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Physico-chemical and Textural Properties of Gelatins and Water Gel Desserts Prepared from the Skin of Freshwater Carps

George Ninan*[1], A.A. Zynudheen[1] and Jose Joseph[2]
[1]*Central Institute of Fisheries Technology, P.O. Matsyapuri, Cochin - 682 029, India*
[2] *Kalekattil, P.O. Kakkanad West, Cochin - 682 030, India*

The physico-chemical properties of fish skin gelatins extracted from cultured freshwater carps *viz.*, rohu, common carp and grass carp, were investigated and compared with commercial food grade mammalian skin gelatins. Water gel desserts prepared from these gelatins were analysed for physical properties and texture profile. Among the fish skin gelatins, grass carp skin gelatin had the highest gel strength of 230 Bloom followed by rohu skin gelatin (188 Bloom) and common carp skin gelatin (181 Bloom). The melting point of fish skin gelatins was in the range of 28.13 – 29.10°C which was found to be higher than that reported for gelatin from many other species of fish. Carp skin gelatin desserts had significantly lower melting point than the mammalian skin gelatin desserts which can help in better flavour release in dessert preparations. Grass carp skin and bovine skin gelatin desserts had similar gel strength, cohesiveness and springiness. Carp skin gelatin desserts had less off odour compared to mammalian skin gelatin desserts.

Key Words: Gelatin, carp skin, mammalian skin, water gel desserts, physico-chemical properties, gel strength.

In India, carps contribute almost 85% of the harvest from freshwater aquaculture. Rohu (*Labeo rohita*), common carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) are important species of cultured freshwater carps in India. The skin constitute about 6 - 7% of the processing waste from these fishes which is a good source of gelatin and a gelatin yield of 10.5 – 12.9% is obtained from the skin of these species (Ninan *et al.*, 2009). Previous studies ascertained freshwater fish to have contain vast amounts of waste after removal of useful edible parts and high gelatin yield can be expected from them (Grossman & Bergman, 1992; Jamilah & Harvinder, 2002; Muyonga *et al.*, 2004). Additionally, most findings suggest that gelatin from these species has an advantage over those extracted from cold water species, providing better rheological properties nearly similar to mammalian gelatins (Veis, 1964; Gilsenan & Ross-Murphy, 2000; Cho *et al.*, 2005).

One of the most important applications of gelatin in food product development is in the preparation of water gel desserts. Gelatin desserts consist of mixtures of gelatin powder, sweetener, water and appropriate flavours and colours with a balancing pH. Although gel strength is one of the important commercial quality criteria for gelatin desserts, this parameter may not represent all the textural properties encountered during the consumption of the product. Gelatin desserts made from various gelatins may differ in textural and gel melting properties, offering new product development opportunities. Water gel desserts prepared from Alaska pollock and tilapia skin gelatin had

* Corresponding author; e-mail: george66jiji@rediffmail.com

lower melting points than pork skin gelatin which accelerate better flavour release from the gel (Zhou & Regenstein, 2007).

The objectives of the present work were to compare the physico-chemical properties of carp skin gelatins with those of mammalian skin gelatins and to study the physical properties and texture profile of water gel desserts prepared from the fish and mammalian skin gelatins.

Materials and Methods

Cultured fresh water fishes *viz.*, rohu (*Labeo rohita*), common carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) were procured from a local fish farm and brought to the laboratory in iced condition. For the separation of skin, the procedure described by Ninan *et al.* (2009) was followed. Gelatin was extracted from the skin by adopting the procedure outlined by Jamilah & Harvinder (2002). Rohu, common carp and grass carp skin gelatins were designated as RG, CG and GG respectively. Two commercial food grade mammalian gelatins *viz.*, high bloom pork skin gelatin of 300 Bloom (PG) and bovine skin gelatin of 225 Bloom (BG) from Sigma, USA (Sigma-Aldrich Inc., St. Louis, MO - 63103) were used along with fish skin gelatins in the formulation and comparison of water gel desserts.

Water gel desserts were prepared by dissolving gelatins (3% w/v) in a flavoured orange drink (prepared from orange flavour instant drink mix, Kraft Foods Ltd., Thailand) at 45°C (Zhou & Regenstein, 2007). The dehydrated powder of orange drink was mixed with the required quantity of water and sugar as per directions in the label for the preparation of soft drink. The soft drink thus prepared was warmed to 45°C, and the gelatin was dissolved in it. The composition of desserts is given in Table 1. The final pH was adjusted to 3.8, 3.7, 3.6, 3.7 and 3.7 for BG, PG, RG, CG and GG respectively. The solutions were poured separately into standard bloom jars (112.5 g) for gel strength determination and cylindrical plastic molds (30 mm dia x 40 mm) for texture profile analyses. All samples were matured at 2 - 4°C for 22 - 24 h before the measurements were made.

Table 1. General composition of water gel desserts

Ingredients	% composition
Gelatin (g)	3.0
Water (g)*	87.0
Sugar (g)*	9.0
Others (g)*	<1.0

*The amount of water and sugar are calculated based on the ingredient label of the flavoured orange drink. The word "others" is based on the ingredient label of the flavoured orange drink, and refers to those compounds providing appropriate orange flavour and colour, and are used to balance the pH

Gelatin solutions at a concentration of 6.67% (w/w) were prepared by dissolving the dry powder in distilled water and heating at 60°C for the determination of viscosity. The viscosity (cP) of 10 ml of the solution was determined using Brookfield digital viscometer (Model DV E Brookfield Engineering, USA) equipped with a No.1 spindle at 30 ± 0.5°C (Cho *et al.*, 2006). pH of the gelatin and dessert samples was measured using a Cyberscan 510 pH meter (BS 757, 1975). Melting point was determined as described by Wainewright (1977). For gel strength determination of gelatin samples, a 6.67% (w/w) gelatin solution was prepared in bloom bottles (Schott Duran, Germany) at 60°C, cooled and kept at 10°C for 17 h for maturation (BS 757: 1975). The resulting gel was tested using a Lloyd texture analyzer

(Model LRX Plus, UK). In the case of dessert samples 3% (w/w) gelatin was used for gel strength determination. Colour analysis of powdered gelatin was performed with a Hunter lab Miniscan ® XE plus spectrocolorimeter (Hunter Associates Laboratory, Inc. Reston, Virginia, USA). Measurements were recorded using the L* a* b* colour scale (CIE, 1986). The CIELAB is a uniform colour scale where the difference between the points plotted in the colour space corresponds to the visual differences between the colours plotted. The three coordinates L* a* b* represent the lightness of the colour of the sample *viz.*, L* = 0 yields black and L* = 100 indicates diffuse white, negative values for a* indicate green while positive values indicate red, negative values for b* indicate blue and positive values indicate yellow.

Sensory evaluation of gelatin solutions was conducted by a seven member panel as per the method described by Muyonga *et al.* (2004). The samples were prepared by dissolving 0.5 g gelatin in 7 ml distilled water, to obtain a solution containing approximately 6.67% (w/w) gelatin. The samples were held in a water bath at 50°C for 15 minutes with the screw caps lightly closed, after which the panelists were instructed to remove the screw caps, sniff the contents, identify the odour they perceived and indicate the odour intensity using a five point scale (0 = no odour, 1 = very mild and only perceivable on careful assessment, 2 = mild but easily perceivable, 3 = strong but not offensive, 4 = strong and offensive, 5 = very strong and very offensive). Similarly, sensory evaluation of gel dessert samples were also carried out.

Texture Profile Analysis (TPA) of gel dessert samples was carried out by the method of Muyonga *et al.* (2004) using a Lloyds texture analyzer (Lloyd Instruments, Model LRX Plus, U.K) with slight modification. The samples were set in cylindrical plastic molds (30 mm dia x 40 mm) at 2 – 4°C for 22 – 24 h. Before testing, the set samples were equilibrated at 25°C for 30 min and were removed from the plastic molds. Sections of 20 mm length were cut off and tested by imparting a 50% strain, double compression, using 75 mm diameter cylindrical probe. Pre-test, test and post-test speed were set at 1 mm s^{-1} and trigger force at 5 g. Hardness, springiness, cohesiveness, chewiness, gumminess and adhesiveness were determined as described by Pye (1996). Textural parameters were calculated from the TPA curve and the results were tabulated using Nexygen Software.

Results were expressed as mean ± SD of triplicate analyses of samples. Statistical analysis between the means using ANOVA and Duncan's Multiple Range test was carried out to test the significance of variance. Statistical package used in the study was SPSS 10.

Results and Discussion

The physico–chemical properties of gelatins are given in Table 2. Grass carp skin gelatin had significantly higher bloom ($p < 0.05$) than the other two fish skin gelatins and comparable bloom to that of bovine skin gelatin. The gelatins from common carp skin and rohu skin had gel strengths of 181.3 and 188.63 Bloom respectively which is comparable to gel strengths of skin gelatin from tropical fish species (Jamilah & Harvinder, 2002; Muyonga *et al.*, 2004; Cheow *et al.*, 2007). The viscosity for the fish skin gelatin samples was in the range of 5.96 – 7.07 and was significantly higher ($p < 0.05$) for grass carp gelatin followed by rohu and common

carp gelatins. Significant differences were observed in the melting temperatures of all the gelatin samples. The melting points of skin gelatins of rohu, grass carp and common carp were higher than that reported for many other species like cod (Gudmundsson & Hafsteinsson, 1997); yellow fin tuna (Cho *et al.*, 2005); Nile perch skin and bone gelatin (Muyonga *et al.*, 2004) and tilapia skin (Jamilah & Harvinder 2002). pH of grass carp skin gelatin was significantly higher ($p < 0.05$) than the other fish and bovine skin gelatins.

The odour scores (Table 2) were significantly higher ($p < 0.05$) for bovine and porcine skin gelatins (3.1 – 3.12) than carp skin gelatins, indicating that they had a distinguishable odour and hence can be considered as inferior to fish skin gelatins in organoleptic qualities. This agrees with the report of Choi & Regenstein (2000) that fish gelatins had less off odour and better aroma than pork gelatins on sensory evaluation.

Instrumental colour measurements of gelatin powders are shown in Table 2. The gelatins from the skin of rohu, grass carp and pork had a snowy white appearance and were light-textured. Lightness (L*) value was the highest for grass carp gelatin (92.53). Common carp and bovine skin gelatin showed significantly lower value ($p < 0.05$) for 'L* than the other two gelatin samples. The a* values for the mammalian and carp skin gelatin samples showed negative values indicating a shift of colour towards green and it was significantly higher for common carp (- 0.41) and bovine skin gelatin (- 0.45). The b* values were positive indicating the degree of yellowness. Common carp and bovine skin gelatin had significantly low b* values (1.82 & 1.75 respectively) than the other samples. Having high L* values could be a positive attribute for carp skin gelatins, since it is easier to incorporate these gelatins into any food system without imparting any strong colour to the product.

The gel strengths, melting point and the odour of the desserts are given in Table 3. The gel strengths of the desserts correspond to the gel strength of the gelatin used. The highest bloom was observed for pork skin gelatin based dessert (PGD), followed by bovine skin (BGD), grass carp (GGD), rohu

Table 2. Physico-chemical properties of gelatins*

Parameters	RG	CG	GG	BG	PG
Gel strength (Bloom)	188.63 ±2.64^a	181.31±2.08^b	230.18±2.88^c	228.08± 3.13^c	296.7± 4.11^d
Viscosity (cP)	6.06 ± 0.04^a	5.96 ± 0.12^a	7.07 ± 0.10^b	7.05 ± 0.12^b	10.09 ± 0.12^c
Melting Temp. (^{0}C)	28.13 ±0.05^a	28.27± 0.05^b	29.1± 0.08^c	31.01± 0.03^d	32.2± 0.06^e
pH	4.08 ± 0.04^a	4.05± 0.06^a	4.42 ± 0.04^b	4.01± 0.04^a	4.88 ± 0.03^c
Odour score	2.30 ± 0.12	2.40 ± 0.11	2.4 ± 0.10	3.1± 0.12^a	3.12 ± 0.11^a
Colour L*	91.89 ± 0.62	90.15 ±0.64^a	92.53 ±0.63	90.10 ±0.36^a	91.65 ± 0.71
a*	-0.35 ± 0.02	-0.41 ± 0.03^a	-0.36 ± 0.02	-0.45 ± 0.02^a	-0.33 ± 0.04
b*	2.76 ± 0.21	1.82 ± 0.45^a	2.70 ± 0.22	1.75 ± 0.22^a	2.68 ± 0.21

RG = Rohu Gelatin; CG = Common Carp Gelatin; GG = Grass carp Gelatin; PG = High bloom Pork skin Gelatin; BG = Bovine skin Gelatin

*All values are mean ± standard deviation of triplicate analyses. Different superscripts in the same row indicate significant differences ($p < 0.05$).

(RGD) and common carp skin gelatin desserts (CGD) in that order. CGD and RGD had similar gel strength. No significant difference in gel strength was observed between GGD and BGD. Melting points of the fish skin gelatin desserts were significantly lower ($p < 0.05$) than mammalian skin gelatin desserts. The lower melting point of the fish gelatin helps in better flavour release in dessert preparations. Ferry (1948) observed that the gel strength was almost squarely proportional to the concentration of the gelatin. Nijenhuis (1981) reported that gel strength of the gel decreased linearly with increasing maturation temperature and melting point in contrast, increased with increasing maturation temperature; and similar pattern was observed for fish and mammalian gelatins. However, melting points of the desserts were lower than that of corresponding gelatins (Table 2) which could be due to the influence of pH.

The gelatin water desserts prepared had a pH in the range of 3.6 to 3.8 which could also be the reason for low gel strength of the desserts. Choi & Regenstein (2000) observed that the gel strength of the gelatins decreased markedly below pH 4. The melting point of the gelatin can have a marked drop below pH 4 which may be the reason for the low melting points of desserts (Crumper & Alexander, 1954; Choi & Regenstein, 2000). The gel strength and melting point of the gelatin water dessert preparations can be influenced by other ingredients used in the formulation of desserts.

Fish skin gelatin had a mild, barely detectable odour (1.5 – 1.6), while the odour of desserts made from mammalian gelatin was easily detectable (2.1 - 2.3), though not offensive (Table 3). In all the dessert samples, the flavour of the soft drink used in the formulation was predominating. Similarly Choi & Regenstein (2000) observed that flavoured fish gelatin dessert had less undesirable off-flavour and off-odour than pork skin based gelatin dessert.

Texture profile of the dessert samples is given in Table 4. The hardness of the desserts was significantly different ($p < 0.05$). The maximum hardness was noticed for PGD, followed by BGD and fish skin gelatin desserts. The minimum hardness was observed for common carp skin gelatin dessert. The hardness is dependent on the gel strength and pork skin gelatin dessert showed maximum hardness. In desserts prepared from Alaska pollock, tilapia and pork skin gelatins, hardness correlated well

Table 3. Gel strength, melting point and odour of gelatin water desserts*

Types of desserts	Gel strength (Bloom)	Melting point (^{0} C)	Odour score
CGD	28.71 ±1.06^a	27.10 ± 0.08^a	1.5 ± 0.27
RGD	30.51 ±1.24^a	27.21 ± 0.05^b	1.6 ± 0.15
GGD	45.96 ±0.91^b	28.73 ± 0.11^c	1.6 ± 0.13
BGD	46.70 ±1.59^b	30.41± 0.14^d	2.1 ± 0.22^a
PGD	67.63 ±1.13^c	31.30 ± 0.11^e	2.3 ± 0.28^a

BGD =Bovine Skin Gelatin Dessert; PGD = Porcine Skin Gelatin Dessert; RGD = Rohu Skin Gelatin Dessert; CGD = Common Carp Skin Gelatin Dessert; GGD = Grass Carp Skin Gelatin dessert

*All values are mean ± standard deviation of triplicate analyses. Different superscripts in the same column indicate significant differences ($p < 0.05$).

Table 4. Texture profile of gelatin water desserts*

Types of desserts	Hardness (gf)	Cohesiveness	Gumminess (gf)	Springiness (mm)	Chewiness (gf.mm)	Adhesive force (gf)
CGD	231.29 ± 12.7^{a}	0.38 ± 0.05^{a}	87.66 ± 13.9^{a}	4.00 ± 0.14^{a}	350.61 ± 0.03^{a}	10.06 ± 0.55^{a}
RGD	296.98 ± 9.3^{b}	0.39 ± 0.02^{a}	115.71 ± 7.8^{b}	4.65 ± 0.14^{b}	538.01 ± 0.02^{b}	11.89 ± 0.62^{b}
GGD	536.56 ± 14.8^{c}	0.61 ± 0.04^{b}	327.12 ± 24.3^{c}	6.21 ± 0.26^{c}	2031.41 ± 0.28^{c}	20.16 ± 0.90^{c}
BGD	769.35 ± 17.1^{d}	0.60 ± 0.03^{b}	461.53 ± 15.5^{d}	6.69 ± 0.32^{c}	3087.51 ± 0.19^{d}	26.25 ± 0.80^{d}
PGD	1021.73 ± 21.7^{e}	0.67 ± 0.05^{b}	684.16 ± 9.9^{e}	7.17 ± 0.4^{cd}	4905.41 ± 0.13^{e}	39.24 ± 1.04^{e}

BGD =Bovine Skin Gelatin Dessert; PGD = Porcine Skin Gelatin Dessert; RGD = Rohu Skin Gelatin Dessert; CGD = Common Carp Skin Gelatin Dessert; GGD = Grass Carp Skin Gelatin dessert

*All values are mean ± standard deviation of triplicate analyses. Different superscripts in the same column indicate significant differences ($p < 0.05$).

with gel strength (Zhou & Regenstein 2007). Cohesiveness is a measurement of the degree of difficulty in breaking down the gel's internal structure. In this study, the desserts prepared from grass carp skin gelatin and mammalian gelatin showed significantly high ($p < 0.05$) values for cohesiveness which indicate the high degree of elasticity than the other two fish skin gelatin desserts. Cohesiveness reported for desserts prepared from Alaska pollock and tilapia skin was 0.9 and 0.93 respectively, indicating a very high elastic gel (Zhou & Regenstein 2007). Gumminess was found to be significantly higher for mammalian skin gelatin desserts when compared to fish skin gelatin desserts ($p < 0.05$). Significantly higher values ($p < 0.05$) for springiness were observed for mammalian and grass carp skin gelatins. High springiness results from the gel structure being broken into a few large pieces during the first TPA compression (Lau *et al.*, 2000) which is not a desirable traint for soft gel desserts. Grass carp skin and mammalian skin gelatin desserts had significantly higher chewiness and adhesiveness than common carp and rohu skin gelatin based desserts ($p < 0.05$). This implies that soft textured desserts can be made from common carp and rohu skin gelatin.

Among the gelatins extracted from cultured freshwater carps, grass carp skin gelatin showed high gel strength, viscosity and melting point; and was comparable to that of food grade bovine skin gelatin. Grass carp skin gelatin based desserts had comparable physical and mechanical properties with that of desserts prepared from mammalian skin gelatin. The fishy odour was not prominent in fish gelatin based desserts. In mammalian gelatin based desserts, the characteristic odour was easily detectable. Hence, the fish gelatin based desserts were rated high in organoleptic evaluation. The information on the physical and texture properties of fish skin based gelatin desserts will be particularly useful in formulating kosher and halal gelatin desserts, and for applications to add more textural variety to commercial gelatin desserts.

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