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Functional Properties of the Microcrystalline Collagen Manufactured from Raw Pigskins

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Abstract

Microcrystalline collagen was manufactured from raw pigskins and its functional properties were measured. It showed a thixotropic behavior. The maximum viscosity was obtained at pH 3.5 and the viscosity increased with the increase of concentration in a nonlinear manner. The increase in temperature decreadsed the viscosity while the effect of temperature was greater at pH below 4.5. Foaming capacity was similar to that of gelatin but superior to that of egg white at 1%. The foam stability was inferior to that of egg white. Emulsifying capacity was lower than that of pork. Values from physical and chemical analysis were somewhat different from those of medical-grade microcrystalline collagen made from bovine corium collagen.

Introduction

Collagen is the major fibrous element of the connective tissues and the most abundant single protein in the body, representing up to 20-25% of the total protein[1]. Therefore, it is one of the most intensively studied proteins. These studies offer almost complete information on structure, polymerization, interaction of collagen with other molecules, reaction of collagen in polar and apolar media, and the effect of drugs, salts, etc. on its structure and properties[2].

Battista [3] stated, "Nature has produced in collagen a polymer architecture of remarkable sophistication, an 'engineering' achievement that qualifies collagen for a role of far greater versatility and complexity than any other known man-made or natural high molecular-weight polymer". Because of its unique structural characteristics, collagen possesses many potential functional properties not only in various food systems but in many other industrial applications under appropriate conditions[4]. There have been extensive reviews[1,5,6] on industrial uses of collagen sch as leather, gelatin, medical and surgical aplications, cosmetic and nutritional applications. On the other hand, except the manufacture of sausage casings, food use of collagen has been limited to comminuted clollagen[7,8,9].

Microcrystalline collagen is a unique form of collagen which is made by converting the native bovine corium collagen through mechanical disintegration in the presence of acids into discrete colloidal fragments(3). It has been reported to have a wide range of applications on medical and surgical uses[10,11,12,13], Pharmaceuticals (14.15)

However, the scientific data on functional properties of microcrystalline collagens are insufficient. Therefore, a study was carried out on physicochemical properties of the microcrystalline collagen made from raw pigskins as a possible food additive.

Materials and Methods

Preparation of the microcrystalline collagen

Raw pigskins were purchased from a local market and washed extensively with tap water to remove any foreign materials. Microcrystalline collagen was manufactured as shown in Fig. 1. Details of the process are described in Lee and Kim[20]

Preparation of microcrystalline collagen gel

Suspensoids of the desired concentration were prepared by attriting microcrystalline collagen fibers in distilled water for 2.5 min in a Waring Blendor. During attrition, the temperature of the mixture was maintained at 25°C by surrounding the jar with a plastic bag partially filled with dry ice[3].

Viscosity

Viscosity of 1% microcrystalline collagen suspensoids was measured within 5 min at 25°C on LV Brookfield Viscometer (Brookfield Engineering Lab Inc., U.S.A.) using 4-spindle at 6 r.p.m. Shear rate and shear stress were measured at 25°C on a Hakke Rotovisco RV2 Viscometer (Schmit Co., Germany) using MV III-spindle.

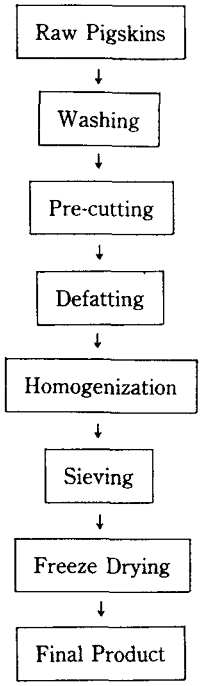

Fig. 1. Flow diagram for the production of microcrystalline collagen from pigskins

Emulsifying capacity, foaming capacity and foam stability

Emulsifying capacity was measured according to the method of Sung and Lee[21]. The measurements of foaming capacity and foam stability were made as described by Regenstein[22].

Water-holding capacity

Microcrystalline collagen(5.0*g*) was added to 75 *ml* distilled water in a 100 *ml* centrifuge bottle. After an hour of agitation, the measurement was carried out as outlined by Yamazaki[23].

pI

The measurement of pI was carried out according to the description by Wainewright[24] with the following modifications.

0.01% microcrystalline collagen solutions were prepared to have a 0.1 pH unit increment from pH 4.0 to 8.0. The absorbances of solutions were measured at 215 nm on UVIDEC-610 Double-beam Spectrophotometer (Jasco, Japan). pI was designated as the pH that had the highest absorbance.

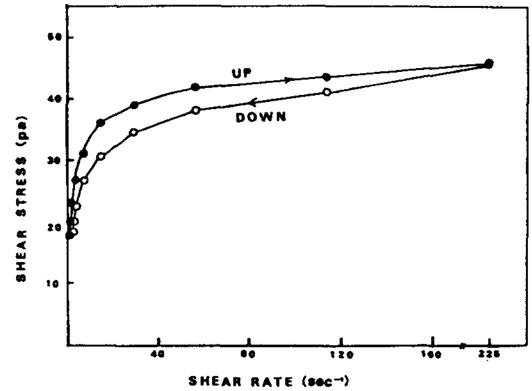

Fig. 2. Shear stress versus shear rate plots for 1% microcrystalline collagen solution at 25°C

Proximate analysis

Chemical analysis was made by AOAC[25] methods.

Results and Discussion

Viscosity

Figure. 2 shows that the microcrystalline collagen gel is a mixed type fluid. Many of the food materials fall into the mixed type having some pseudoplastic characteristics with a yield value[26]. Mixed type fluids are usually thick solution with suspended particles of irregular shape. Foods showing this characteristics are sandwich spread, jelly and marmalade. Figure 2 also suggests that it is a thixotropic fluid that shows a hysterisis loop where the curve on the way down lies below the curve on the way up[27].

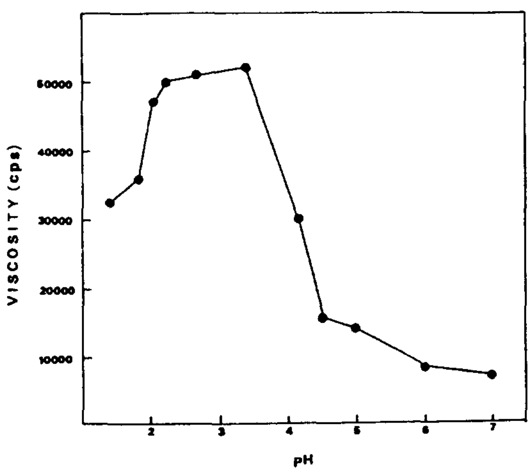

Fig. 3. Viscosity of 1% microcrystalline collagen at 25°C as a function of pH

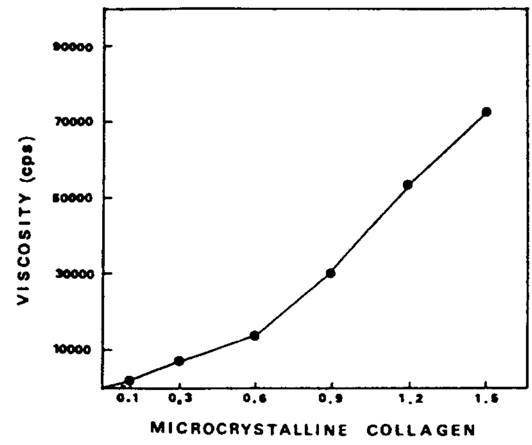

Fig. 4. Viscosity of microcrystalline collagen solutions as a function of concentration at 25°C

Viscosity of a fluid can be affected by various parameters such as pH, concentration, temperature and molecular weight[28]. The effect of pH on the viscosity of microcrystalline collagen gel is described in Figure 3. Viscosity increased continuously from pH 1.5 to 3.5, and then decreased sharply upto pH 4.5 and thereafter slowly, giving the highest value at pH 3.5. The result could be explained by the phenomenon that collagen fibrils in aqueous dispersions seem to collapse to the unswollen state, freeing water and reaggregating into a ropy, fibrous mass in the 4.3-8.5 pH range[29].

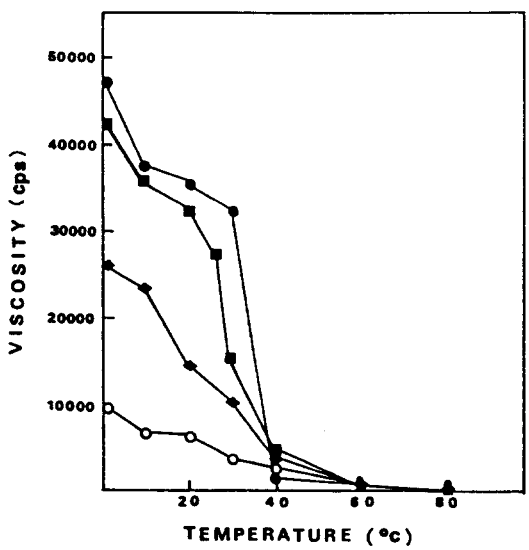

Fig. 5. Viscosity as a function of temperature for 1% microcrystalline collagen at four pH; pH 3.75 (●), pH 1.6(■), pH 4.5 (◆), pH 7.0 (o)

Figure 4 illustrates that the viscosity increased with the increase of concentration but not in a linear manner. Above the concentration of 1.5%, it was almost impossible to measure the viscosity of the gel with commercial viscometers. There is usually a direct nonlinear relationship between the concentration of a solute and viscosity at constant temperature[27]. The effect of temperature on the viscosity is shown in Figure 5. With the increase of temperature, the viscosity decreased regardless of pH. However, the effect of temperature was greater at pH below 4.5 It has been reported that there is an inverse relationship between viscosity and temperature[27]. Its viscosity building properties are greater than gelatin, therefore, microcrystalline collagen can improve various physical properties of foodstuffs such as eating quality, appearance and tactual, visual and taste textures[3]. It has a substantially stable viscosity over a long period without a gradual increase in viscosity and setting into a gummy mass as occurs with gelatin[15].

Foaming capacity and foam stability

Table 1 provides foaming capacity and foam stability of the microcrystalline collagen at various concentrations. Foaming capacity was maximum at 1% which was identical to that of 1% gelatin solution and greater than that of egg white. However, foam stability was inferior to that of egg white. It was suggested that microcrystalline collagen could replace egg white in the preparation of meringue and gelatin for marshmallow[14,15].

Table 1. Foaming capacity and foam stability of microcrystalline collagen at various concentrations, egg white and 1% gelatin solution at pH 7

Material	Conc. (%)	Foaming capacity *(ml)*	Foam stability(%)	
			15 min	30 min
Microcrystalline collagen	0.1	15	0	0
	0.3	65	85	54
	0.6	185	16	11
	1.0	205	0	0
	1.4	135	0	0
	1.8	60	0	0
Egg white	as is	145	97	97
Gelatin	1.0	205	24	15

Emulsifying capacity

Emulsifying capacity of the microcrystalline collagen is shown in Table 2. At pH 3.75 which is its natural pH, it had about 55 ml of oil/g of emulsifying capacity while no emulsifying capacity was obtained at pH 7.0. It might show that the hydrophilic-hydrophobic balance of collagen and fatty constituents was influenced by pH of the medium[4]. Lean pork showed 60-80 ml of oil/g of emulsifying capacity at its natural pH values (5.55-6.15) with or without salt[21].

Even though microcrystalline collagen did not show a good emulsifying capacity, it may act as an emulsion stabilizer by thickening and increasing the viscosity of the aqueous phase or by means of a protective colloid acting like gelatin and gum arabic[28]. Battista[14,15] reported that a mayonnaise type salad dressing and ice cream could be prepared with a very smooth texture, appearance and consistency using the microcrystalline collagen. Furthermore, it can be used in the preparation of meat products such as sausage and meat loaf[3].

Physical and chemical properties

Table 3 provides analytical data of the microcrystalline collagen. Compared with those of medical-grade microcrystalline collagen[3] made from bovine corium collagen, this product gives less water-holding capacity (27 vs 15), less water content (10 vs 4.5), more fat and ash content (< 0.3 vs 0.53; 0.03 vs 0.1) and higher pH (3.2 vs 3.75). pI falls into normal range of that for natural collagen (pH 5-7)[4].

Table 2. Emulsifying capacity of microcrystalline collagen at various concentrations

Conc. (%)	pH	Emulsifying capacity *(ml of oil)*
0.1	3.75	0
0.3	3.75	0
0.6	3.75	57.8
1.0	3.75	55.5
1.3	3.75	62.7
0.1	7.00	0
0.3	7.00	0
0.6	7.00	0
1.0	7.00	0
1.3	7.00	0

Table 3. Physical and chemical properties of microcrystalline collagen

Parameter	Typical value
Water-holding capacity ($g\ H_2O/g$)	15 ± 2
Moisture (%)	4.5 ± 2
Protein (%)	92.6 ± 2
Fat (%)	0.53 ± 0.2
Ash (%)	0.1 ± 0.02
pH at 25°C (1% aqueous gel)	3.75 ± 0.2
pI	6.7
Color	milky white
Form	fibrous
Odor	slight proteinaceous

In addition to its functional properties, considering the fact that it is bland in both taste and odor and has very little color and is free of textural defects, it can be successfully incorporated into various food system to control the texture, juiciness and organoleptic characteristics. It is especially useful to maintain a uniform dispersion of insoluble ingredients and thicken liquid foodstuffs. It is also well suited as an inexpensive replacement for egg white and gelatin in various types of food products because of its capability of producting the same effect at lower concentration[3].

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생돈피에서 제조된 미세결정성 콜라겐의 기능적 성질

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생돈피를 원료로 하여 제조한 미세결정성 콜라겐의 기능적성질을 측정하였다. 미세결정성 콜라겐겔은 딕소트로픽 유체였으며 pH 3.5에서 최대의 점도를 보였다. 점도는 겔 농도가 증가할수록 비선형으로 증가하였으며 온도가 증가할수록 감소하였고 온도의 영향은 pH 4.5이하에서 더 컸다. 거품형성용량은 젤라틴과 비슷하였으나 난백보다는 좋았다. 그러나 거품안정성은 난백에 비해 떨어졌다. 유화용량은 돈육에 비해 열등하였다. 물리화학적 분석치는 우피의 진피층을 원료로 한 의약용 미세결정성 콜라겐의 것과 약간 달랐다.