.1) was used.

Results and discussion



Fig. 1 Soft Steamer Ai musu type ATS-10

A. Sweet potato:

Starch granules can be seen as a large number

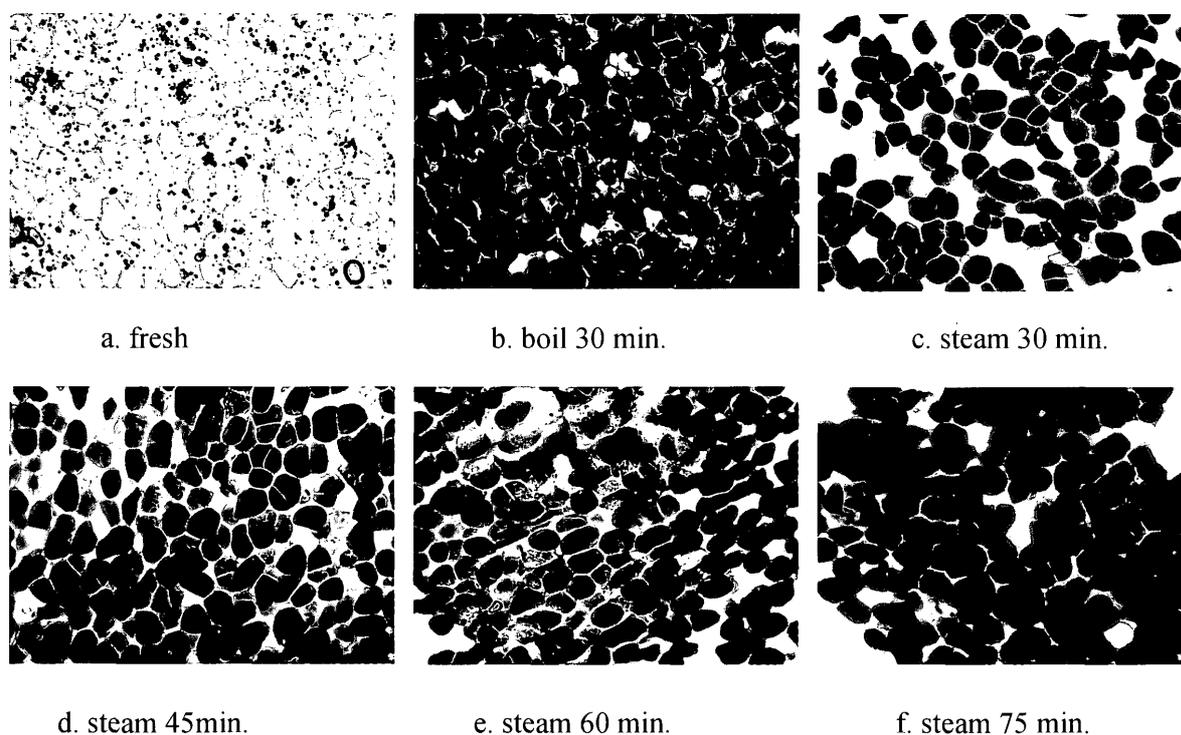


Fig.2 Histological comparison with iodine staining of sweet potatoes under various cooking methods and time. (magnification of 150)

of small dots in fresh tissue (Fig.2-a), but swollen and gelatinized granules, often broken ones, occupy the cell after 30 minutes of boiling and thus a reduction of intercellular spaces is observed (Fig2-b).

In low temperature steaming, swelling of granules and gelatinization of starch were also observed, but the loss of pectin material from cell walls was observed as well and the increase of intercellular spaces became significant. Some of the pectin was dissolved and moved into intracellular space created by alteration of starch. As heating time increased, decomposition of pectin reduced the cellular adhesion and the tissue becomes softer⁵⁾; however, the increased thickness of cell wall of surface cells produced a good taste and kept the samples' shape while reducing the stickiness and sogginess, relative to the boiled sample (Fig.2-c, -d, -e, -f).

B. Mino:

The first of four stomachs of cattle is the biggest and occupies nearly half of the abdominal space and is surrounded by a stringy muscular-pillar structure. Mino is such a muscular part isolated from the first stomach wall, consisting of smooth muscle fibers bundled up by connective tissue, and thus pillar consists of bundles of smooth muscle fibers. Such fibers are twisted to form structure like a fist with scattered cutting points and they are wrapped by collagen fibers⁶⁾. It is unsuitable for eating under ordinary cooking.

Heating induces the shrinkage in parallel of the fibers and a loss of weight of 60% in roasting and 50% by steaming. Even under extended heating, the reduction rate is not altered. To the contrary, the reduction continues as time of boiling increases; and a sample will reach 40% of its fresh weight after one hour. Non-stained longitudinal sections of Mino show shrinkage of smooth

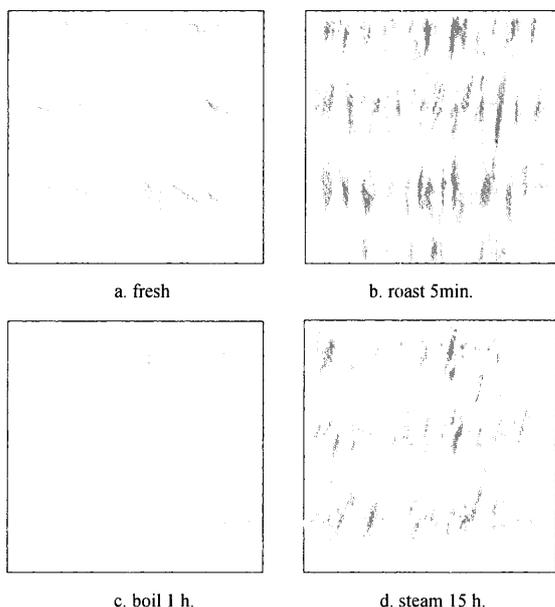


Fig.3 Histological comparison of mino longitudinal section under various cooking methods. (magnification of 1500)

muscle fiber and condensation of collagen fibers (Fig.3 a-d). The baked or boiled tissue shows a rather clear division between fibers (muscle cells) without change in their thickness. A long-term steaming increased the gaps between fibers due to the prolonged shrinkage, and then the muscle pillar became separable and easier to eat. However, a sample with only 3 hours of steaming did not show any significant change from the fresh material.

Fig.4 a-d shows a non-stained cross section of Mino. Changes similar to longitudinal sections after steaming can be observed.

Orange-colored fat granules stained by Sudan III are in Fig.5. Steaming for 3, 5 and 15 hours produces larger fat granules (fig.5b) although some of the original small ones remain in the cells (Fig.5a). The surface cells of the tissue baked on a frying pan contain larger fat granules and are stained stronger (data not shown). The boiled tissue showed weaker stain with fewer granules, suggesting the loss of fat into the cooking medium.

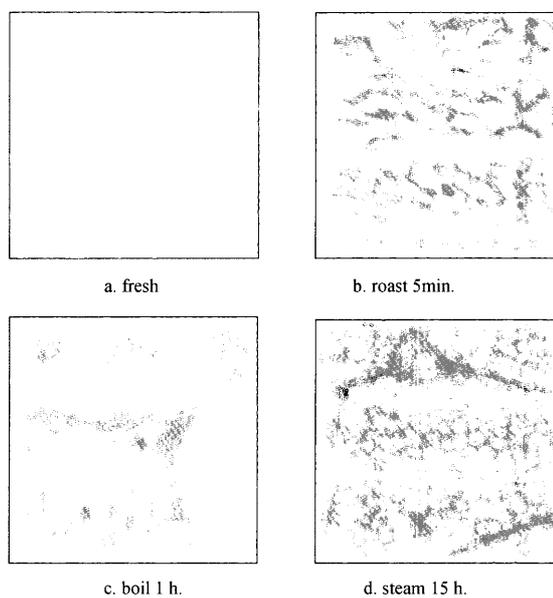
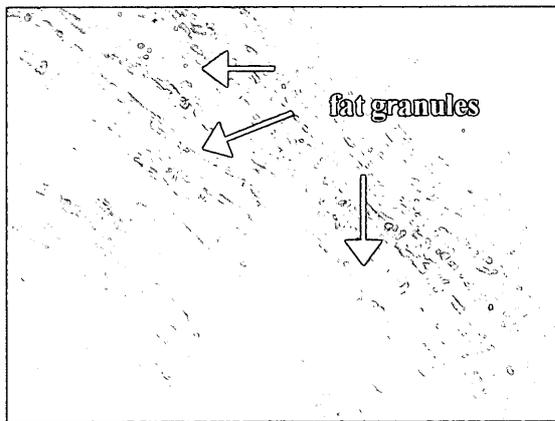


Fig.4 Histological comparison of mino cross section under various cooking methods. (magnification of 1500)

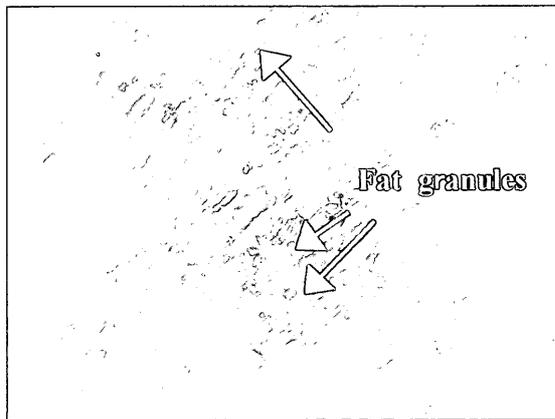
Fig.6 shows the photograph of Mino tissue stained with hematoxylin-eosin where the nuclei and cytoplasm stained blue and red, respectively. Few alterations in color and intensity have been observed.

The observation of the surface and intra-structure of food material can be achieved by microscopic studies. The surface having a close relationship to sheen and texture that contribute to a consumer's feeling towards food, can be better observed by scanning electron microscope (SEM). Inside structure related to hardness, plasticity and viscosity in the mouth and the texture of food can be studied by an optical microscope and a transmission electron microscope (TEM) using sectioned materials. Better results will be obtained through a better choice of proper samples and suitable technology.

The authors have started to develop cooking methods of food using low temperature steaming aimed especially at helping people with difficulty of masticating and swallowing food. Histological studies of food material are only technology



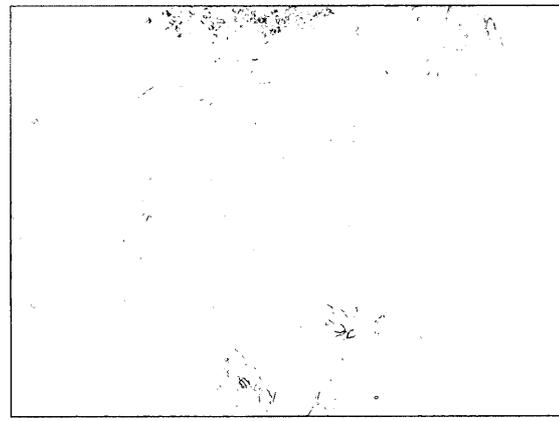
a. fresh



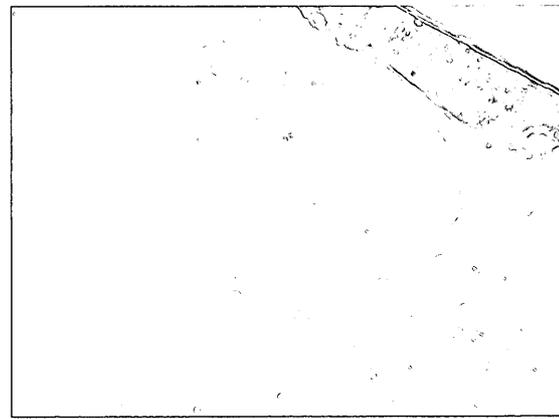
b. steam 15 h.

Fig.5 Histological comparison of mino longitudinal section stained with sudan III under various cooking methods. (magnification of 1500)

to follow the change of structure by means of visual imaging and they suggested to us a variety of possible food preparation techniques. In this report, the structural change of food material using a low temperature steaming method was discussed but the alteration of nutritional components, improving of taste with the induction of "umami" by enzyme activity and the possible use of hard material by using protease-digestion will be reported later.



a. fresh



b. steam 15 h.

Fig.6 Histological comparison of mino longitudinal section stained with hematoxylin-eosin under various cooking methods. (magnification of 1500)

Summary

Microscopic observation on the texture of food, sweet potato and Mino (wall of cattle stomach) after cooking under various temperatures and lengths of time in a low temperature steam cooker was carried out. As the length of usual heating increased, the intercellular space of sweet potato decreased, while in low temperature steaming a thickening of cell walls at the surface area increased and the intercellular space diminished. The relation between acceptable not soggy taste

with good maintenance of shape, and this histological alteration had been suspected. A long period of steaming of mino induced an increase of space between fibers as the contraction of fibrous material progressed and, thus, it became easier to eat due to the loosening of fiber columns. It has been suggested that low temperature steam cooking is suitable one for the portions and/or materials, which are hard to eat after the ordinary cooking.

References

- 1) Yano, T. and Kawabata, A.: Culinary Technology, pp.47-50, Kenpakusha Publ., Tokyo, 1998.
- 2) Hirayama, I.: Steam in Food Technology, Kourin Publ. Tokyo, 1986.
- 3) Fuchigami, M., Termitte, A., and Sasaki, A.: Changes in firmness, pectic substances and histological structure of sweet potatoes during cooking, preheating or pressurization. Jour. Cookery Sci. Jpn. 35: 343-356, 2002.
- 4) Tamura, S., Kawamura, C., Senda, T., Fuchigami, M.: Effects of various salts on the softening of cooked Japanese radish roots and on the fine structure of the parenchyma cell wall after cooking. J. Home Econ. Jpn. 40:633-641, 1993.
- 5) Tamura, S.: Histology of Foods ° Cooking ° Processing. Pp.66-68 Gakusosha Publ., Tokyo, 1998.
- 6) Tamura, S.: *ibid.* pp.116-117.