# The effect of replacement of cow's gelatin by *Cyprinus carpio* skin gelatin on the some mineral contents and color parameters of functional pastill

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## Abstract

Gelatin is a valuable protein source and a commercial hydrocolloid which is particularly applied for food, pharmaceutical, and photographic industries. Commercial gelatin is basically from pig and cow, which because of religious reasons and risk of transmission of *Bovine* spongiform encephalopathy (BSE) respectively, not acceptable to use. Therefore gelatin extraction from fish, and especially it's waste has considerable importance. In the present study, after the extraction of gelatin from economic fish skin of carp (*Cyprinus carpio*), various formulations of this gelatin with cow's gelatin have been used in ratios of 0, 25, 50, 75 and 100% to pastill production. Then, the physicochemical experiments include of ash, protein, moisture, iron, phosphorus, zinc and lithium content, and color measurement were done on one day after of pastill production. The results showed that the treatment based on 75% fish gelatin had the highest moisture, protein, phosphorus, iron, ash and zinc content ($p<0.05$) while the highest level of potassium and lithium content was related to treatment based on 100% industrial gelatin (Cow's) ($p<0.05$). Industrial treatment showed the highest $L^*$ value (lightness) and the lowest index $a^*$ (green–red) and $b^*$ (blue–yellow) value ($p<0.05$). It can be concluded that useless waste of fish as halal gelatin can be a good substitute instead of other gelatin for children's favorite junk foods, which has higher levels of zinc and protein content with economical benefits.

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## Introduction

Gelatin is a transparent and tasteless protein source and has a rheological property of thermo-reversible transformation between sol and gel which has been widely applied in food products, pharmaceutical, and photographic industries (Cho, Kwak, Park, Gu, Ji & Jang, 2004). It's applications in food products are very broad including improving elasticity, consistency and stability of product. Gelatin is also applied as a thickening agent, certainly in dairy products (Giménez, B., Gómez-Guillén & Montero 2005).

Gelatin is used in food formulation as foam and texture stabilizer and improve the water holding capacity and fat reduction (Nishimoto, Sakamoto, Mizuta & Yoshinaka 2005, Karim & Bhat 2009). Gelatin protein is obtained from collagen hydrolysis of animal skin or bone such as beef bone, hide, pig skin and more recently, pig bone and produced through thermal denaturation or collagen partial degradation of animal skin and bone (Hao, Li, Yang, Cen, Shi, Bo & He 2009). The gel strength, viscosity, setting behaviour and melting point of gelatin depend on their molecular weight distribution and the amino acid composition, the imino acids proline and hydroxyproline are important in the renaturation of gelatin subunits during gelling (Mariod & Adam 2013). Muslims refuse to consume all pig related products because of religious concerns and also they prohibite to consume of all cow-related products because of risk potential of transmission of bovine spongiform encephalopathy disease (BSE) that has long incubation period and the disease affects the nervous system of human. The fish processing industries generated a large amounts of waste which can be used in gelatin production due to low prices of them (Giménez *et al.*, 2005). Some information was reported on gelatin processing through extraction and gelatin characteristic of skin and bone from cod (Gudmundsson & Hafsteinsson 1997), black tilapia (*Oreochromis mossambicus*) and red tilapia (*Oreochromis niloticus*) (Bakar & Harvinder 2002; Bakar, Tan, Hartina & Ahmad 2011), hake (Montero, Borderıas, Turnay, and Lizarbe 1990), sin croaker (*Johnius dussumieri*), lumpfish (Osborne, Voigt, Hall 1990), megrim (Montero and Gomez-Guillen 2000) and shortfin scad (*Decapterus macrosoma)* (Cheow, Sarbon, Kyaw & Howell 2007), grouper (*Epinephelus sexfasciatus*), yellow streaked snapper (*Lutjanus lemniscatus*), mackerel (*Rastrelliger kanagurta*), and sand bass (*Morone chrysops*) (Irwandi, Faridayanti, Mohamed, Hamzah, Torla & Che Man 2009).

The purpose of this investigation was to determine the chemical composition of functional pastill in terms of mineral elements and color parameters, and to establish the relationships between industrial (cow) and fish gelatin skin.

## Materials and Methods

### Fish samples

The fish samples were obtained from Karaj fish market and transferred to Science and

Technology Park Laboratory (Karaj, Alborz province) under appropriate temperature conditions. After entering the laboratory, frozen skins was washed with cold water immediately. Fish meat was removed using a knife. After washing, the skin was cleaned with cold water, then frozen again at -20 °C and stored for further use. Then the frozen skin was cut into small pieces (about 2-3 centimeters square) while still frozen and were kept in a refrigerator (4 °C).

**Fish gelatin**

All gelatin manufacturing processes consist of three main stages: pretreatment of the raw material, extraction of the gelatin, and purification and drying. Depending on the method in which the collagens are pretreated, two different types of gelatin can be produced. Type A gelatin (isoelectric point at pH = 6–9) is produced from acid-treated collagen, and type B gelatin (isoelectric point at approximately pH = 5) is produced from alkali-treated collagen. Acidic treatment is most suitable for the less covalently crosslinked collagens found in pig or fish skins, while alkaline treatment is suitable for the more complex collagens found in bovine hides (Stainsby 1987). It should be noted that 1% guar gum as stabilizer was used.

**Sample preparations**

The gelatin extraction procedure followed was essentially as described by Grossman and Bergman (1992) with a little modifications. The cleaned and drained fish skins were given a pretreatment with an alkaline solution followed by an acid solution. Cleaned skins were taken in conical flask and treated with different concentrations of sodium hydroxide (1:6 w/v) for variable times. The samples were then rinsed with tap water and drained using cheesecloth. The above treatment was repeated for 2 times. The samples were treated with different concentrations of sulphuric acid (1:6 w/v) for variable times. The samples were then rinsed with tap water and drained using cheesecloth. The acid treatment was also repeated two times. The treated samples were squeezed manually using cheesecloth to remove excess water prior to the extraction. The pretreated fish skins were taken in flasks for gelatin extraction with varying volumes of deionized water, extraction time and temperature. The flasks were covered with parafilm and the extraction was carried out in a water bath. Finally, the gelatin solutions were filtered through 4 layers of cheesecloth, and dried prior to further work (Mostafa, Shaltoit, Abdallah & Osheba 2015).

**Pastill preparsion by gelatin**

To produce 100 grams of pastill, at first, gelatin was dissolved in distilled water (twice the gelatin weight) using a magnetic mixer at 60°C and to remove the air bubbles and clarification, the resulting mixture was placed in a hot water bath (70 °C) (Abbasi, Mohammadi & Rahimi 2011). At the next stage, glucose syrup (15 g), monohydrated dextrose powder (15 g) and sugar (35 g) with a few drops of distilled water was used to prepare sugar syrup. The mixture was heated to 120 °C and sugar syrup was prepared with brix % 80. The sugar syrup was added to the gelatin solution after the temperature was reduced and the resulting mixture was placed in a warm bath (70 °C) to remove the air bubbles completely. Then, to reach pH = 3, citric acid (1.5 g) was added and mix slowly to prevent the entering the air bubbles (Demars *et al.* 2001). After mixing, a gelatin-sugar solution was poured into the mould and after being exposed to the oven (37 °C/24 h), it was exposed to ambient temperature for 24 h and then removed from the mould. The properties of the treatments are presented in Table 1.

**Table 1.** The characteristics of the treatments

| Treatment | Cow's Gelatin | Fish gelatin |
|---|---|---|
| S100 | 100 | 0 |
| S75 | 75 | 25 |
| S50 | 50 | 50 |
| S25 | 25 | 75 |
| S0 | 0 | 100 |

## Physicochemical tests

### Moisture measurement

To determine the moisture content of the pastill, 10 g of each of the sample were placed in a glass plate, and then, transfered to the oven under a vacuum at 70°C and a pressure of 2.5 inches of mercury to reach a constant weight. After removing from the oven and weighting, moisture content based on wet weight was calculated from the equation 1, where $W_m$ and $W_o$ are sample weight, respectively, before and after the incubation (Tsami 1990).

(Equation 1) $$\text{Moisture (\%)} = W_m - W_o / W_m$$

### Protein measurement

In order to determine the protein content, the Kjeldahl method was used and three stages including digestion, distillation and titration were used. For this purpose, nitrogen content in the treatments was determined and then the protein content was obtained (ISIRI, NO.695).

### Potassium, iron and phosphorus measurement

The measurements of potassium, iron and phosphorus were carried out by atomic light spectroscopy according to National Iranian Standard No. 9266. Then, the elements content was measured in the prepared solutions (ISIRI, NO.9266).

### Ash measurement

A certain amount of sample was burnt in an electric furnace according to National Iranian Standard No. 2685 and the ash content was calculated (ISIRI, NO.2685).

### Color measurements

The color of the pastill samples was measured using a Hunter $L^*a^*b^*$ colorimeter (Hunter Lab, Color Flex, USA). The results were expressed in accordance with the CIELAB uniform color system in terms of $L^*$, lightness (values increase from 0 to 100%); $a^*$, redness to greenness (positive to negative values, respectively) and $b^*$, yellowness to blueness (positive to negative values, respectively). The measurements were done at 20 ± 5°C under constant light conditions and replicated 3 times (Khosravi Darani, Gholami & Gouveia 2017).

### Statistical analysis

Analysis of variance (ANOVA) was performed and means comparison was done using Duncan's multiple range tests for amino acid comparison between scales and gelatin data. Analysis was performed using SPSS ver. 24.0 for Windows (SPSS Inc., Chicago, IL, USA).

## Results

### Moisture content

According to Table 2, increasing the proportion of industrial (cow) gelatin, the moisture content (MC) of the samples decreased. The highest and lowest moisture content belonged to the treatment containing 100% fish gelatin and 100% industrial gelatin respectively. There was no significant difference between treatments with 75% gelatin content (p>0.05), but difference with other treatments was significant (Table 2).

**Table 2.** The average comparsion of moisture content of treatments

| Treatment | Moisture (%)* |
|---|---|
| S0 | 12.51 ± 0.90ᵃ |
| S25 | 11.46 ± 0.18ᵇ |
| S50 | 9.20 ± 0.16ᵈ |
| S75 | 9.83 ± 0.19ᶜ |
| S100 | 7.05 ± 0.19ᶜ |

*Means ± SD of triplicate determinations. Means with different superscript letters (a,b,…) show significant difference (p<0.05).

## Protein content

According to Table 3, the highest protein content was found in the formulation containing 75% fish gelatin, which had a significant difference with other treatments (p<0.05). The lowest protein content related to the treatment containing the equal level of two which showed a significant difference between the protein content of this treatment and other treatments (p<0.05). No significant difference was observed between treatments containing 100% fish gelatin, 100% and 75% industrial gelatin (p>0.05) (Table 3).

**Table 3.** The average comparsion of protein content of treatments

| Treatment | Protein (%)* |
|---|---|
| S0 | 81.35 ± 0.08ᵃᵇ |
| S25 | 82.39 ± 0.14ᵃ |
| S50 | 80.33 ± 0.20ᵇ |
| S75 | 81.08 ± 0.49ᵃᵇ |
| S100 | 81.20 ± 0.58ᵃᵇ |

*Means ± SD of triplicate determinations. Means with different superscript letters (a,b,…) show significant difference (p<0.05).

## Potassium content

Figure 1 shows the standard calibration curve of potassium which based on, the R-square ($R^2$) was 0.9067 (Fig 1). According to Table 4, treatment based on 100% industerial gelatin had the highest potassium content, which was not significantly different from treatment with equal levels of both types of gelatin (p>0.05), but it's difference with other treatments was quite significant (p<0.05). In general, a high proportion of industrial gelatin showed a higher potassium content (Table 4).

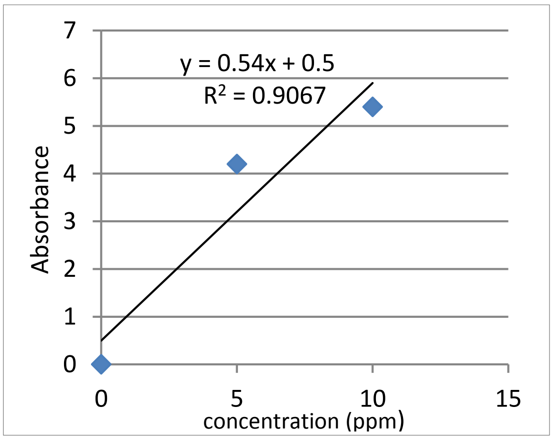


**Figure1.** The calibration curve of potassium standard

**Table 4.** The average comparsion of potassium content in treatments

| Treatment | Potassium (%)* |
|---|---|
| S0 | 0.27± 0.007ᵇ |
| S25 | 0.25 ± 0.004ᶜ |
| S50 | 0.28 ± 0.004ᵃ |
| S75 | 0.27 ± 0.004ᵇ |
| S100 | 0.29 ± 0.004ᵃ |

*Means ± SD of triplicate determinations. Means with different superscript letters (a,b,…) show significant difference (p<0.05).

## Phosphorus content

Figure 2 shows the standard calibration curve of phosphorus which based on the R-square ($R^2$) was 0.9407 (Fig 2). According to Table 5, by increasing the proportion of industrial gelatin from 25% to 100%, the phosphorus content decreased. The highest phosphorus content related to the treatment containing 75% fish gelatin which there was a significant difference between this treatment and other treatments (p<0.05).

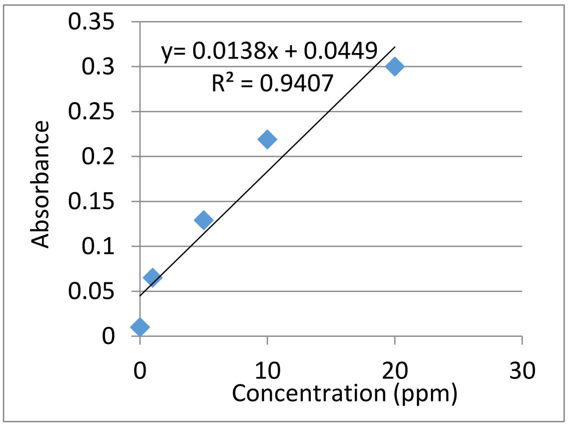


**Figure 2.** The calibration curve of phosphorus standard

In contrast, the lowest phosphorus content was related to 100% industrial gelatin, which did not differ significantly with treatment containing 75% of this gelatin (p>0.05), but it's difference with other treatments was significant (p<0.05) (Table 5). In present study, the highest phosphorus content belonged to the treatment containing 75% fish gelatin, which statistically showed a significant difference between this treatment and other treatments (p<0.05). In contrast, the lowest phosphorus content was related to 100% industrial gelatin, which did not differ significantly with treatment containing 75% of this type of gelatin (p>0.05).

**Table 5.** The comparsion average of phosphorus content in treatments

| Treatment | Phosphorus (%)* |
|---|---|
| S0 | $4.58 \pm 0.007^b$ |
| S25 | $5.44 \pm 0.004^a$ |
| S50 | $3.40 \pm 0.004^c$ |
| S75 | $0.25 \pm 0.004^d$ |
| S100 | $0.17 \pm 0.004^d$ |

*Means ± SD of triplicate determinations. Means with different superscript letters (a,b,…) show significant difference (p<0.05).

## Iron content

Figure 3 shows the standard calibration curve of iron which based on, the R-square ($R^2$) was 0.9795 (Fig 3).

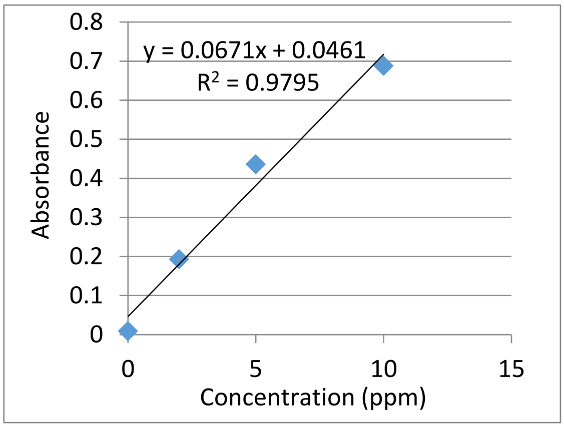


**Figure 3.** The calibration curve of iron standard

According to Table 6, higher levels of fish gelatin had more ferrous content. By increasing the proportion of industrial gelatin from 25 to 100 %, the trend of iron changes was declining. Therefore, the lowest iron content belonged to 100% industrial gelatin, which had a significant difference with other treatments (p<0.05), However, there was a significant difference between all treatments (p<0.05) (Table 6).

**Table 6.** The comparsion average of iron content in treatments

| Treatment | Ferous (%)* |
|---|---|
| S0 | $0.044 \pm 0.0001^b$ |
| S25 | $0.053 \pm 0.0001^a$ |
| S50 | $0.038 \pm 0.0001^c$ |
| S75 | $0.031 \pm 0.0001^d$ |
| S100 | $0.027 \pm 0.0001^e$ |

*Means ± SD of triplicate determinations. Means with different superscript letters (a,b,…) show significant difference (p<0.05).

## Ash content

According to table 7, treatment based on 75% fish gelatin had the highest ash content and it's difference with other treatments was quite significant (p<0.05). The lowest ash amount belonged to the treatment containing 100% industrial gelatin, which had a significant difference with other treatments ($p<0.05$). In general, the ash content was higher in treatments containing higher levels of fish gelatin (Table 7).

**Table 7.** The comparsion average of ash content of treatments

| Treatment | Ash (%)* |
|---|---|
| S0 | $1.59 \pm 0.015^{b}$ |
| S25 | $1.91 \pm 0.015^{a}$ |
| S50 | $1.32 \pm 0.020^{c}$ |
| S75 | $1.08 \pm 0.072^{d}$ |
| S100 | $0.83 \pm 0.015^{e}$ |

*Means ± SD of triplicate determinations. Means with different superscript letters (a,b,…) show significant difference ($p < 0.05$).

### Color parameters ($L^*a^*b^*$)

According to Fig. 4, the highest brightness ($L^*$) value was related to the treatment containing 100% industrial gelatin (59.94 ± 0.52), which had a significant difference with other treatments ($p<0.05$).

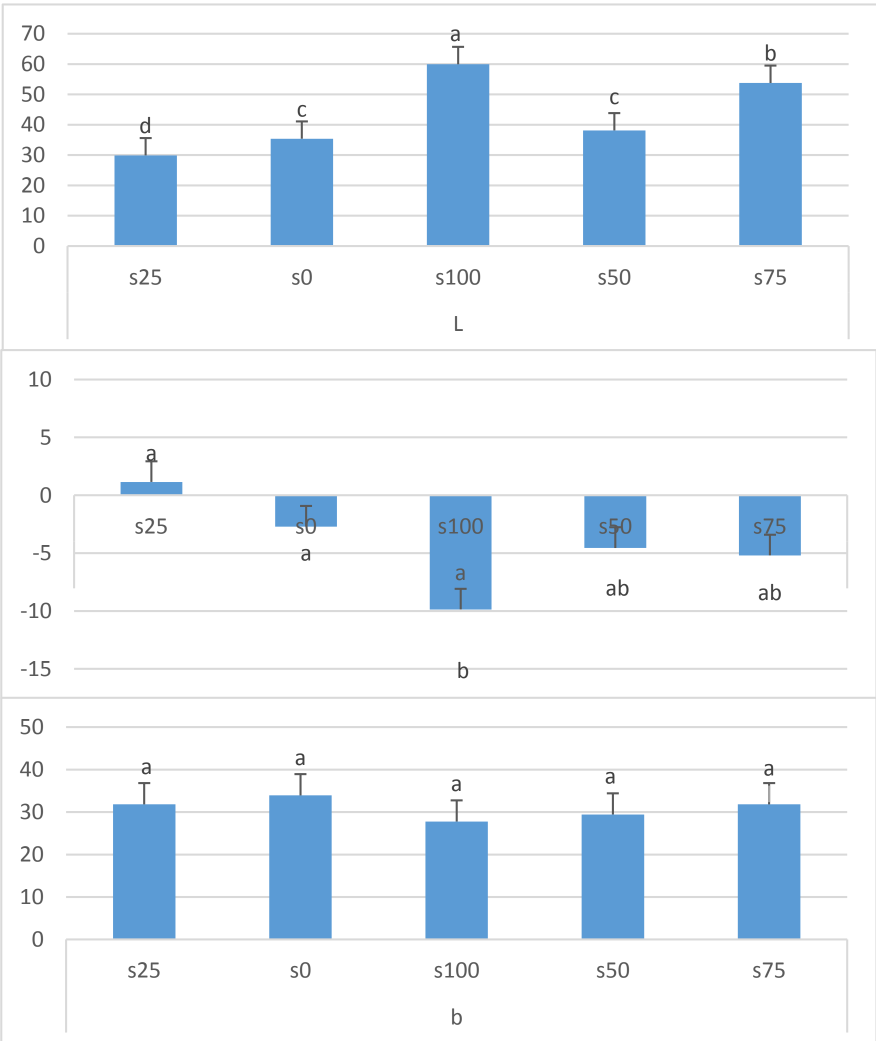


**Figure 4.** The comparsion average of color parameters ($L^*a^*b^*$) of treatments

## Discussion

Fish gelatin as a halal source can replace gelatin derived from mammals in all industries, especially in food products and can be prepared from fish waste. In this paper, after the extraction of gelatin from economic fish skin of carp (*Cyprinus carpio*), various formulations of this gelatin with cow's gelatin have been used in ratios of 0, 25, 50, 75 and 100% to pastill production. Then, the physicochemical experiments include of ash, protein, moisture, iron, phosphorus content, and color measurement were done on one day after of pastill production.

The results showed that the highest and lowest moisture content belonged to the treatment containing 75% fish gelatin and 100% industrial gelatin respectively. Gelatin contains 8-13% moisture. When gelatin granules are soaked in cold water they hydrate into discrete, swollen particles (Finch & Jobling 1977).

Moisture content is one of the most important quality factors of food (Pittia, Nicoli & Sacchetti 2007; Reh, Gerber, Prodolliet & Vuataz 2006). Elevated MC of stored foods is the important cause of growth of fungi. To be more exact, it is the thermodynamic water activity ($a_w$) that limits activity of microorganisms. The water availability can also be explained in terms of the associated equilibrium relative humidity (ERH). Food products in contact with an atmosphere of a given relative humidity (RH) or $a_w$ will come to (near) equilibrium at a MC that is based on the food composition (Chen 2000). Hansson, Andersson and Leufven (2001) stated that when the pastill formulations have a very low water content, viscosity and water activity ($a_w$) are two parameters that affect the diffusion and release of aromatic compounds. In the present study, the highest MC belonged to the treatment based on 75% fish gelatin, which has a significant difference with other treatments. Different MC in a products containing gelatin or gelatin-based foods can be due to the difference in extraction conditions (time, temperature ect.) and product type (Trindade Alfaro, Balbinot, Weber, Tonial & Machado-Lunkes 2015).

The highest protein content was found in the formulation containing 75% fish gelatin, which had a significant difference with other treatments ($p<0.05$). Marine by-products such as fish wastes have been reported to be suitable sources for functional food ingredients (Barrow & Shahidi 2007). Fish by-products contain both valuable lipid and protein fractions as well as other compounds (Rustad, Storrø & Slizyte 2011). Fish is increasingly demanded for use as food and feed. However, nutritional advantages of fish are limited by it's rapidly perishable nature and therefore short shelf-life (Jim, Garamumhango & Musara 2017). Muyonga, Colec and Duodub (2004) reported that the protein content in the collagenous material represents the possible maximum yield of the gelatin. The main cause of the difference in qualitative properties of mammalian gelatin with fish gelatin can be observed in the absence of proline and hydroxyproline gelatin in the absence of amino acids in mammals gelatin (Haug, Draget, & Smidsrod 2004). In this study, the lowest protein content belonged to the equal level of two kind of gelatin, which showed a significant difference between the protein content of this treatment and other treatments ($p<0.05$).

Treatment based on 75% fish gelatin had the highest ash content and it's difference with other treatments was significant ($p<0.05$). In general, the ash content was higher in treatments containing higher levels of fish gelatin (Table 7). The ash content in Grass carp gelatin was 0.12% (Kasankala, Xue, Weilong, Hong & He 2007). The presence of ash and lipids in low amounts is considered very important for the quality of gelatin obtained. Ash is higher in bone and higher ash content, shows higher levels of minerals, which depends on the type of fish and extracted gelatin (Trindade Alfaro *et al.* 2014).

Regarding human nutrition, fish meat, in addition to large amount of easily assimilated animal protein and vitamins, is a valuable source of minerals (Lombardi-Boccia, Lanzi & Aguzzi 2005) such as calcium, sodium, magnesium, potassium, iron, copper, manganese and zinc (Kunachowicz, Nadolna, Przygoda & Iwanow 2005). The results showed that the treatment based on 75% fish gelatin had the highest phosphorus, iron and zinc content ($p<0.05$) while the highest level of potassium and lithium content was related to treatment based on 100% industrial gelatin (Cow's) ($p<0.05$).

Potassium is an essential nutrient where it plays a key role in maintaining cell function particularly in important cells such as muscles and nerves. Potassium is a major intracellular ion that widely distributed in foods derived from living tissues (Weaver 2013). Fish are known for having abundant amounts of minerals, including phosphorus (El.Deen and El-Shamery 2010) and Iron (Jesu prabhu 2015). Iron is a component of haemoglobin and myoglobin, and is responsible for the transport of respiratory gases. Both Zn and Fe are absorbed from the food rich in animal protein better than from plant foods (Blicharski, Ksiazek, Pospiech, Migdał, Jozwik, Poławska & Lisiak 2013).

Industrial treatment showed the highest $L^*$ value (lightness) and the lowest index $a^*$ (green–red) and $b^*$ (blue–yellow) value ($p<0.05$). The sensory evaluation is crucial aspect to acceptability, and color is most important parameter in food specially junk food such as pastill. This sensory quality depends on the combination of some factors related to processing conditions, materials, storage, and facilities used (Curt, Trystram, Nogueira-Terrones, & Hossenlopp 2004). Many studies have shown that color curves can substantially impact upon human flavor perception (Levitan, Zampini, Li & Spence 2008; Zampini, Sanabria, Phillips & Spence 2007). The color of gelatin depends on the nature of the raw material used and whether the gelatin represents a first, second or further extraction (GMIA 2012).

According to the standard, pastill should have the uniform color. Researchs have shown that there is a close relationship between hydrocolloids such as gelatin, starch and pectin, and color structures in food products (Saha & Bhattacharya, 2001). The highest brightness index ($L^*$) was related to 100% industrial gelatin without fish gelatin, which had a significant difference with other treatments, which there was a significant difference with other treatments. This result is consistent with the results of some researchers (Ajandouz & Puigserver 1999). The presence of fish gelatin in pastill formulation resulted in a more redness. Therefore, the type of gelatin had a significant effect on the color profile in pastill. Considering the higher average of $b^*$ value in treatments with higher fish gelatin ratio, it can be said that the yellow spectrum in these treatments was higher than that of industrial gelatin. One of the reasons can be attributed to the presence of carotenoids in fish tissues, which causes the trends to yellow color of treatments. Another reason can be related to Millard browning reactions (Dawson & Acton 2017).

Specific carotenoids excist in fishes. The diverse carotenoids commonly occurring in fishes with different colours are tunaxanthein (yellow), lutein (greenish yellow), beta carotene (orange), doradexanthins (yellow), zeaxanthin (yellow orange), canthaxanthin (orange red), astaxanthin (red), eichinenone (red) and taraxanthin (yellow) (Theis, Salzburger, Egger 2012).

**Conclusion**

The use of fish gelatin such as *Cyprinus carpio* can play a critical role in and reducing waste and improving food quality. The results of this study showed that the treatment based on 75% fish gelatin had the highest protein, ash, phosphorus and iron content, hile the highest content of moisture and potassium were related to treatment based on 100% industrial gelatin. Therefore, fish gelatin had a more significant effect on protein and essential elements, especially phosphorus and iron, compared to the industrial type.

In terms of color parameters, the treatment containing 100% industrial gelatin showed the highest $L^*$ value and the lowest $a^*$ and $b^*$ value. In other words, pastills produced with 100% industrial gelatin had a bright color in comparsion with those made from fish gelatin, which is considered as a defect in sensory evaluation of pastill.

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## Conflict of interests

The authors declare that there is no conflict of interest.

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# تأثیر جایگزینی ژلاتین گاوی با ژلاتین پوست ماهی کپور معمولی بر محتوای معدنی و خصوصیات رنگ در پاستیل فراسودمند

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## چکیده

ژلاتین یک منبع پروتئینی ارزشمند و یک هیدروکلویید تجاری بوده که به ویژه در صنایع غذایی، دارویی و عکاسی کاربرد دارد. ژلاتین‌های تجاری اساساً از خوک بوده که به دلایل مذهبی و یا از گاو به دلیل خطر انتقال بیماری جنون گاوی قابل پذیرش نیست، به همین دلیل استخراج ژلاتین از ماهی و به ویژه ضایعات آن به عنوان منبع جایگزین ژلاتین تجاری اهمیت قابل توجهی یافته است. در پژوهش حاضر، بعد از استخراج ژلاتین از پوست ماهی پرورشی قابل دسترس و به صرفه کپور معمولی، فرمولاسیون های مختلف از این ژلاتین همراه با ژلاتین گاوی و در نسبت‌های صفر، ۲۵، ۵۰، ۷۵ و ۱۰۰ درصد به صورت منفرد و دوتایی در تولید پاستیل به کار رفت و در روز بعد از تولید به عنوان پیش تیمار، آزمایش‌های فیزیکوشیمیایی شامل میزان خاکستر، پروتئین، رطوبت، آهن، فسفر، روی و لیتیم و رنگ سنجی بر اساس پردازش تصویر بر روی نمونه‌های پاستیل امکان سنجی گردید. نتایج نشان داد که تیمار بر پایه ۷۵ درصد ژلاتین ماهی بیشترین میزان رطوبت، پروتئین، فسفر، آهن، خاکستر و روی را داشت، در حالی که بالاترین سطح پتاسیم و لیتیم مربوط به تیمار بر پایه ۱۰۰ درصد ژلاتین صنعتی (گاو) بود. تیمار صنعتی بالاترین شاخص $L^*$ (میزان روشنایی) و پائین‌ترین شاخص $a^*$ (قرمزی نمونه‌ها) و $b^*$ (میزان زردی) را نشان داد. بنابراین می‌توان از زایداتی که مصرف خاصی ندارند، ژلاتینی با منشأ حلال و با املاح بالاتر فسفر و روی، با پروتئین بیشتر و با صرفه اقتصادی را جایگزین ژلاتین‌های دیگر به ویژه در تنقلات مورد علاقه کودکان نمود.

**کلمات کلیدی:** پاستیل، ژلاتین پوست ماهی، ژلاتین گاوی، رنگ سنجی، خصوصیات فیزیکوشیمیایی

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