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## Original Research Article

# Effect of gelatin concentrations and glucose syrup to sucrose ratios on textural and optical properties of gelatin gel

***Malynn Porayanee[1*], Pichayada Katemake[2] and Kiattisak Duangmal[1]***

[1]*Department of Food Technology, Faculty of Science, Chulalongkorn University, Phayathai Rd., Patumwan, Bangkok 10330, Thailand.*

[2] *Department of Imaging and Printing Technology, Faculty of Science, Chulalongkorn University, Phayathai Rd., Patumwan, Bangkok 10330, Thailand.*

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## ABSTRACT

The gel strength of gelatin gel depends on gelatin concentrations and sweetener is commonly incorporated into gelatin products to improve the textural properties and clarity of the gel. The effect of glucose syrup (0-40%) to sucrose (0-40%) ratios (0:0, 0:100, 30:70, 70:30, 100:0) and gelatin concentrations (7.75%, 8.00% and 8.25%) on textural properties and optical properties were examined using Texture Analyzer and spectrophotometer. Gelatin gel samples were prepared using a 5 cm (L) x 5 cm (W) x 2.5 cm (H) silicone mold. The addition of sugars showed an increase in gumminess and hardness when compared to samples with no sugars ($p \leq 0.5$). At all levels of gelatin concentrations and sweetener ratios used, a small difference in values of cohesiveness and springiness was observed; values ranging from 0.95-0.99 and 0.93-1.00, respectively. The reflectance spectra of all gelatin gel samples showed the same trend with two dips in the blue zone at 420 nm and 440 nm. CIELAB, L* increased as increasing amount of glucose syrup, and C* increased with increasing sucrose. However, the hue angel values showed that all gelatin gel samples were yellow, with different chroma. The results from this study suggested that sugars had stronger effect on textural and optical properties than gelatin concentration did.



* *Corresponding author*: Tel.: +66804067161
Email: malynn.porayanee@gmail.com

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## Introduction

Gelatin is considered to be one of the most common gels in the food products. Gelatin is a transparent and colorless substance that derived from collagen. The temperature dependent form of gel state gives gelatin its unique properties. Upon cooling the molecule in gelatin form triple helices or gel-like structure; and upon increasing the temperature the triple helices will "melt" giving the gelatin the ability to melt at human's body temperature (Aguilera, 2004). Texture and appearance are important factors that give quality to gelled product and determine consumers' acceptability of the food (Sanderson *et al.*, 1988). Gelatin gel is soft with limited textural properties. The gel strength of gelatin gel depends on the gelatin concentration (Lau *et al.,* 2000) and sugar is often introduced into the system for their textural and reflectance attribution (Burey *et al.,* 2009).

Generally, the strength of gelatin gel increases with an increase in concentration of gelatin (Lau *et al.,* 2000). In gelatin gel, sugars are added to stabilize protein network and improve texture. Sucrose is used as sweetener and often used in combination with glucose syrup. The addition of sugar to gelatin gel system reduces the haziness, enhances thermal stability and supports gel structure (Holm *et al.,* 2009; Kasapis*et al.*, 2003). Glucose syrup is used to prevent sucrose crystallization. Due to glucose syrup's high dissolved solid content, it helps preventing microbial growth by lowering water activities (Burey *et al.,* 2009). Therefore, addition of preservative is not necessary.

Texture and appearance are two important factors describing qualified characteristics of products. Instrumental Texture Profile Analysis (TPA) is useful for the determination of gelatin gel texture. Not only does the TPA describe the gel strength, but it is also well correlated with sensory evaluation (Lau *et al.,* 2000; Muñoz *et al.,* 1986). Understanding the interaction of light is very important when measuring the color of translucent product like gelatin gel. This is because light influences the perceived color (Hutchings, 2002). Measuring colors using spectrophotometer gives the object's reflectance spectra in the visible range. The strongest reflected wavelength is the color perceived. However, other present colors seem not to be apparent because they are reflected so weakly (Holtzschue, 2011). Even though some works on textural properties of gelatin gelwith different ratios of sugars have been studied, work on optical properties has not been investigated yet. The objective of this study was to develop an understanding of the effect of glucose syrup to sucrose ratios and gelatin concentrations on textural and optical properties of gelatin gels using Texture Analyzer and spectrophotometer, respectively.

## Materials and methods

### Sample preparation

The concentrations of gels prepared were 7.75%, 8.00%, and 8.25% with 40% sugars at four glucose syrup to sucrose ratios (0:100, 30:70, 70:30, 100:0). Gelatin gels were prepared by soaking gelatin leaves (AG Gelita, Gemany) in iced water (0*±1*°C) and gradually added into a beaker containing hot water with appropriate amount of sugar mixtures; the control was made without sugars (0:0). The mixtures were left at room temperature (25±1°C) to cool down before pouring into molds with 5 cm (L) x 5 cm (W) x 2.5 cm (H). Once they began to set, they were placed into a refrigerator (4±1°C) to finish setting and held overnight prior to texture and reflectance measurements.

### Textural property measurement

The gels were removed from their molding and leftto equilibrate at room temperature (25±1°C) before subjected to a Texture Analyzer (Stable Micro Systems Ltd. Surrey, UK). A deformation of 30% was chosen and applied for all samples; this was to avoid gel fracture during the two-cycle compression-decompression. The gel samples were placed between parallel flat plate, using probe with 100 mm diameter and compressed twice at 1.0 mm/s. Textural parameters (hardness, cohesiveness, gumminess, springiness and chewiness) were calculated from the TPA curve.

### Optical property measurement

### Spectral Reflectance

Reflectance measurements were carried out using a spectrophotometer (X-Rite-SP62, Grand Rapids, MI, USA) for all samples prepared against white background using white ceramic tiles as their background. The measurements were performed in triplicate and each sample was measured three times at the same pointand then averaged. The reflectance measurements were recorded between 400 nm and 700 nm at every 10 nm intervals.

### CIELAB

The color of the gel samples measured using a spectrophotometer against white ceramic tile ($L^*$ = 87.28, $a^*$ = -0.15, $b^*$ = 0.69) was expressed in CIELAB system with reference to illuminate D65 and visual angle of 10°. Hue angle values were also calculated using the equation: $h_{ab} = tan^{-1}(b^*/a^*)$. Hue angle expresses in degrees from 0° to 360°, where 0° (red) being a location on the $+a^*$ axis, then rotating anti-clockwise to 90° (yellow) for the $+b^*$ axis, 180° (green) for $-a^*$, 270° (blue) for $-b^*$, and back to 360° = 0°.

### Statistical analysis

The experiments were conducted in triplicate, and the average values of three replications were reported for which mean values and standard deviation were determined. Analysis of variance (ANOVA) was performed and means comparison was determined using Tukey's multiple range test for textural properties. Differences were considered at significant level of 95% ($p \le 0.05$) using SPSS v17.0 software.

## Results and discussion

### Textural property analysis

The effect of gelatin concentrations and glucose syrup to sucrose ratios (glu:su) on hardness is shown in Figure 1a. Hardness is the strength of gelatin gel structure under compression. Figure 1a shows that the hardness significantly increased with increasing gelatin concentration ($p \le 0.05$). An increase in gelatin concentration resulted in greater gel strength because the higher gelatin concentrations gave more intense intermolecular contacts and stronger protein-protein interaction (Zayas, 1997). Lau *et al.* (2000) reported that in gellan/gelatin mixed gel, the gel strength of gelatin gel was dependent on gelatin concentration. Our results were in agreement with previous studies showing that the gel force increased with increasing concentration of gelatin in gelatin gels (Muñoz *et al.,* 1986). The additionof sugars significantly increased the hardness compared to the samples with no sugar ($p \leq 0.05$). At the same level of sugar (70:30) used, maximum strength hardness occurred at the gelatin concentration of 8.25% ($p \leq 0.05$). Sugars stabilized protein by increasing the rigidity and strengthening protein-to-protein interaction in food protein gel (Semenova*et al.,* 2002). Sucrose helps gelatin dissolution and the combination of sucrose and glucose syrup establishes a continuous phase in gelatin, which strengthen gelatin gel (Burey *et al*., 2009). The addition of sugar has been reported to increase the gel strength in gellen gum gels (Holm *et al.,* 2009), gelatin gels (Kapasi*et al*., 2003) and cornstarch gel (Sun *et al.,* 2014), which concurrent to our results in Figure 1a.

0:100, and there was in cohesiveness among gelatin gel samples with different concentrations of gelatin with different ratios of sugars. Obtaining results on cohesiveness was very similar to a study done by Muñoz *et al.* (1986) on measurement of texture of gelatin gels at different gelatin concentrations and different compression forces.

Gumminess is the multiplication of hardness and cohesiveness and it is the energy required to break down product into a ready to swallow state. Because of this correlation, the value of gumminess increased in the same trend as the hardness did (Figure 1c). The addition of sugars significantly increased the gumminess compared to the samples with no sugar ($p \leq 0.05$). Among different concentrations of gelatin gels at the same level of sugar (70:30), the highest gumminess observed was significantly increased at 8.25% ($p \leq 0.05$).

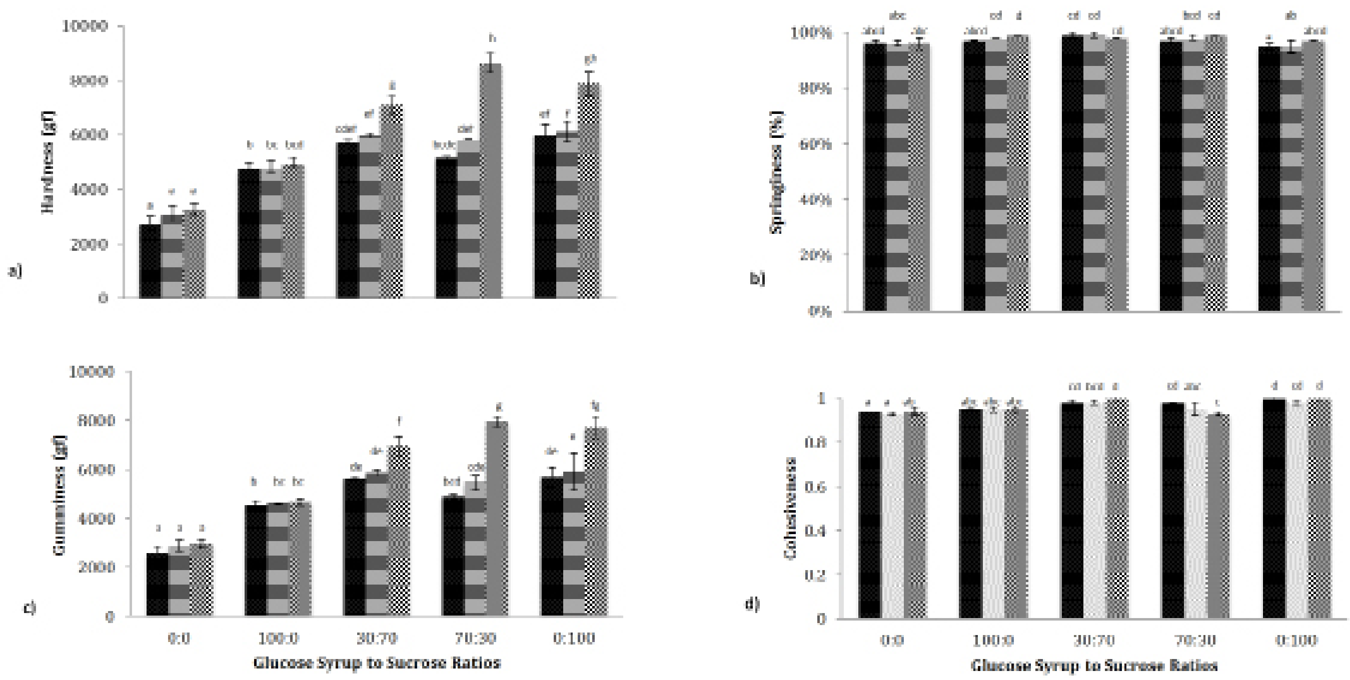


**Figure 1** Textural properties of gelatin gels at different concentrations: = 7.75% = 8.00% = 8.25% gelatin a) hardness b) springiness c)gumminess d) cohesiveness. Different superscript letter are significantly different ($p \leq 0.05$). All determination were performed in triplicate of three replications

At all levels of gelatin concentrations and sugar ratios used, a small difference in value of springiness, and cohesiveness was observed, as shown in Figure 1b and 1d. Springiness is the ratio of the time duration of force input during the second compression to first compression. The obtaining results on springiness showed that the gels had high springiness. When springiness is high, it required more chewing energy in mouth (Rahman and Al-Mahrouqi, 2009). There were slight differences in springiness among gels with different concentrations of gelatin with different ratios of sugars. These results agreed well with previous work done by Sun *et al.* (2014) on corn starch gels that all springiness values at different sugar concentrations were similar. Cohesiveness is the ratio of the area of the positive force of the second compression to the first compression. The highest cohesiveness was found at 8.25% concentration with

**Optical property analysis**

**Spectral parameter analysis**

We studied the reflectance spectra using white background. Figure 2 shows the graphs of reflectance spectra at different gelatin concentrations with different levels of sugar ratios. The reflectance spectra showed the increasing trend with a dip at blue zone (450 nm) and the highest reflectance was observed at yellow-orange zone (600-700 nm). Gelatin gel samples appeared to be yellow. The result of the absorption of light in the blue zone and highly reflected at yellow zone gives the object its yellow in color. This fact can explain the dip in the blue zone of the reflectance spectra of gelatin gels because the result of this absorption causes the reflectance at 450 nm to drop (Holtzschue, 2011). However, a color is not a result of a reflectance of a single wavelength, it reflects light in a range of wavelength with some wavelengths stronger than the others. From this experiment, the strongest reflected wavelength was in yellow to orange zone (600-700 nm), which correlated well with the perceived color of gelatin gel sample as yellow. Similar trends of reflectance spectra were presented for all treatments as shown in Figure 2.

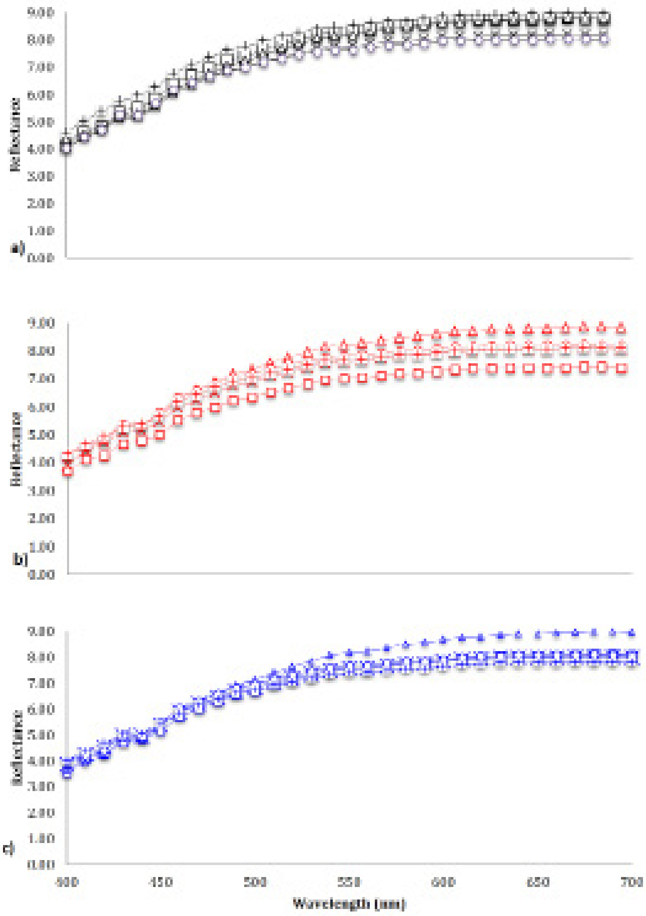


**Figure 2** Reflectance spectra of gelatin gels at different glucose to sucrose ratios 0:0 (—□—), 0:100 (—△—), 30:70 (—✕—), 70:30 (—○—), 100:0 (—+—). a) 7.75% b) 8.00% c) 8.25% gelatin.

Gelatin gel samples containing glucose were more transparent compared to gelatin gel samples containing sucrose because the refractive index of glucose [12% (n=1.3478), 28% (n=1.3635), and 40% (n=1.3937)] was relatively close to reflective index of gelatin (n=1.3471) compared to that of sucrose. The reflective index of sucrose at 12%, 28%, and 40% were 1.3513, 1.3728 and 1.4441, respectively. As refractive indices of mixtures in the sample are close to each other, less scattering occurs causing a higher transparency in samples resulting in higher *L**. The difference of the refractive index between sucrose and gelatin was higher than the difference of reflective index between glucose and gelatin resulting in a more scattering and less transparency in the layer of gelatin.

**CIELAB**

An increase in sucrose concentrations led to a small increase in *b**, chroma and hue angle values as shown in Table 1. Regarding the hue angle values all gelatin gel samples showed the same color shade, which appeared to be yellow. The results showed that gelatin gel samples with higher sucrose concentration were lighter and more intense with the same shade of yellow. The highest *C** was found when only sucrose was presented (0:100) and the lowest *C** was found when only glucose syrup were presented (100:0) at all gelatin concentrations used.

## Conclusions

This study demonstrated that texture of gelatin gel was affected by glucose syrup to sucrose ratios and gelatin concentration levels. Hardness and gumminess were strongly affected by the addition of sugars.For all sugar levels at gelatin concentration of 7.75% and 8.00% did not show a significant difference on textural properties. An addition of glucose syrup into the mixture showed a positive effect on *L** and negative effect on the *C**, inversely for sucrose mixture. Therefore, textural properties of gelatin gel samples could be manipulated based on gelatin concentrations and sugar ratio within this range without affecting the optical properties. In order to see the effect of gelatin concentration, a larger gap range among the concentration would probably be more suitable. Also to avoid the light leakage around the periphery, measuring the reflectance of gelatin gel samples should be in an opaque covered container.

## Acknowledgements

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**Table 1** CIE L*a*b*,CIE C* and hue angle values of gelatin gel samples.

| Gelatin Concentration | Glucose Syrup to Sucrose Ratios | L* | a* | b* | C* | Hue Angle (degrees) |
|---|---|---|---|---|---|---|
| 7.75% | 0:0 | 34.11 ± 0.17 | -0.75 ± 0.03 | 8.08 ± 0.11 | 8.11 ± 0.11 | 84.72 ± 0.15 |
| | 0:100 | 32.34 ± 0.36 | -0.54 ± 0.04 | 8.53 ± 0.87 | 8.54 ± 0.86 | 86.37 ± 0.11 |
| | 30:70 | 32.89 ± 0.54 | -0.83 ± 0.06 | 7.64 ± 0.42 | 7.68 ± 0.41 | 83.80 ± 0.71 |
| | 70:30 | 33.05 ± 0.27 | -0.90 ± 0.02 | 6.96 ± 0.03 | 7.25 ± 0.04 | 82.64 ± 0.12 |
| | 100:0 | 34.72 ± 0.41 | -0.79 ± 0.06 | 7.21 ± 0.57 | 7.02 ± 0.55 | 83.72 ± 0.91 |
| 8.00% | 0:0 | 32.81 ± 0.68 | -0.75 ± 0.10 | 7.29 ± 0.30 | 7.33 ± 0.31 | 84.14 ± 0.59 |
| | 0:100 | 32.48 ± 1.00 | -0.69 ±0.14 | 8.75 ± 1.75 | 8.78 ± 1.73 | 85.21 ± 1.9 |
| | 30:70 | 32.98 ± 1.13 | -0.74 ±0.08 | 7.51 ± 0.45 | 7.54 ± 0.44 | 84.34 ± 0.89 |
| | 70:30 | 32.32 ± 0.57 | -0.92 ± 0.02 | 7.00 ± 0.54 | 7.07 ± 0.54 | 82.45 ± 0.77 |
| | 100:0 | 33.28 ± 0.89 | -0.79 ± 0.07 | 6.88 ± 0.06 | 6.92 ± 0.06 | 83.45 ± 0.57 |
| 8.25% | 0:0 | 31.51 ± 0.44 | -0.75 ± 0.09 | 8.94 ± 0.61 | 8.97 ± 0.62 | 85.17 ± 0.23 |
| | 0:100 | 32.69 ± 0.10 | -0.57 ± 0.03 | 9.99 ± 0.77 | 10.01 ± 0.77 | 86.73 ± 0.13 |
| | 30:70 | 32.92 ± 0.25 | -0.83 ± 0.06 | 7.71 ± 0.24 | 7.89 ± 0.21 | 83.87 ± 0.55 |
| | 70:30 | 33.87 ± 0.36 | -0.98 ± 0.04 | 7.82 ± 0.22 | 7.76 ± 0.23 | 82.85 ± 0.41 |
| | 100:0 | 33.95 ± 0.33 | -0.75 ± 0.05 | 7.05 ± 0.01 | 7.09 ± 0.01 | 83.89 ± 0.38 |

Values are mean ± standard deviation of three replication determination. All determinations were performed in triplicate.

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