Physicochemical Properties of Salted Pickled Yolks from Duck and Chicken Eggs

SUEY-PING CHI and KUO-HSUEN TSENG

ABSTRACT

Duck egg yolk pickled by salt attained more desirable characteristics, such as orange color, oil exudate, and grittiness, than salted chicken egg yolk. Salted duck egg yolk reached a hardening ratio of 90% in 28-days; 35 days were required for the salted chicken egg yolk to achieve the same hardening. Moisture content of egg yolk affected the quantity of extracted lipid, an index of oil exudation. The moisture content of duck egg yolk was 19%, and the extracted lipid was 30%. But less than 4% lipid was extracted when moisture content was >27.5%. Under scanning electron microscopy, yolk spheres dominated the yolk structure probably responsible for the gritty texture.

Key Words: salting, duck egg, chicken egg, lipid, pickling

INTRODUCTION

SHELL EGG IS PICKLED BY SALT AND THE SALTED EGG YOLK (EY) is a traditional Chinese product, very popular in Asia. It is commonly consumed especially with rice gruel for breakfast. Salted EY is also widely used in bakery products, such as moon cake and joanz (Chinese tamale). Desirable characteristics of salted EY include orange color, oil exudation, and gritty texture. Traditionally, salted eggs are made from duck eggs because they attain more desirable characteristics. Conventionally, egg is coated with a paste-like mixture consisting of red soil, salt, and water. The coated shell egg is aged for 20–35d at ~27°C. Another method is to immerse shell eggs into a solution containing table salt for 20–30d. During pickling, the yolk gradually becomes solidified and hardened. The egg white (EW) loses viscosity and whipping capability and becomes watery.

Salted duck eggs had more oil exudate than chicken eggs due to less hydrogen sulfide evolution from duck egg (Arroyo et al., 1973). Differences in salt and nitrogen content, composition of lipids and storage stability of chicken salted EY from both conventional and immersion methods were compared (Peh et al., 1982). A higher salt concentration in the immersion solution or coating paste resulted in higher penetration rate of salt into EY. In attempts to produce salted EY from fresh yolk without success (Chiang and Chung, 1986) EY became watery and did not attain desirable characteristics. However, the dehydration and salt content could have been major factors affecting the hardness of salted yolk. The granulation in salted EY could be related to salt and its interaction with low density lipovitellenin (Wang, 1991).

A systematic understanding of the product characteristics has not been developed or reported. Our objectives were to investigate the physicochemical properties of salted EY and to compare the differences between salted duck and chicken egg products.

MATERIALS & METHODS

FRESH DUCK AND CHICKEN SHELL EGGS AND RED SOIL WERE PURchased (Tze-Hsin Egg Store, Taipei, Taiwan). Clay-like properties were the only requirements for the soil which appears red due to high iron content and can be readily obtained in Taiwan. Shell eggs were obtained within 7 days after laying and stored at 4°C before experiments. Red soil, refined table salt (99.5% sodium chloride), and distilled water, at a mass ratio of 2:2:1, were mixed to a paste-like mixture which was called coating-paste and used as the pickling medium. The red soil acted as a thickener and adhered to the egg shells during pickling. Surfaces of duck and chicken eggs were spread with the coating-paste at a thickness of 2 mm and pickled at 20–25°C for 49 days according to the commercial method. No other special conditions were required.

Eight duck and chicken eggs were removed, designated as a sampling group, for analysis every 7d. Before analysis, the coating-paste was washed off with water and the EY was separated from the EW. The reported data are average values from the analysis of 8 eggs.

Color of both interior and exterior portions of uncooked yolks was measured with a color meter (TC-1, Tokyo Denshoku Co., Japan) using Hunter L, a, b color scale. The instrument was calibrated using a standard white tile (L = 95.95, a = 0.34, b = 0.13).

Hardening ratio of yolk was defined as the weight percent of hard exterior yolk and used as an index for the completeness of pickling determined as follows: The EY was rolled over regular facial tissue to remove the EW, then weighed (WO). The EY was cut with a knife and the readily removable interior yolk was scraped out using a teaspoon. The exterior part was hard enough that only the interior (soft or liquid) portions were scraped out. The weights of exterior and interior yolk were measured separately. The exterior yolk was designated as W_{ex}. The hardening ratio (H_a) of the EY was calculated as

$$H_a = W_{ex}/W_o \times 100\% \qquad (1)$$

Moisture content of EW, exterior (m_{ex}) and interior (m_{in}) EY was measured separately according to AOAC (1984). The average moisture content (m) of yolk was calculated as

$$m = m_{ex} \times H_a + m_{in} \times (1 - H_a) \qquad (2)$$

NaCl content was analyzed by an ion analyzer (Suntex 300A, Taipei, Taiwan). EY or EW (1–3g) was mixed with 150 mL deionized water and the solution was vigorously homogenized (Ystral, X10/20, Yastral GmbH, Dottingen, Germany). The concentration of chloride ion was measured by an ion analyzer with chloride electrode (Ingold Messtechnik AG, Urdorf, Switzerland). The chloride ion and NaCl content were calculated from the following equations:

$$Cl^{-}\ (\%) = Cl^{-}\ (ppm)/W\ (g) \times 150/10^6 \qquad (3)$$

$$NaCl\ (\%) = Cl^{-}\ (\%) \times 58.5/35.5 \qquad (4)$$

where W is the weight of sample in grams.

Hardness of the yolk was measured by the method of Chiang and Chung (1986) using a rheometer (Fudoh NRM-3002D, Tokyo, Japan) with plunger #8. The maximum reading as the plunger reached the midpoint of solidified yolk was recorded as hardness.

According to the method of Schultz et al. (1968), about 2g yolk were mixed with 150 mL petroleum ether and homogenized (X10/20, Ystral GmbH, Dottingen, Germany) 1 min at room temperature. The mixture was then filtered by paper (Whatman No. 1). Petroleum ether was recovered from the filtrate by steam bath and the residual was dried at 105°C in an oven for 2 hr. The weight of lipid in the

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Author Chi is with the Food & Agriculture Dept., Council of Agriculture, 37 Nanhai Rd., Taipei, Taiwan, Republic of China. Author Tseng is with the Graduate of Food Science & Technology, National Taiwan Univ., Taipei, Taiwan, Republic of China.

filtrate was determined and designated as free lipid. Crude lipid was determined using the Soxhlet method (AOAC, 1984). The ratio of free lipid to crude lipid was defined as the extracted expressed as percentage. The percentage of extracted lipid was reported as the index of oil exudation.

A typical method was used for scanning electron microscopy (SEM). Exterior and interior chicken EY were freeze-dried to a moisture content <5%. The freeze-dried sample was cut into a 0.3 3 0.3 3 0.2 mm piece and then mounted on SEM stubs using a double-backed cellophane tape. The stub and samples were coated with gold-palladium, examined using a scanning electron microscope, (Jeol JSM-6300, 20 kV, Japan), and photographed. The micrographs were made in triplicate.

RESULTS & DISCUSSION

AVERAGE COMPOSITION OF FRESH DUCK AND CHICKEN YOLK WERE compared (Table 1) and confirmed the report by Cotterill (1986). Duck EY (DY) was heavier than chicken EY (CY) and had more crude protein and lipid. During pickling, the solidification of EY initiated near the vitelline membrane and proceeded toward the center as the yolk became orange and hardened. The thickness of the orange-colored layer increased with pickling time. The orange-colored layer had the appearance of commercial salted EY and was designated as "exterior yolk." The yolk in the center with similar appearance of fresh yolk was designated as "interior yolk." The difference has not been reported.

The interior and exterior yolks had different characteristics and it was more reliable to analyze separately their physicochemical properties after pickling.

DY formed an initial hardened layer after 7-d pickling but 21d were needed for CY to form an initial hardened layer. The color data for DY and CY (Table 2) showed lightness (L) and yellow indices (b) of exterior and interior DY decreased gradually when pickling time was <28d. After that, L and b values increased. The change in color might be due to the dehydration of EY during pickling. Yellow color of EY comes from xanthophyll and zeaxanthin (Schaible, 1970; Hinton et al., 1974; Karunajeewa, 1978; Burdick and Fletcher, 1984) and has been influenced by concentration of pigments. The EY stored at low moisture for a long time became darker yellow, due to removal of moisture (Lin, 1983). This suggested that the orange color of salted EY may be due to the increase in concentration of pigments. The color of CY also darkened during pickling (Table 2), but it did not result in the desirable orange color. Thus the dehydration of EY during pickling affected both texture and color of the product.

For DY, the hardened layer was initially formed with a thickness of 3 ± 1 mm after 7-d pickling and increased to 7 ± 1 mm after 28d. In that time, the hardening ratio increased from 63.2 to 90.2% (Fig. 1) and pickling was completed when the hardening ratio became >90% which for duck egg was 28d. The hardening rate for CY (Fig. 1) was slower than that for DY. The hardening ratio of CY was 30.4% after 7-d pickling and 35d were needed to reach a hardening ratio >90%. The yield from duck egg was 100% and ~80% for chicken egg due to contamination of microorganisms.

Salted DY had higher hardness scores than salted CY and hardness increased with pickling time (Fig. 1). Due to formation of hardened layer, the hardness of DY and CY was measurable after 14 and 21-d pickling, respectively. The hardness score of DY increased from 180g (28-d pickling) to 765g (42-d pickling). For CY, the hardness score was <200g after 35-d pickling and increased to 325g after 42-d pickling.

The moisture content in duck EW (DW) decreased from 87.5 to 82.3% in 49-d pickling (Fig. 2). The change of moisture content in chicken EW (CW) was similar which indicated that reduction of moisture in EW was very slight. The initial moisture content of the exterior DY (DYE) was 27.4% (Fig. 2) and decreased to 18.1% after 49d. Thus, dehydration resulted in formation of the exterior layer. The moisture content of interior yolk (DYI) was reduced from 46% to 42.4% after 7-d pickling and remained ~36 ± 1% after 21d. Most

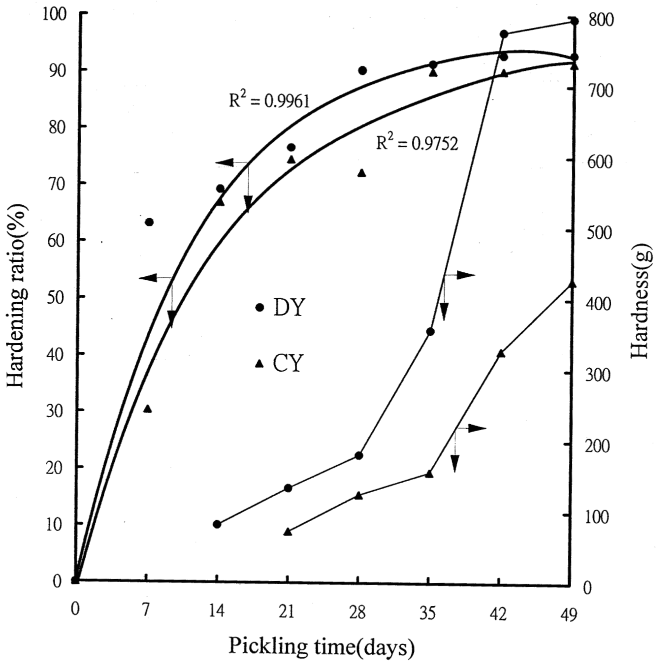

Fig. 1—Variations of hardening ratio and hardness of salted yolks during pickling. (DY = duck egg yolk; CY = chicken egg yolk).

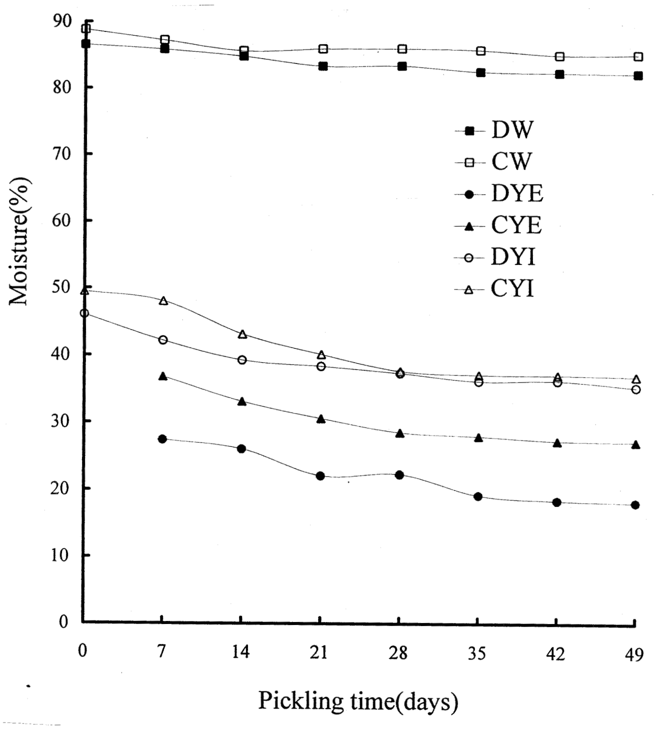

Fig. 2—Reduction in moisture contents of salted eggs during pickling. (DW = duck egg white; CW = chicken egg white; DYE = exterior duck egg yolk; DYI = interior duck egg yolk; CYE = exterior chicken egg yolk; CYI = interior chicken egg yolk).

Table 1—Weight and proximate composition of chicken and duck yolk in a single egg

	Chicken egg yolk	Duck egg yolk	n*
Weight (g)	17.11 ± 1.3	24.62 ± 2.2	80
Moisture (%)	49.44 ± 1.1	46.01 ± 1.5	12
Protein (%)	16.32 ± 1.1	19.08 ± 1.9	3
Lipid (%)	32.25 ± 1.7	36.53 ± 2.1	3
Ash (%)	0.96 ± 0.2	0.82 ± 0.2	3

* n = number of eggs analyzed.

Table 2—Color measurements[a] of salted duck and chicken egg yolk during pickling

Pickling time (days)	Salted duck egg yolk L	Salted duck egg yolk a	Salted duck egg yolk b	Salted chicken egg yolk L	Salted chicken egg yolk a	Salted chicken egg yolk b
(interior) 7	20.47 ± 2.15	0.80 ± 0.13	13.22 ± 0.99	26.94 ± 1.08	1.67 ± 0.06	14.11 ± 1.69
14	20.72 ± 1.45	1.70 ± 0.36	12.31 ± 0.86	23.57 ± 2.59	0.33 ± 0.01	14.68 ± 0.22
21	18.04 ± 1.36	1.97 ± 0.34	10.41 ± 0.94	19.43 ± 0.39	0.89 ± 0.09	12.66 ± 1.52
28	16.75 ± 1.34	3.10 ± 0.51	9.51 ± 1.14	19.52 ± 1.46	1.49 ± 0.43	10.80 ± 1.14
35	18.21 ± 1.00	2.06 ± 0.32	10.92 ± 0.55	18.28 ± 1.74	2.33 ± 0.41	10.96 ± 0.55
(exterior) 7	17.72 ± 0.36	2.40 ± 0.46	6.58 ± 0.83			
14	14.97 ± 0.15	2.31 ± 0.25	6.38 ± 0.89	13.79 ± 0.25	0.61 ± 0.06	5.36 ± 0.19
21	16.11 ± 0.65	1.82 ± 0.28	6.95 ±1.29	14.04 ± 0.21	1.92 ± 0.18	6.42 ± 0.67
28	14.75 ± 0.29	1.97 ± 0.64	6.07 ± 1.13	15.57 ± 0.78	2.49 ± 0.46	7.74 ± 0.58
35	16.51 ± 1.16	2.12 ± 0.44	5.72 ± 0.88	17.66 ± 0.88	4.12 ± 0.92	8.17 ± 0.69
42	16.62 ± 0.33	3.67 ± 0.42	7.23 ± 0.73	15.35 ± 0.62	3.15 ± 0.13	6.32 ± 0.60

[a] Measurements were made in triplicate for each sampling group.

dehydration occurred in DYE and moisture reduction also occurred in CY. The moisture content of exterior CY (CYE) was reduced from 36.9% after 7-d pickling to ~30% after 28d. The reduction in moisture content of interior CY (CYI) was similar to that of DYI. Moisture reduction during pickling was due to the difference in osmotic pressure between EW and EY. Water migrated from EY to EW, then to the envirorunent through the egg shell. More reduction in moisture content occurred for DY than for CY which might be due to differences in pore sizes and structures of the shell.

As expected, the salt content in EW increased with pickling time (Fig. 3). After 28-d pickling, DW contained 7.5% salt and CW contained 5.5% salt. The results confirmed previous studies (Peh et al., 1982; Chiang and Chung, 1986; Wang, 1991). The permeability of egg shell for salt might be the major reason for the difference in salt contents as salt migrated from coating-paste into EW, then to EY. Thus, the salt content in EY also increased with pickling time and dehydration of EY and diffusion of salt into EW and EY occurred concurrently during pickling. Both effects could cause the hardening of EY.

The exterior yolks exhibited more oil exudation than the interior yolk which had < 3% extractable lipid in 49 d. The extracted lipid from DYE was >25% after 35-d pickling and the CYE yielded ~15% extracted lipid (Fig. 4). Moisture contents and amounts of extracted lipid appeared to be related (Fig. 5). For DY, the extracted lipid was <4% when the moisture was >27.5% and increased to 30% when the moisture was reduced to 19%. Similar trends were observed for the CY except a rapid increase in extracted lipid occurred at a moisture content of 33.5% instead of the 27.5% of comparable DY samples. Schultz et al. (1968) pointed out that removal of water from EY increased extracted lipid due to the structure change of low density lipoprotein. Thus, the dehydration during pickling probably enhanced oil exudation.

Gritty texture is a major factor affecting consumer acceptance of these products. Yang and Hsu (1989) reported polyhedral granules with a diameter of 23 to 127 µm in salted DY. The microstructure of the CYE by SEM indicated that polyhedral granules were packed closely due to dehydration during pickling (Fig. 6a). The granules were in the size range of 90 to 100 µm. The presence of such granules probably provided the gritty texture sensation. According to the granule size, these polyhedral ganules were formed by yolk spheres with similar sizes (Woodward and Cotterill, 1987a; Yang and Hsu, 1989). Therefore, the yolk spheres are necessary to produce salted EY with a gritty texture. After pickling, polyhedral granules were found in the CYI (Fig. 6b) and the packing of the granules was not as tight as in the exterior region. There were some subdroplets on the surface which indicated that the moisture content affected packing of the granules. The more water removed, the tighter the granules were packed. Salt disrupted small yolk spheres which appeared as subdroplets in the

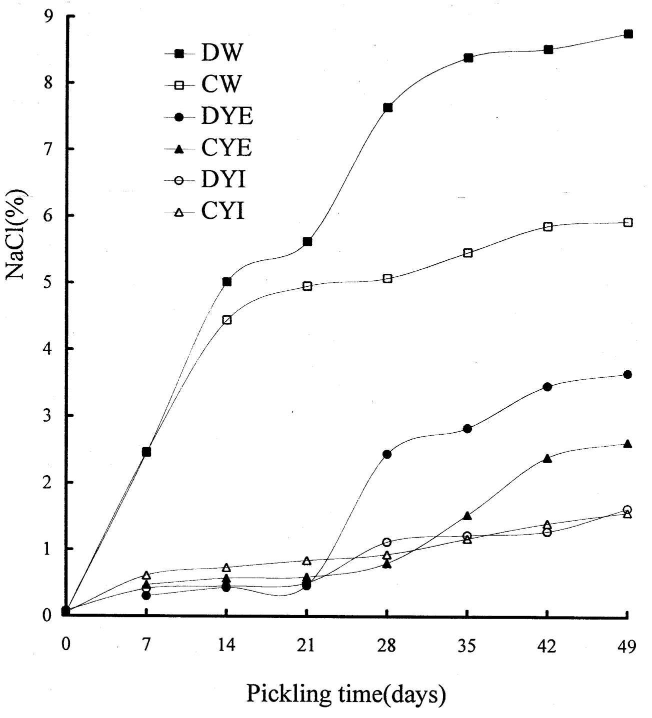

Fig. 3—Increase in salt (NaCl) content of salted eggs during pickling. (DW = duck egg white; CW = chicken egg white; DYE = exterior duck egg yolk; DYI = interior duck egg yolk; CYE = exterior chicken egg yolk; CYI = interior chicken egg yolk).

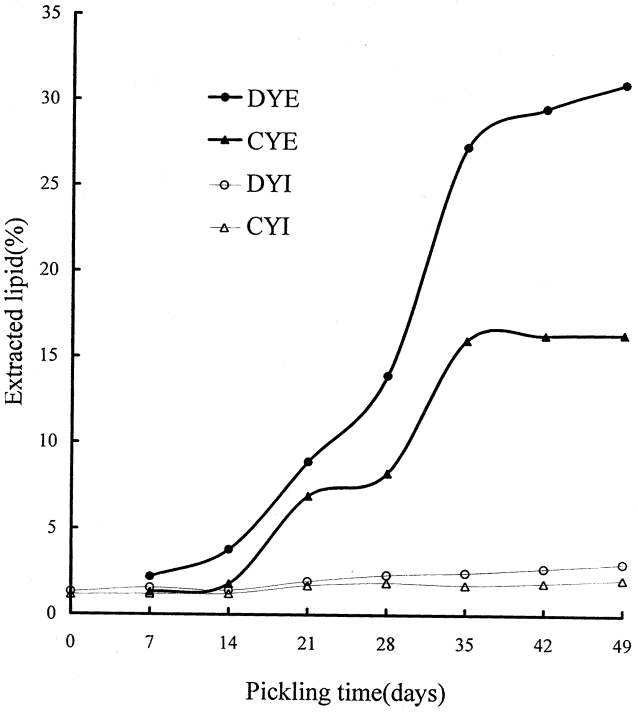

Fig. 4—Effect of pickling time on extracted lipid from salted eggs. (DYE = exterior duck egg yolk; DYI = interior duck egg yolk; CYE = exterior chicken egg york; CYI = interior chicken egg yolk).

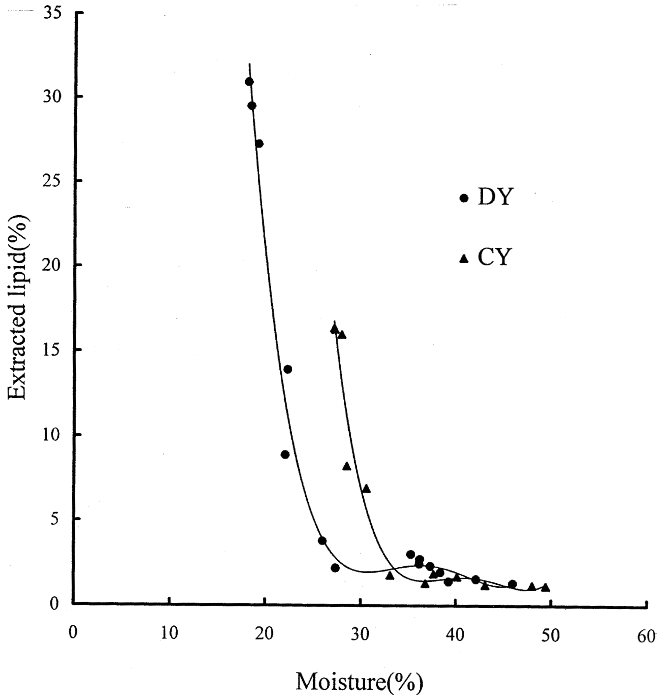

Fig. 5—Extracted lipid as a function of moisture content. (DY =duck egg yolk; CY = chicken egg yolk).

interior yolk (Chang et al., 1977; Woodward and Cotterill, 1987b), thus, no subdroplets were observed in CYE.

CONCLUSION

PICKLING APPEARED TO CAUSE MOISTURE REMOVAL FROM EY AND the diffusion of salt into EW and EY. This suggested that the time for pickling could be shortened after the separation of EY and EW. But the yolk spheres should be retained to result in a gritty texture. Thus, the cost of producing salted EY could be reduced. In addition, the EW would retain its original characteristics and could be used as a by-product, diminishing the waste problems from salted EW.

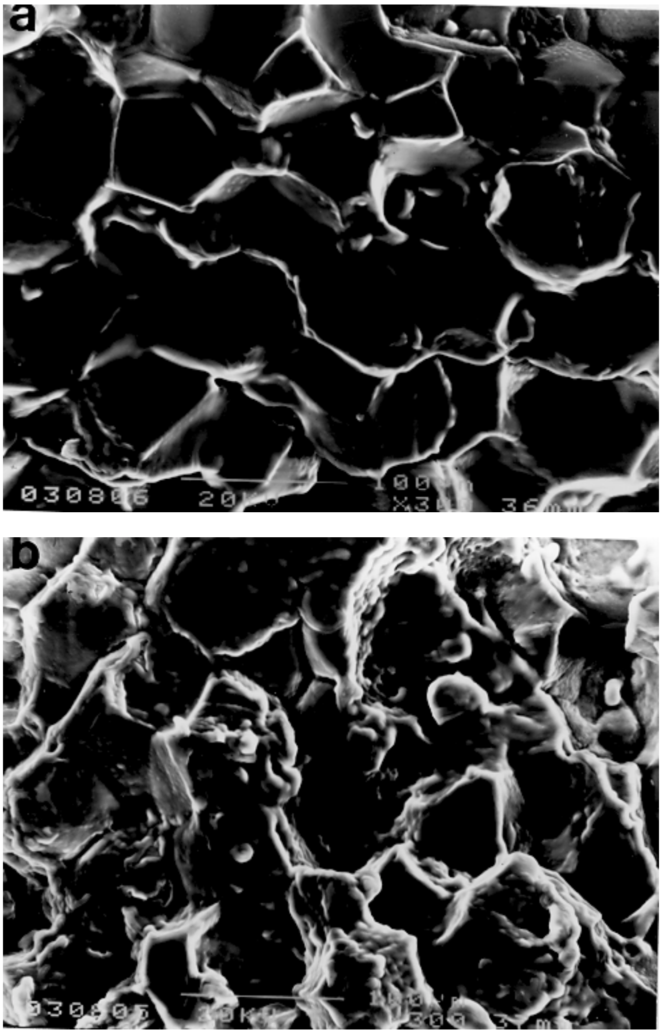

Fig. 6—Scanning electron micrograph of salted chicken egg yolk. (a) exterior yolk, (b) interior yolk.

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