6-42 EVALUATION OF ORIENTAL HIGH SUGAR DRIED PORK

H. W. Ockerman and J. C. Kuo, Department of Animal Science, The Ohio State University, U.S.A. and Department of Food Science, Tunghai University, Taichung, Taiwan

INTRODUCTION. Chinese dried pork is a very sweet meat snack which is dried until it reaches 45-70% of its original weight (Chen, 1983). The tenderness, texture and shelf-life of the dried product is influenced by the degree of dryness. Dried pork flavor results primarily from the sugar, salt and soy sauce incorporated into the product (Ockerman & Kuo, 1982). Chen (1983) reported that Chinese dried pork was sometimes made with from 15 to 30% sugar, from 0.5 to 2.5% salt and other ingredients but many variations are used and the most desirable combination of salt and sugar is uncertain.

Dried foods generally have a_w values below 0.75 and a safe a_w level for storage is usually considered to be 0.70 or less. Banwart (1979) also reported that dried meat was sensitive to oxidative reactions. Labuza (1970) reported that oxidative rancidity rate usually increased with an increase in the water activity level. However, Ockerman and Kuo (1982) reported that dried pork had no major rancidity problem under their experimental conditions.

The purposes of this research were to investigate the effects of sugar and salt levels and refrigerated storage time (0, 7, 14 and 21 days) on the water activity value (a_w), dried weight (%), finished weight (%), pH value, total aerobic plate count, total anaerobic plate count, TBA value, and the sensory flavor of Chinese dried pork.

MATERIALS AND METHODS

PREPARATION OF SAMPLES. Dried pork can be manufactured by a new, more rapid tumbling and forced air drying technique described by Ockerman and Kuo (1982) or by the conventional methods of dry curing with sun and non-heated air drying which required more time and labor. A conventional curing method was used in this research but a more rapid drying method was employed which consisted of a forced air oven and wire racks.

Frozen, boneless ham was partially thawed then defatted of all subcutaneous fat and sliced to 0.2 cm thickness with a power slicer. The ham slices were divided into 9 treatments and dry cured with 3 different sugar levels (15, 22.5 and 30%) in combination with 3 different salt levels (0.5, 1.5 and 2.5%). All 9 treatments also contained with the same % of soy sauce (5%), monosodium glutamate (0.6%), sodium tripolyphosphate (0.2%), sodium nitrite (0.012%), and sodium erythorbate (0.05%).

Ham slices were cured for 36 hr. at 4° C. After curing, the edges were pressed together to form a large sheet and placed on wire racks to dry in a forced air oven at 55° C. The dried pork was then cooked (approximately 180° C) on a grill and then cooled at room temperature. The cooked dried pork from each individual treatment was then placed into 4 plastic bags, folded closed without sealing, and stored at 4° C. Packages of dried pork from each individual treatment were randomly assigned to be held for 0, 7, 14 and 21 days. The research was replicated four times.

MICROBIOLOGICAL EVALUATIONS AND pH DETERMINATION. At each storage interval, each package of dried pork was asceptically removed and mixed with 90 ml of sterilized distilled water in a sterilized blender. After the microbiological determination, the same solution was also used to determine the pH value of dried pork by a pH meter (Beckman Expandomatic SS-2).

Total aerobic plate counts were determined by using Tryptone Glucose Extract Agar and incubating at 37° C for 48 hrs. Total anaerobic plate counts were established by using anaerobic agar and incubating at 25° C for 3 days with an anaerobic jar (vacuumed and flushed with nitrogen 5 times).

WATER ACTIVITY (a_w). The water activity of dried pork was determined with a hydrometer.

TBA VALUES. Thiobarbituric acid (TBA) values were determined according to Tarladgis, et. al. (1960) as described by Ockerman (1984). A "K" value of 7.2 was experimentally obtained and results were expressed as mg of malonaldehyde per kg of dried pork.

SENSORY EVALUATION. The dried pork was served cold to each of 5 experienced (average of six years of meat evaluation experience) Oriental panelists. Panelists evaluated each sample for dried pork flavor by using a 10-point hedonic scale with 10 representing liked extremely and 1 representing disliked extremely.

STATISTICAL ANALYSIS. Data were analyzed by analysis of variance and individual F-test was used to determine the significance of sugar, salt, storage time and the interaction effects and means were separated by the Duncan's New Multiple Range Test (Duncan, 1955) technique.

Results and Discussion

The cured weight (%), dried weight (%), moisture content (%) and water activity (a_w) of the dried pork treatments are shown in Table 3. The cured weight of dried pork was affected ($P<0.01$) by added sugar, but surprisingly not by the lower percentages of added salt. With the same level of added salt, the treatments with 30% sugar had higher ($P<0.05$) cured weights (%) than the other treatments with 15 and 22.5% sugar. This difference was high enough to be significant ($P<0.05$) in all treatments except treatment 8 which also had a higher cured weight but it was not large enough to be significant. In all cases, when the same level of salt is compared, the 22.5% sugar treatment had an intermediate cured weight when compared with the 15% and 30% sugar level although this was usually not significant. This suggested that a relative percentage of sugar based on its concentration would be lost during the curing process, thus, considerable quantities of added sugar increased the weight of the cured pork and contributed to a higher cured weight (%) in the dried pork.

The dried weight of the product was also affected ($P<0.01$) by the level of added sugar. In general, the pattern was similar to the cured weight with the treatments with higher percentage of sugar having slightly higher percentage of dried weight.

The moisture content (%) of dried pork was not significantly different among these 9 treatments (Table 3). However, the water activity of dried pork, as expected, was affected ($P<0.01$) by salt. At each level of added sugar, the dried pork cured with 2.5% salt had lower ($P<0.05$) water activity than dried pork cured with 0.5% salt. This trend, although not significant, of reduced water activity with increased salt was also suggested at the 15 and 22.5% sugar level when the 1.5 and 2.5% salt treatments were compared. In this study, the effect of sugar on water activity of dried pork was surprisingly not significant, even though in general it decreased with added sugar. If the difference of concentrations of added sugar (%) were greater, its effect on water activity of dried pork probably would be more significant. Ranwart (1979) reported that the water activity could be lowered by removing water or by adding salt and/or sugar and that dried foods generally had water activity levels below 0.75. In this study, the dried pork had a water activity level from 0.81 to 0.88 which was high enough for moderate bacterial growth; therefore, the dried pork produced by this technique was refrigerated at 4° C during storage in order to increase its shelf-life.

The total aerobic plate counts (log) of dried pork during refrigerated storage are shown in Table 1. At each level of added salt the treatments with 30% sugar, in general, had less total aerobic microorganisms than the other treatments with 15 and 22.5% sugar during the 21 days of storage. This suggested that the addition of high levels of sugar could be effective in retarding the growth of microorganisms in dried pork. Ockerman (1983) reported that high percentages of sugar (20-80%) were usually needed to retard bacterial growth in meat.

During the 21 day storage period, dried pork with higher percentages of salt, as expected, had lower ($P<0.05$) total aerobic microorganisms than dried pork with the lower percentage of salt. With the addition of 15% and 22.5% of sugar, the differences of total aerobic microorganisms among the 3 different salt levels became more significant with the increase of storage time. In general, this same trend was also observed at the 30% sugar level particularly in the later stages of storage. Salt is used to retard bacterial growth in meat by reducing water activity, oxygen solubility and effectiveness of bacterial proteolytic enzymes (Ockerman, 1983).

The total aerobic counts of all 9 treatments increased ($P<0.05$), as would be expected, with an increase of storage time. The quality of dried pork, thus, would be expected to decrease due to the increase of aerobic microorganisms. Table 1 and 3, indicates, again as would be expected, that the lower the water activity of dried pork, the longer its shelf-life.

The initial total aerobic bacterial counts of dried pork in this study were higher than that of dried pork studied previously by Ockerman & Kuo (1982). This was probably due to different microbiological conditions of raw materials , ingredients added, processing, drying and cooking techniques.

Table 1 shows the total anaerobic bacterial counts of dried pork. During storage, the anaerobic bacterial counts of dried pork were highly correlated ($r=0.92$) with the aerobic bacterial counts. Both increased sugar and salt levels were found to reduce ($P<0.01$) the total anaerobic bacteria levels. At each level of added sugar the treatments with 2.5% salt, as expected, had slightly lower anaerobic bacterial counts than the other treatments with 1.5% and 0.5% salt at the 14-21 day sampling periods. With the same percentage of added salt, the treatments with 30% sugar also had slightly lower anaerobic bacteria levels than the treatments with 15 and 22.5% sugar. This suggested, as expected, that the higher percentage of sugar (30%) and salt (2.5%) is more effective in retarding the anaerobic bacterial growth in dried pork.

The TBA values of Chinese dried pork during storage are shown in Table 2. At zero days of storage, the TBA values among these 9 treatments, in general, were not significantly different. However, there is a trend of the TBA values increasing with the increase of storage time. After 21 days of storage, the range for the TBA values of dried pork was from 0.31 to 0.42. This level of low TBA values developed during storage of Chinese dried pork probably was the reason that no major rancidity flavor was detected by the panelists. Ockerman and Kuo (1982) reported that nitrite could act as an antioxidant to retard oxidative rancidity of Chinese dried pork. Soy sauce might also mask some of the rancidity flavor at low or moderate rancidity levels.

At each level of added sugar, the treatments with 2.5% salt, in general, had slightly higher TBA values than the other treatments with 0.5 and 1.5% salt during the 21 days of storage. This suggested that salt would accelerate the development of rancidity of Chinese dried pork during storage (Ockerman 1983).

At each level of added salt the treatments with 30% sugar had slightly higher TBA values than the other two treatments with 15 and 22.5% sugar during the 7-21 days of storage. This indicated that sugar would slightly increase the TBA values of Chinese dried pork during storage. This phenomenon is hard to explain; particularly when it is related to the a_w (0.81-0.88) of dried pork (Table 3). Since sugar would decrease the a_w of meat (Table 3) and also slightly increases the oxidative rancidity rate of dried pork. This does not agree with the work of Labuza (1970) who showed that an increase of water activity (from 0.35 to 0.80) would also increase the oxidative rancidity rate; however, it should be pointed out that the range of water activity values and TBA values in the current research is quite small.

The pH values (Table 3) among these 9 treatments were not significantly different at the 0 time. This suggested that neither sugar nor salt itself affected the pH values of Chinese dried pork directly. Kuo and Ockerman (1984) also found that the pH values for frozen beef were not significantly affected by the addition of salt. However, sugar or salt could affect the pH values of dried pork indirectly by inhibiting bacterial growth. The pH values for all 9 treatments slightly increased, as expected, during the 21 days of storage. However, the pH values for most of the treatments (except treatment 4) at 7-day of storage slightly decreased (not significantly) comparing to that at 0 time. This is probably due to the microorganisms becoming acclimated to their new cured meat environment.

At the 21 day storage period, the treatments (1, 4 and 7 with 0.5% salt) with higher pH values had higher total aerobic and anaerobic microbiological counts (Table 1). Therefore, it appears that the pH values for Chinese dried pork could be used as an indication of bacterial quality.

In order to determine the most sensory acceptable recipe for dried pork during storage, the panel flavor of dried pork was investigated in this research. Since the flavor of this product is very different from most western dried products only trained Oriental panelists were used.

Table 1 shows the panel flavor scores of dried pork during storage. In general, the dried pork made with high sugar levels had higher panel flavor scores than the dried pork which was made with lower levels of sugar. With the same level of added sugar, the treatments with 2.5% of added salt seemed to have slightly higher panel flavor scores than the treatments with lower percentages of salt, however, these differences were not always significant.

After 7-day of storage, the panel flavor score of treatment 1 was significantly lower than the other treatments. This was probably due to the higher total aerobic and anaerobic microorganisms in this treatment (Table 1) which produced some off-flavor. Treatments 1,4,5 and 7 had lower panel flavor scores than the other treatments after 14-day of storage. This suggested that the treatments with higher a_w would have higher aerobic and anaerobic microbiological counts (Table 1) and lower sensory quality during storage. During the 21 days of storage, the panel flavor scores of all 9 treatments decreased with increased storage time, however, treatments 2, 3, 5 6, 8, and 9 were still acceptable by the panelists at 21 days. This suggested that the dried pork with a a_w lower than 0.85 (Table 3) would be expected to have longer shelf-life. Therefore, in order to increase the shelf-life of dried pork, it should be manufactured to have a_w values lower than 0.85 by adding more sugar and/or salt, or reducing the moisture content. However, the flavor and tenderness (the drier, the tougher) of dried pork should also be considered during processing. According to the description of the panelists, the rancidity flavor was slightly developed at the 21-day storage period. Ockerman and Kuo (1982) also reported that rancid odor and rancid flavor caused no major problem in dried pork under their experimental conditions. Panel color and tenderness scores were not determined in this research; however, Ockerman and Kuo (1982) reported the color was partially affected by the amount of soy sauce and degree of evaporation and tenderness scores were influenced by the moisture content of dried pork.

This research would suggest that a satisfactory Chinese dried pork product can be made with 30% sugar and 2.5% salt and satisfactorily stored under refigeration for 21 days.

References

Banwart, G. J. 1979. "Basic Food Microbiology". AVI Publishing Company, Inc. Westport, Connecticut.

Chen, M. T. 1983. "Meat Science and Technolgoy". Taipei, Taiwan.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Labuza, T. P. 1970. Proceedings of 3rd International Congress. Food Sci. Technol., (1971), Washington, D.C. P618

Kuo, J. C. and Ockerman, H. W., 1984. Effect of rigor, salt, freezing, lyophilization and storage time on pH, water-holding capacity and soluble protein nitrogen in beef muscle. J. Food Protection. 47:316.

Ockerman, H. W. 1983. "Chemistry of Meat Tissue". Animal Science Dept., The Ohio State University, Columbus, Ohio.

Ockerman, H. W. 1984. "Quality Control of Post-Mortem Muscle Tissue, Vol. 1". Animal Science Dept., The Ohio State University, Columbus, Ohio.

Ockerman, H. W. and Kuo, J. C. 1982. Dried pork as influenced by nitrate, packaging method and storage. J. Food Sci. 47:1631.

SAS Ins. Stat. Anl. System. 1979. SAS User's Guide. SAS Ins. Inc., Raleigh, NC.

Tarladgis, B. G., Watts, B. M. and Younathan, M. T. 1960. A distillation method for the quantitative determination of malonaldehyde in rancid foods. J. Amer. Oil Chem. Soc. 37:44.

Table 1. The total aerobic and anaerobic plate counts[1] (log) of Chinese dried pork during storage

Treatment	Sugar (%)	Salt (%)	AEROBIC				ANAEROBIC			
			0 days	7 days	14 days	21 days	0 days	7 days	14 days	21 days
1	15	0.5	$3.84^{a,w}$	$5.11^{a,x}$	$7.25^{a,y}$	$8.95^{a,z}$	$2.39^{a,w}$	$4.12^{a,x}$	$5.87^{a,y}$	$7.18^{a,z}$
2	15	1.5	$3.74^{a,x}$	$4.21^{b,c,x}$	$5.79^{c,d,y}$	$7.41^{c,z}$	$2.34^{a,w}$	$3.91^{a,x}$	$5.38^{a,b,y}$	$6.62^{a,b,c,z}$
3	15	2.5	$3.66^{a,x}$	$4.07^{b,c,x,y}$	$4.48^{e,y}$	$6.20^{d,z}$	$2.55^{a,x}$	$3.61^{a,y}$	$3.94^{d,e,y}$	$5.72^{d,z}$
4	22.5	0.5	$3.91^{a,w}$	$4.78^{a,b,x}$	$6.61^{a,b,y}$	$8.49^{a,b,z}$	$2.49^{a,x}$	$4.18^{a,y}$	$4.39^{c,d,y}$	$7.12^{a,b,z}$
5	22.5	1.5	$3.83^{a,x}$	$4.50^{a,b,c,x}$	$5.61^{d,y}$	$7.39^{c,z}$	$2.65^{a,w}$	$3.81^{a,x}$	$4.95^{b,c,y}$	$6.04^{c,z}$
6	22.5	2.5	$3.55^{a,x}$	$4.06^{b,c,x}$	$4.81^{e,y}$	$6.22^{d,z}$	$2.33^{a,x}$	$3.61^{a,y}$	$3.79^{d,e,y}$	$5.04^{e,z}$
7	30	0.5	$3.82^{a,x}$	$4.41^{a,b,c,x}$	$6.41^{b,c,y}$	$8.25^{a,b,z}$	$2.68^{a,w}$	$3.33^{b,x}$	$4.10^{d,e,y}$	$6.61^{a,b,c,z}$
8	30	1.5	$3.55^{a,x}$	$3.96^{c,x}$	$4.51^{e,y}$	$6.25^{d,z}$	$2.45^{a,x}$	$3.39^{b,y}$	$3.69^{e,y}$	$5.11^{d,e,z}$
9	30	2.5	$3.55^{a,x}$	$4.02^{c,x,y}$	$4.56^{e,y}$	$6.11^{d,z}$	$2.59^{a,x}$	$3.40^{b,y}$	$3.57^{e,y}$	$4.88^{e,z}$

1/ Data within columns with different letters (a,b,c,d,e) are significantly different (P<0.05); data within rows and within type of plate count with different letters (w,x,y,z) are significantly different (P<0.05)

Table 2. The TBA and pH values of Chinese dried pork during storage.

			TBA VALUES				pH VALUES			
			0 days	7 days	14 days	21 days	0 days	7 days	14 days	21 days
1	15	0.5	$0.20^{b,x}$	$0.29^{b,c,y}$	$0.30^{b,c,y}$	$0.33^{c,d,y}$	$6.11^{a,x}$	$6.07^{a,b,x}$	$6.22^{a,y}$	$6.28^{a,y}$
2	15	1.5	$0.22^{a,b,x}$	$0.27^{b,c,y}$	$0.30^{b,c,y}$	$0.31^{d,y}$	$6.10^{a,x}$	$6.03^{a,b,x}$	$6.09^{b,c,x}$	$6.09^{b,c,x}$
3	15	2.5	$0.21^{a,b,x}$	$0.27^{b,c,y}$	$0.30^{b,x,y,z}$	$0.33^{c,d,z}$	$6.04^{a,x}$	$6.00^{b,x}$	$6.03^{c,x}$	$6.07^{c,x}$
4	22.5	0.5	$0.20^{b,x}$	$0.29^{b,c,y}$	$0.26^{c,y}$	$0.34^{c,d,z}$	$6.09^{a,x}$	$6.10^{a,x}$	$6.14^{a,b,x}$	$6.17^{b,y}$
5	22.5	1.5	$0.22^{a,b,x}$	$0.29^{b,c,y}$	$0.29^{b,c,y}$	$0.36^{b,c,d,z}$	$6.07^{a,x}$	$6.05^{a,b,x}$	$6.04^{c,x}$	$6.07^{c,x}$
6	22.5	2.5	$0.21^{a,b,x}$	$0.25^{c,x}$	$0.33^{a,b,y}$	$0.37^{b,c,y}$	$6.09^{a,x}$	$6.02^{a,b,x}$	$6.06^{b,c,x}$	$6.07^{c,x}$
7	30	0.5	$0.24^{a,b,x}$	$0.30^{b,y}$	$0.34^{a,b,y}$	$0.39^{a,b,z}$	$6.10^{a,x,y}$	$6.06^{a,b,y}$	$6.09^{b,c,x,y}$	$6.17^{b,x}$
8	30	1.5	$0.24^{a,b,x}$	$0.36^{a,y}$	$0.36^{a,y}$	$0.40^{a,b,y}$	$6.10^{a,x}$	$6.04^{a,b,x}$	$6.07^{b,c,x}$	$6.07^{c,x}$
9	30	2.5	$0.26^{a,x}$	$0.36^{a,y}$	$0.36^{a,y}$	$0.42^{a,z}$	$6.05^{a,x}$	$6.03^{a,b,x}$	$6.06^{b,c,x}$	$6.06^{c,x}$

1/ Data within columns with different letters (a,b,c,d) are significantly different (P<0.05); data within rows for TBA Values and for pH Values with different letters (x,y,z) are significantly different (P<0.05).

153 [illegible]

Table 3. The cured weight (%), dried weight (%), moisture content (%), water activity (a_w) and panel flavor scores of Chinese dried pork[1].

Treatment	Cured Weight % of Original Weight	Dried Weight % of Original Weight	Moisture Content %	Water Activity (a_w)	PANEL FLAVOR SCORES 0 days	7 days	14 days	21 days
1	62.30^{c}	54.10^{b}	60.63^{a}	0.88^{a}	$6.5^{e,w}$	$5.5^{c,x}$	$4.5^{d,y}$	$2.0^{e,z}$
2	61.93^{c}	54.23^{b}	61.23^{a}	$0.84^{b,c}$	$6.8^{d,e,x}$	$7.0^{a,b,x}$	$7.1^{a,b,x}$	$5.6^{b,c,y}$
3	62.50^{c}	$54.90^{a,b}$	60.90^{a}	0.82^{c}	$7.0^{c,d,e,x}$	$7.2^{a,b,x}$	$7.0^{a,b,x}$	$6.4^{a,x}$
4	$63.30^{b,c}$	$55.78^{a,b}$	60.33^{a}	0.88^{a}	$6.9^{d,e,x}$	$6.5^{b,x,y}$	$5.8^{c,y}$	$2.1^{e,z}$
5	$63.43^{b,c}$	$55.83^{a,b}$	61.80^{a}	$0.85^{a,b,c}$	$7.2^{c,d,e,x}$	$6.8^{a,b,x}$	$6.5^{b,c,x}$	$5.4^{c,y}$
6	62.90^{c}	$55.18^{a,b}$	61.61^{a}	0.82^{c}	$7.4^{b,c,d,x}$	$7.2^{a,b,x}$	$7.2^{a,b,x}$	$6.0^{a,b,c,y}$
7	66.78^{a}	57.58^{a}	60.80^{a}	$0.86^{a,b}$	$7.8^{b,c,x}$	$7.3^{a,b,x,y}$	$6.5^{b,c,y}$	$3.2^{d,z}$
8	$64.33^{a,b,c}$	$56.70^{a,b}$	62.83^{a}	0.81^{c}	$8.2^{a,b,x}$	$7.5^{a,x,y}$	$7.2^{a,b,y,z}$	$6.5^{a,z}$
9	$66.18^{a,b}$	57.13^{a}	61.65^{a}	0.81^{c}	$8.8^{a,x}$	$7.5^{a,y}$	$7.4^{a,y}$	$6.3^{a,b,z}$

1/ Data within columns with different letters (a,b,c,d,e) are significantly different (P<0.05); data data within rows for panel flavor scores with different letters (w,x,y,z) are significantly different.