Effect of Sugars on Texture of Dried Meat

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SUMMARY: To clarify the reason for the soft texture of dried meat with sugars, the drying rate of the sliced pork and the denaturing rate of myofibrillar proteins prepared from the sliced pork were compared during heat-drying treatment of the sliced pork in the presence of sugars. When sugars were added to the sliced pork, the denaturing rate delayed more than the drying rate. From this result, we assumed that the dried pork would be soft since the decrease in moisture of the sliced pork would occur prior to the denaturation of contractile proteins during heat-drying treatment in the presence of sugars.

1. INTRODUCTION

Recently, the Japanese consumer prefers soft textured muscle food, including dried meat. However, the texture of dried meat is generally stiff. On the other hand, Chinese style dried pork, "Nikukan", which contains high concentrations of sucrose has a soft texture. In this study, we clarified the reason for the soft texture of dried meat containing high concentrations of sugars.

2. MATERIALS AND METHODS

2-1. Preparation of heat-dried pork

Lean and frozen ham was sliced into 3 mm thick pieces. The sliced pork was massaged with pickling solution (sliced pork:pickling solution = 2:1, w/w) containing 0.75 % sodium chloride, 0.2 % sodium pyrophosphate, and 0 - 75 % glucose or 0 - 75 % sucrose under vacuum condition for 16 hours. The added pickling solution was completely absorbed by the sliced pork. Immediately after massaging, the sliced-massaged pork was heat-dried at $50^{\circ}C$. At appropriate intervals, a part of the meat was packed in a polyvinylidenechloride coated polyester/polyethylene pouch and cooled in ice-water(1). The texture or biochemical properties of the heat-dried pork was then measured.

2-2. Preparation of myofibril

Myofibril from heat-dried pork was prepared according to Hashimoto and Arai(2), and suspended in 0.16 M KCl and 40 mM Tris-HCl (pH 7.5).

2-3. Solubility of myofibril

Myofibril prepared from heat-dried pork was suspended in 0.6 M KCl and 40 mM Tris-HCl (pH 7.5) or 8 M urea, 2 % SDS, 2 % 2-mercaptoethanol and 20 mM Tris-HCl (pH 8.0), and kept at $5^{\circ}C$ overnight. The protein concentration of the whole suspension before and of the supernatant after centrifugation at 3,000 X g for 30 min were measured. Solubility means the relative concentration value before and after centrifugation (3).

2-4. Ca-ATPase activity of myofibril prepared from heat-dried pork

Ca-ATPase activity of myofibril prepared from heat-dried meat was assayed at $25^{\circ}C$ in a medium of 0.1 M KCl, 5 mM $CaCl_2$, 25 mM Tris-maleate (pH 7.0), 1 mM ATP, and 0.2 - 0.4 mg/ml of myofibrillar protein. The ATPase reaction was started by adding ATP, and it was stopped at certain intervals by adding perchloric acid to make its final concentration of 5 %. Liberated inorganic orthophosphate (Pi) was determined by the method of Youngbrug-Youngbrug (4) with stannous chloride as the reagent.

2-5. Shear force value

The shear force value of heat-dried pork (1.5 X 5 mm) was measured using a Fudo-rheometer (1).

2-6. Protein concentration

The protein concentration was determined by the biuret method (5), using bovine albumin as a standard.

2-7. Calculation of the changing rate constant of some properties and the additional effect of sugars on the changing rate constant

The changing rate constant (k) for the decrease in moisture content of sliced pork, inactivation of Ca-ATPase activity of myofibril, or decrease in solubility with 0.6 M KCl, 40 mM Tris-HCl (pH 7.5) were calculated using the relation:

$k = (\ln C_0 - \ln C_t) X 1/t$,

where C_0 and C_t are the value before and after t second of heat-drying treatment.

The additional effect (e) of sugars were calculated using the relation:

$e = (\log k_0 - \log k_a) X 1/a$,

where k_0 and k_t are the first order rate constants for the decrease in moisture content of the sliced pork, inactivation of Ca-ATPase activity of myofibril, or decrease of solubility with 0.6 M KCl, 40 mM Tris-HCl (pH 7.5) in the absence and presence of sugars (a M).

3. RESULTS AND DISCUSSION

3-1. Comparison of some properties of dried pork

Moisture content, solubility with 0.6 M KCl (pH 7.5) or 8 M urea 2 % SDS, 2 % mercaptoethanol (pH 8.0) of myofibril prepared from dried pork and shear force value of four dried porks purchased in a market were compared. As shown in Fig.1, the four dried porks contained the same amount of moisture (14.5 - 15.5 %), but they showed different shear force values. Shear force values of the four dried meats seemed to be associated with the solubility with 0.6 M KCl (pH 7.5) of myofibril; the higher the shear force value of the dried meat, the lower the solubility. Therefore we assumed that the denaturation of myofibrillar protein has an influence upon the texture of the dried pork. Jerky D, shown in Fig. 1, was Chinese style dried pork, "Nikukan", and it contained high concentrations of sucrose as shown in Table 1.

3-2. Changes of some properties during heat-treatment of sliced pork without sugar

Changes in solubility with 0.6 M KCl (pH 7.5) and Ca-ATPase activity of the myofibril prepared from the sliced pork and moisture content of the sliced pork during heat-drying was investigated. As shown in Fig.2, when sliced pork was heat-dried at 50°C, moisture content of the sliced pork and Ca-ATPase activity and solubility with 0.6 M KCl (pH 7.5) of the myofibril prepared from the sliced pork changed according to a first order reaction rate. The order of changing rates was the rate constant of inactivation of Ca-ATPase > the decrease in solubility > the decrease in moisture content. This fact suggested that contractile protein started to denature in the early period of the heat-drying treatment, and then the moisture of the sliced pork continuously started to decrease during heat-drying.

From these results, we assumed that the texture of the dried pork would be tender, if denaturation of the contractile protein of the sliced pork could be prevented during the heat-drying process.

3-3. Effect of sugars on the changing rate of properties of sliced pork during heat-treatment and on the texture of the dried pork

Biochemical properties of myofibril prepared from the sliced pork such as Ca-ATPase activity and solubility with 0.6 M KCl, 40 mM Tris-HCl (pH 7.5) solution and moisture content of the sliced pork were measured during heat-drying of the sliced pork containing various concentrations of sucrose or glucose.

Plotting the logarithm of the rate constant versus the initial molality of sucrose (Fig. 3) or glucose (Fig. 4), linear relations were obtained for all indices employed. A slope of the logarithm of the rate constant versus the initial molality of sugar expressed the effect (e) of sugar versus heat-treatment of the sliced pork. The order of the effect was the "e value" for the inactivation of myofibrillar Ca-ATPase > that for the decrease in solubility of myofibril > that for the decrease of moisture content of sliced pork.

Judged from the "e value", it was strongly suggested that the added sugar during the heat-treatment of sliced pork effectively delayed the speed of the denaturation of contractile protein compared with that of the decrease in moisture content of the sliced pork. In addition, the effect of sucrose was nearly two-fold stronger than that of glucose for the change in indices employed (see Table 2).

When sliced pork containing no sugar, 2 M glucose, or 2 M sucrose were heat-dried at $50^{o}C$, shear force values of sliced pork containing no sugar increase rapidly, then that of sliced pork containing 2 M glucose, and then that of sliced pork containing 2 M sucrose, as shown in Fig.5.

From these results, we assumed that the dried pork would be hard since the denaturation of contractile protein would occur prior to the decrease in moisture of the sliced pork during heat-drying treatment without sugar, and that, on the other hand, the dried pork would be soft since the decrease in moisture of the sliced pork would occur prior to the denaturation of contractile protein during heat-drying treatment with sugar.

4.REFERENCES

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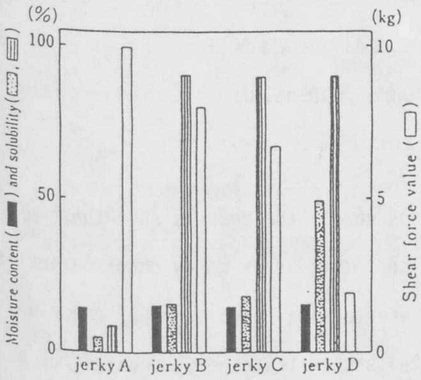

Fig.1. Comparison of some properties of four dried porks purchased in a market.

Moisture content (▮) ,solubility of myofibril with 0.6 M KCl, 40 mM Tris-HCl (pH 7.5) (▨) or 8M urea, 2 % SDS, 2 % 2-mercaptoethanol, 20 mM Tris-HCl (pH 8.0) (▥) , and shear force value (□) of four dried pork purchased in a market were compared.

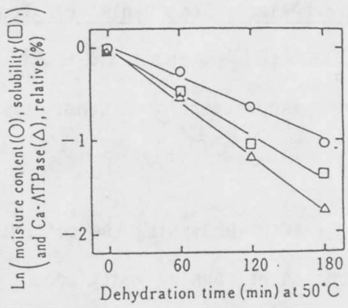

Fig.2. Changes in moisture content of dried pork, solubility with 0.6 M KCl, 40 mM Tris-HCl (pH 7.5), and Ca-ATPase of myofibril prepared from sliced pork during heat-drying at 50_0C.

Preparation of heat-dried massaged sliced pork was done as described in section "2-1". Moisture content was measured using a part of the dried pork. Myofibril was prepared using the other part of the dried pork. Solubility was measured as described in section "2-3", and Ca-ATPase activity was measured as described in section "2-4".

Table 1 Chemical composition of Chinese style dried pork "Nikukan"

Chemical composition (%)		Carbohydrate composition	(%)	(g/100 g dry)
Water	16.79			
Protein	35.05			
Fat	7.18			
Carbohydrate	37.24	Glucose	0.17	0.20
Ash	3.40	Sucrose	35.05	42.12
Others	0.34	Others	2.02	2.43
Sum	100.00	Sum	37.24	44.75

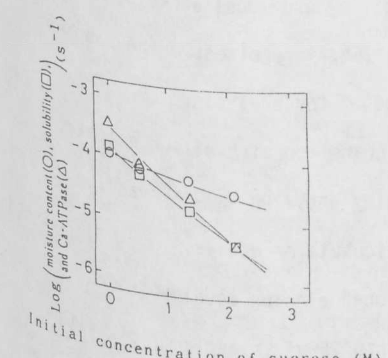

Fig.3. Logarithmic plot of the apparent rate constant for the changes in moisture content,Ca-ATPase activity, and solubility as a function of sucrose initial concentration.

Heat-dried preparation of massaged sliced pork containing various concentrations of sucrose were done as described in section "2-1". The first order rate constants for the changes of moisture content Ca-ATPase activity , and solubility were calculated as described in section "2-7".

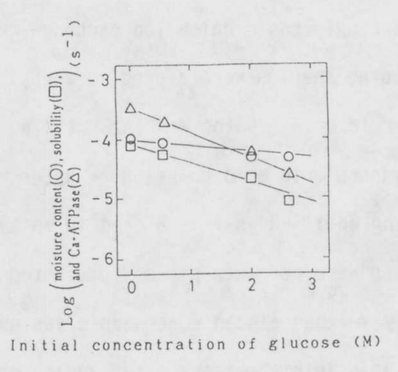

Fig.4. Logarithmic plot of the apparent rate constant for the changes of moisture content ,Ca-ATPase activity, and solubility as a function of glucose initial concentration.

Glucose was used instead of sucrose. Other conditions were same as in Fig. 3.

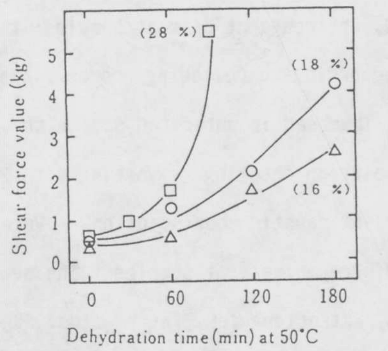

Fig. 5. Change in stiffness of sliced pork containing no sugar, 2 M glucose, or 2 M sucrose during heat-drying at 50^{0}C

Heat-dried preparation of massaged sliced pork containing no sugar (□) , 2 M glucose (○) , or 2 M sucrose (△) were done as described in section "2-1". The shear force value of the dried pork was measured. Numbers in parenthesis indicate the final moisture content of the sliced pork.

Table 2. Additional effect of added sucrose and glucose on changing rate of three indicator upon heat-drying of sliced pork.

Indicator	Additional Effect (e M^{-1})		e_s/e_G
	Glucose	Sucrose	
Moisture content	0.15	0.27	1.8
Ca-ATPase activity	0.44	0.88	2.0
Solubility	0.35	0.70	2.0

The additional effect of sucrose and glucose on changing rate were estimated from the linear relations between the logarithm of the rate constant and the initial sugar concentration (M) as described in section "2-7".