Change of Nutritional Components during Low Temperature Steam Cooking

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Keywords: Low temperature steam cooking, Vitamin C, Phyto-protease, Sweet potato, Mino (stomach wall of cattle)

Introduction

Recent development in technology and equipment for low temperature steam cooking which can control the cooking temperature at any temperature below 100℃ are becoming increasingly common[1)]. This allows a new cooking and food processing in which during cooking the nature of food and nutritional values are better preserved and heat is more cost effective. Furthermore, they demonstrate the possibility of producing novel tastes out of ordinary materials. The application of this method has spread over Europe and may replace traditional steam cooking in various applications[2)].

A comparative study on tissue structure after ordinary steaming and low temperature steam cooking was carried out and a significant difference was found in their tissue structure and, at the same time, in their taste[3)]. In this paper, we would like to report the alteration of nutritional components, activity of enzymes and taste during low temperature steam cooking.

Materials and methods

Tissue from sweet potato and mino (the stomach wall of cattle) used for this study were the same, and were handled identically as in our previous paper[3)].

For the sweet potato, the following methods were used. ① hydrazine method for vitamin C, ② Somogyi method for reducing sugar, ③ creep meter RE3305 (Yamaden Co.) for rupture property and ④ five point sensory test for taste. For mino tissue, the following were carried out. ① content of RNA, DNA and protein of fresh and heated tissues were determined by UV absorption after fractionation by Schmidt-Thannhauser method, ② phyto-protease activities (from pineapple, papaya and banana) and their optimal temperature were determined on BSA (bovine serum albumin) as a substrate at a temperature range from 30 ℃ to 100 ℃ under shaking for 60 minutes, ③ protein content of mino after the cooking with phyto-protease (10,000xg supernatant from crude extract), ④ portions of each sample were subjected to rupture property tests and sensory tests using a portion of fresh and cooked samples.

Results and discussion

1. From sweet potato:

(1) Remaining of vitamin C: Relative to normal boiling, low temperature steam cooking leaves a larger quantity of vitamin C in the tissue (Fig.1). This is the first report of this kind, although many reports are available about the change of vitamin C content during and after food processing[4-9)]. In general, water-soluble vitamin C is lost into surrounding water but the loss is much less with steaming than with boiling. While the general boil-cooking is carried out at 100℃, low temperature steaming can be carried

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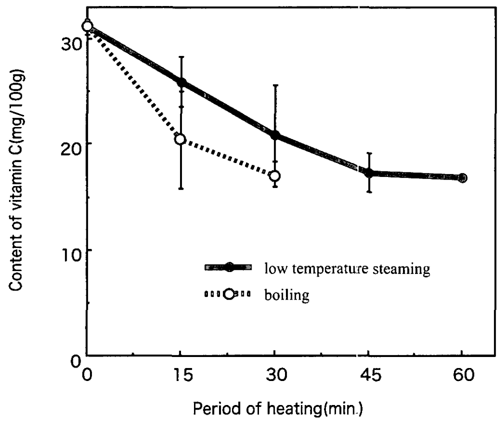


Fig 1. Change of vitamin C content of sweet patato in heating.

out at various temperatures lower than 100℃, as one wishes. Thus, one does not need to control heat and/or shift the cover of the pan to release the steam. Under low temperature steaming, the temperature inside the food material increases by heat exchange through a very thin film of water formed on the surface of the material. Under such conditions, water will not be lost but the volatile fatty acids evaporate out and low melting temperature fats and some water soluble proteins may dripped out of the food. Surrounding oxygen and bitterness components inside will be reduced[10]. These are advantage of this type of cooking.

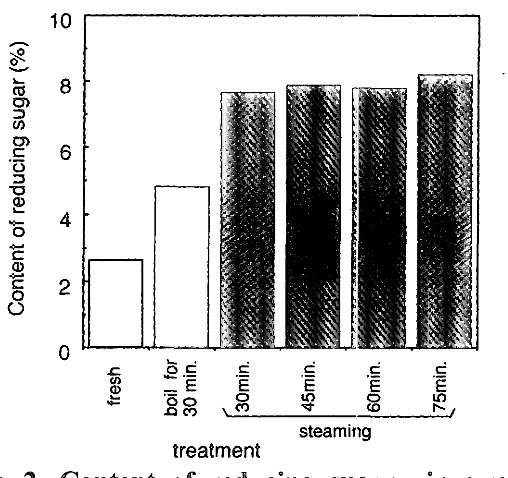


Fig 2. Content of reducing sugar in sweet potato.

(2) Increase of reducing sugar: Fig.2 indicates the increase of reducing sugar relative to boiling. Sweet potato baked using heated rocks is known to be sweeter and such slow heating is the most suitable cooking method to increase sweetness which comes from the formation of maltose from starch by β-amylase action[11]. In low temperature steaming, the temperature at the center of the food material is 80℃, where the β-amylase is expected to be still active and increasing maltose production. The nature of this enzyme and the activity change will be published in a separate paper.

2. From mino:

Histological studies on fresh, baked and low temperature steam cooked have been reported and the latter showed the clear loosening of tissue fibers, indicating the separation of muscle fiber-bundles, under the optical microscope, suggesting greater ease of eating[3].

(1) Biochemical alteration induced by different cooking methods: Quantitative changes in fat, nucleic acids and protein during low temperature steam cooking are presented in Table 1 and 2. As time lapses, fat, RNA and DNA were reduced, while the weight remained almost the

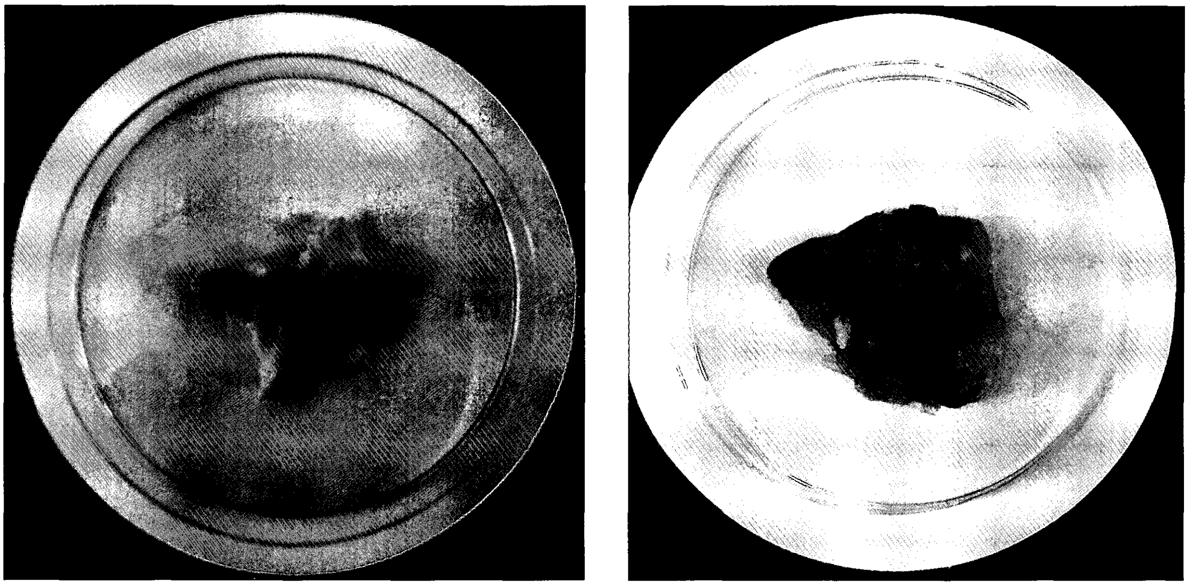
Table 1. Change of fat content during low temperature steaming.

Steaming time	0h. (fresh)	5h.	15h.
Fat content (μg/g of fresh weight)	84	65	60

Fat was extracted as methanol:chloroform soluble fraction.

Table 2. Change of nucleic acids and protein content during low temperature steaming.

Steaming time	0h. (fresh)	3h.	5h.	15h.
RNA (mg/g of fresh weight)	0.46	0.31	0.30	0.33
DNA (μg/g of fresh weight)	99.7	59.2	67.3	49.1
Protein (mg/g of fresh weight)	92.8	79.9	74.2	55.4



Mino　　　　　　　　　　Mino + Pineapple

Fig 3. Appearance of mino treated by phyto-protease(s)

same and the mass of protein found in dripping stayed constant, independent of heating period. We suspect that reduction of molecular weight in materials is induced by the endogenous enzymes during this steaming. Preparations by baking and boiling gave inconsistent results, probably due to the fluctuation of heating temperature. Obtaining constant temperatures and/or more accurate measurements needs to be improved.

(2) Shortening the cooking period by using phyto-protease(s): ① Phyto-protease(s) softens the meat. Fig.3 showed that meat 5 mm in thickness placed between two 3 mm thick sections of fruit, followed by a 4-hour low temperature steaming. They became extremely soft. Using pineapple sections, meat began to liquidity and barely held its shape. ② A sensory test was carried out on mino treated for 3 hours of low temperature steam cooking with and without pineapple enzyme solution (Fig.4). Mino treated with enzyme was soft and not rubber-like in nature, and anyone could easily bite into it. However, the flavor and sweetness of pineapple created a poor value in sensory tests. Rupture tests gave data only on enzyme-treated mino, supporting the sensory test data. ③ The optimal temperature on the activities of phyto-proteases was measured (Fig.5). Proteases were obtained from both mature and immature fruit of pineapple, papaya, and banana, commercially available. All of them showed their optimal activity at 70 ℃ and a somewhat gradually reduced activity at 80-90℃, although the mature ones showed stronger specific activities. If cooked in normal baking or boiling, they quickly lose their activity. Low temperature steam cooking can utilize the externally given enzyme(s). The proteases of pineapple and papaya are well studied[12] but protease(s) of banana is relatively unknown. However, in this study, a strong activity of banana protease(s) was found. This encouraged us to use banana, which is familiar and low priced, for cooking. However, as mentioned earlier, the taste and smell of banana charges the meat flavor. This can be avoided by pre-treating the meat with suitable seasoning and sauce, or by purifying the protease(s). Nevertheless, low temperature steam

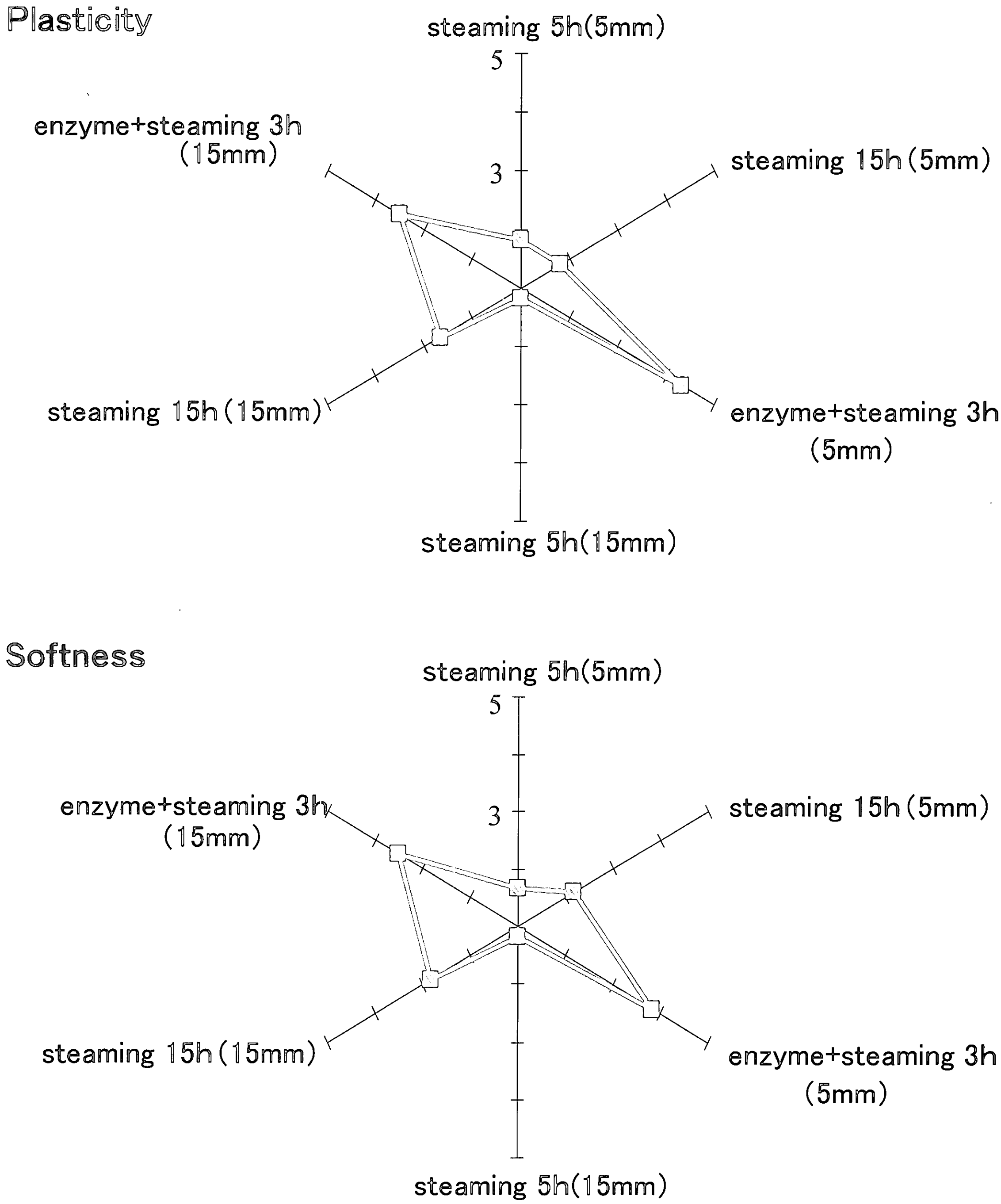


Fig. 4. Softening of meat by protease (Evaluation by sensory test)

[Five point evaluation: No plasticity and hardness are represented by 1 point, and plasticity and softness are represented by 5 points. Numbers in ( ) show the thickness of the meat.]

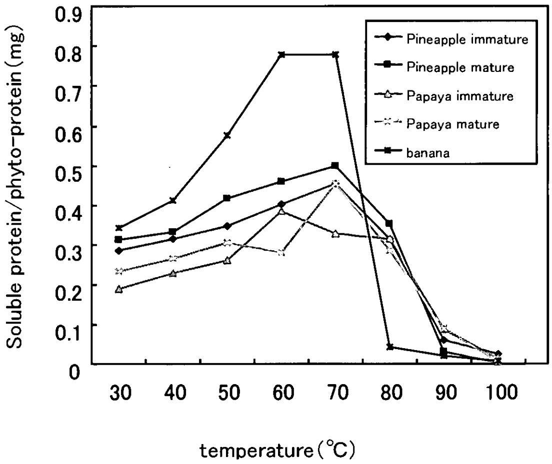


Fig. 5 Optimal temperature curve of phyto-proteases.

cooking has the advantage of accelerating the endo- and exo- enzyme function of softening ordinary non-edible hard tissue as well as shortening the cooking period and saving energy.

We have described the alteration of properties of food material in low temperature steam cooking, using sweet potato and mino. The results indicate an increase of sweetness from maltose, together with an attractive yellow color development in sweet potato. Mino, rarely used due to its hardness, but full of proteins, has been made soft and easily edible with the aid of phyto-protease(s), in a short period. It has been said that low temperature steam cooking takes a longer period but we have demonstrated a reduction of cooking time if one uses protease(s). The penetration of the taste and flavor of sauce and seasonings was also accelerated in our preliminary studies, which suggests to us the possibility of this application in mass food production.

Summary

1. In low temperature steam cooking of sweet potato, an increase of the amount of vitamin C remaining, maltose content, actual sweetness, and bright yellow color.
2. Mino became loose in bundling and more easily edible in cooking.
3. Mino becomes soft and easily edible in very short periods when phyto-protease(s) is applied. Finally, we would like to propose low temperature steam cooking as an excellent cooking if method employed optimal temperature for enzyme activities.

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