



# Quality and antioxidant properties of jelly supplemented with apricot juice concentrate

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## Abstract

Gummy jellies are becoming more popular than in the past as a dessert or snack in the Korean food market. Taking advantages of diverse functional activities of apricot juice concentrate (AJC), it can be incorporated into snack food such as jelly to meet consumers' emerging demands regarding health concerns. However, there has been a scarcity of reports on the most appropriate concentration of AJC in jellies. This prompted us to undertake the present investigation with the objective to evaluate the physical, sensory, and antioxidant characteristics of jellies containing various concentrations of AJC (7.5%, 15%, 22.5%, and 30%). The pH, moisture content, and lightness ( $L^*$ ) decreased significantly while total soluble solids (TSS), hardness, redness ( $a^*$ ), and yellowness ( $b^*$ ) increased significantly with increasing concentrations AJC ( $p < 0.05$ ). In addition, the 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2'-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) radical scavenging activities significantly increased ( $p < 0.05$ ) at higher AJC concentrations. A consumer acceptance test indicated that the incorporation of 22.5% AJC had favorable effects on consumer preferences for all the tested attributes. Based on our study, jelly incorporated with 22.5% AJC is recommended for developing AJC-supplemented jellies with improved overall qualities without sacrificing consumer acceptability and while taking advantage of the functional properties of AJC.

**Keywords :** apricot juice concentrate, jelly, physicochemical properties, consumer acceptance, antioxidant properties

## Introduction

Apricot (*Prunus armeniaca* L.) is a branch of deciduous glaucoma belonging to the rose family, native to eastern Asia and widely cultivated in Korea, China, and Japan (1,2). The fruit has a pleasant aroma which encourages its consumption worldwide (3). Apricots are a rich source of sugars, fibers, minerals, and vitamins (4). In addition, they contain appreciable amounts of carotenoids (mainly beta-carotene), polyphenols, fatty acids, and polysaccharides, and have been shown to exert various biological activities that are beneficial to human health (5).

Although apricots are considered as one of the most promising functional foods due to the crucial constituents (such as dietary fiber, sorbitol, potassium, copper, and

phenolic compounds) which contribute to many aspects of human health (6), they are one of the least studied functional foods. Apricot juice, apricot juice concentrate (AJC), and apricot juice powder have been used limitedly in recent studies to improve the quality of muffins (2), cookies (6), tofu (7), suggidduk (8-10), and haengbyeong (11). The development of new types of food supplemented with AJC could be useful for consumers with health concerns.

Gummy jellies are a widely consumed dessert or snack, and are popular with various age groups due to their texture and ease of cooking (12,13). Jellies are prepared with concentrated sugar solutions, gelling agents, and other minor ingredients (coloring, acid, and flavoring agents) (14). The raw material is first gelatinized by heating, mixing with acids, coloring, and flavoring, after which the molten product is formed in molds of different sizes and shapes (15). The market share of jelly products had dramatically increased from 68 billion Won in 2014 to 202 billion Won in 2020, which is likely due to new and unique products emerging in the market and appealing to 20-30-year old consumers (16).

A review indicated that various concentrates, such as black

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ginseng (17), *Rehmannia radix* (18), purple sweet potato (19), cranberry (20), and corn (13) concentrates have been successfully used in jelly manufacturing. Nevertheless, little information is available regarding the effects of AJC on the physicochemical and sensory properties of gummy jellies.

In this study, AJC was supplemented with water to improve its functional and nutritional value. Therefore, the aim of this research was to determine the effects of the incorporation of different concentrations of AJC (7.5–30%) on the physical and sensory characteristics of jellies. The antioxidant properties of AJC-supplemented jellies were also determined.

## Materials and methods

### Jelly materials

Commercial grade AJC (Korea F&B Corp., Chungbuk, Korea), gelatin (Samwon, Daegu, Korea), and sugar (CJ, Seoul, Korea) were purchased from a local market. The relevant characteristics of AJC were determined as follows: pH = 5.64, soluble solids content = 3.06 °Brix, L\*-value = 27.01, a\*-value = 17.95, and b\*-value = 25.09. This concentrate contained purified water, white sugar, fructose, citric acid, and sodium citrate as indicated by the manufacturer. All ingredients are generally recognized as safe (GRAS).

### Preparation of jellies

The appropriate concentration of AJC varied depending on the model food system investigated. Several preliminary experiments using various AJC concentration in the formulation were conducted. The addition of ≤ 30% AJC seemed appropriate based on the quality of apricot jellies checked by the principal investigators. Finally, the test jelly samples were prepared by supplementing the standard jelly recipe with 0%, 7.5%, 15%, 22.5%, and 30% AJC.

The standard jelly recipe was used for the control and consisted of 400 mL of water, 30 g of white granulated sugar, and 10 g of gelatin. First, sugar (30 g) was dissolved in boiling water (200 mL) for 4 min, followed by 200 mL of water with dissolved gelatin (10 g) for 2 min, after which the appropriate amount of AJC was incorporated. The final mixture was covered and boiled for 4 min. The mixture was then immediately poured into molds and allowed to cool for 30 min at room temperature, after which samples were refrigerated at 4°C for 3 h prior to experiments. The samples were warmed at room temperature prior to each analysis.

### Physical analysis

Ten grams of sample mixed with 90 mL of distilled water was prepared to measure the pH of jelly samples using a pH meter (MP230, Mettler Toledo, Schwerzenbach, Switzerland) at room temperature. The same samples were used to determine total soluble solids (TSS; expressed in °Brix), using an Atago refractometer (PR-201, Atago Co., LTD, Tokyo, Japan). The moisture content was determined by drying pre-weighed amounts of samples to a constant weight at 105°C in an oven for 24 h. All measurements were repeated five times, and mean values were compared.

Color was measured in terms of L\*, a\*, and b\* CIE values using a Minolta Spectrophotometer (CM-600d, Minolta Co., Osaka, Japan) equipped with a D65 standard illuminant, an 8-mm aperture, and a 10° standard observer. The spectrophotometer was calibrated with a standard white calibration cap supplied by the manufacturer. Color was measured at the same location (six sides of each cube) using five jelly cubes (3×3×3 cm) for each treatment.

Textural characteristics were evaluated by 30% compression of the individual samples (3×3×3 cm) with a computer-controlled Advanced Universal Testing System (LRXPlus, Lloyd Instrument Limited, Fareham, Hampshire, UK) at room temperature with a 5-cm-diameter stainless-steel disc probe. The crosshead speed was 1 mm/s. Fifteen samples for each replication were tested, and their mean values were compared.

### Antioxidant analysis

The 2,2-diphenyl-1-picrylhydrazyl (DPPH)-radical scavenging activities of samples were measured in terms of their hydrogen-donating or DPPH radical scavenging activity. The assay was performed as previously described by Brand-Williams et al. (21) with some modifications. Briefly, 0.2 mM solution of DPPH radical in ethanol was prepared, after which 5 mL of this solution was added to 1 mL of sample solution in ethanol at different concentrations. The solution was then shaken and left to stand for 10 min. Decolorization of the DPPH-donated protons was determined by measuring the absorbance at 517 nm using a spectrophotometer (Optizen 2020 UV Plus, Mecasys Co., Ltd., Daejeon, Korea). The DPPH radical scavenging activity was calculated using the following equation:

$$\text{Radical scavenging activity (\%)} = \frac{[(Abs_{\text{control}} - Abs_{\text{sample}}) / Abs_{\text{control}}] \times 100}{}$$

Spectrophotometric analysis of the 2,2'-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS)<sup>+</sup> radical scavenging activity was carried out according to the method used by Re et al. (22) with slight modifications. The assay is based on the ability of antioxidants to reduce ABTS<sup>+</sup> (blue/green) for the generation of ABTS<sup>-2</sup> (colorless). Briefly, the ABTS<sup>+</sup> cation radical was produced by a reaction between 7.4 mM ABTS in H<sub>2</sub>O and 2.6 mM potassium persulfate during storage in the dark at room temperature for 12–16 h. Before use, the ABTS<sup>+</sup> solution was diluted with methanol to obtain an absorbance of 1.10±0.02 at 734 nm. Subsequently, 3 mL of the ABTS<sup>+</sup> solution was added to 0.1 mL of the sample. After 10 min, the percent inhibition at 734 nm was calculated for each concentration relative to blank absorbance.

### Sensory analysis

The AJC-supplemented jellies were evaluated by 50 consumer panelists (9 males and 41 females), consisting of undergraduate and graduate students, who had an interest and volunteered for the participation. Five samples were presented in random order and panelists were asked to evaluate consumer attributes of color, aroma, taste, texture, and overall acceptability. Panelists were asked to evaluate preference levels using a nine-point hedonic scale (9 = like extremely, 5 = neither like nor dislike, and 1 = dislike extremely). Each AJC-supplemented jelly sample (3×3×3 cm) was randomly coded using a three-digit number. Panelist received a tray containing the samples, a glass of water, and an evaluation sheet and were advised to rinse their palates between samples to minimize residual flavor effects. Enough space was given to handle the samples and the questionnaire, and the evaluation time was not constrained. No specific compensation was given to the participants.

This study was approved by the Daegu University Institutional Review Board (IRB # 1040621-201711-HR-018-002).

### Statistical analysis

Statistical analysis was carried out using the SAS for Windows version 9.1 (SAS Inst. Inc., Cary, NC, USA). Results were expressed as mean values with the corresponding standard deviation, and significant differences were compared with Duncan's multiple range test at a 5% level of significance.

## Results and discussion

### Physical characteristics

Table 1 describes the physical characterization of the jellies supplemented with different levels of AJC. The pH in jellies ranged from 5.65 to 6.62 and decreased upon addition of an increasing amount of AJC ( $p < 0.05$ ). Similar reductions of pH have been observed in jellies incorporated with corn (13) and jujube (23) concentrate, which is likely due to the weak acidic nature of the supplemented concentrate.

Moisture contents of samples ranged from 72.15 to 86.84% (w.b.), and the control sample exhibited the highest moisture content. This range is in good accordance with the moisture content of jellies incorporated with corn concentrate (80.06–89.34%) (13) and jujube concentrate (79.56–84.35%) (23), where similar decreasing trends were reported with the addition of higher amounts of both supplements. However, other studies have reported slightly lower moisture contents due to the formulation of different ingredients and additives. Moisture contents ranged from 59.37–62.23% and 65.22–74.81% for jellies incorporated with *Rehmannia radix* concentrate (18) and *Gastrodia elata* concentrate (24), respectively, and TSS increased significantly with an increasing AJC concentration ( $p < 0.05$ ) (Table 1). This result is likely to be attributable to the addition of soluble solids from AJC, which showed a TSS of 3.06 °Brix. Similar results were reported for jellies supplemented with corn concentrate (13).

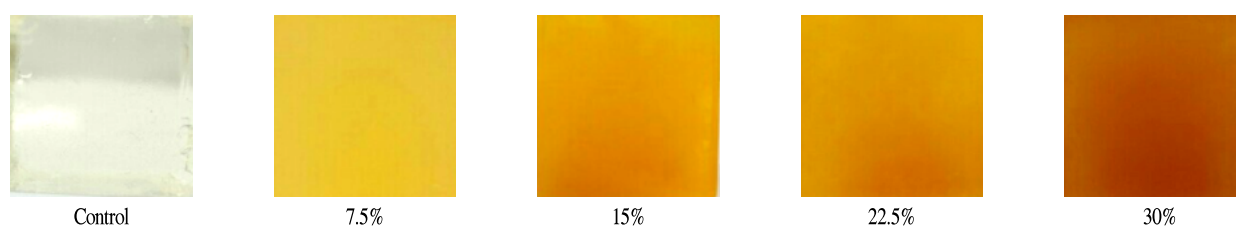
Texture analyses found that the hardness of jellies increased significantly as the AJC concentration increased ( $p < 0.05$ ) hardness of jellies ranging from 3.64 N at 0% addition to 6.58 N at 30% addition. The higher hardness of jellies containing a higher amount of AJC could be attributed to a lower water holding capacity (19) as well as a lower moisture content. A similar result was reported for jellies incorporated with corn concentrate (13) and black ginseng concentrate (17).

Surface color is a very important element determining initial consumer acceptability. Jellies with added AJC showed significantly different surface color values compared to the control ( $p < 0.05$ ). L\*-values decreased significantly with increase in the concentration of AJC ( $p < 0.05$ ). On the other hand, a\*- and b\*-values showed reverse trends ( $p < 0.05$ ); as the concentration of AJC in the formulation increased, jellies became darker and more reddish and yellowish (Fig. 1). These results are in accordance with the findings reported for jellies

**Table 1. Physical properties of jelly incorporated with different concentrations of apricot juice concentrate (AJC)**

Property	AJC (%)					
	0	7.5	15	22.5	30	
pH	6.62±0.06 <sup>a</sup>	6.27±0.05 <sup>b</sup>	6.05±0.02 <sup>c</sup>	5.83±0.15 <sup>d</sup>	5.65±0.04 <sup>e</sup>	
Moisture content (%)	86.84±0.21 <sup>a</sup>	84.65±0.26 <sup>b</sup>	82.28±0.19 <sup>c</sup>	77.52±0.19 <sup>d</sup>	72.15±0.48 <sup>e</sup>	
Total soluble solids (°Brix)	0.92±0.08 <sup>e</sup>	1.24±0.05 <sup>d</sup>	1.46±0.05 <sup>c</sup>	1.74±0.05 <sup>b</sup>	2.00±0.07 <sup>a</sup>	
Hardness (N)	3.64±0.15 <sup>e</sup>	3.86±0.21 <sup>d</sup>	4.35±0.41 <sup>c</sup>	5.65±0.33 <sup>b</sup>	6.58±0.27 <sup>a</sup>	
Color	L*	38.37±0.35 <sup>a</sup>	31.21±0.92 <sup>b</sup>	31.06±0.61 <sup>b</sup>	30.50±1.03 <sup>b</sup>	29.28±0.72 <sup>c</sup>
	a*	-1.48±0.02 <sup>e</sup>	6.14±0.25 <sup>d</sup>	7.52±0.15 <sup>c</sup>	9.78±0.11 <sup>b</sup>	14.58±0.31 <sup>a</sup>
	b*	5.86±0.12 <sup>e</sup>	10.63±0.71 <sup>d</sup>	13.45±0.44 <sup>c</sup>	16.03±0.59 <sup>b</sup>	20.44±0.63 <sup>a</sup>

Means within the same row with a different letter (a-e) are significantly different ( $p < 0.05$ ).



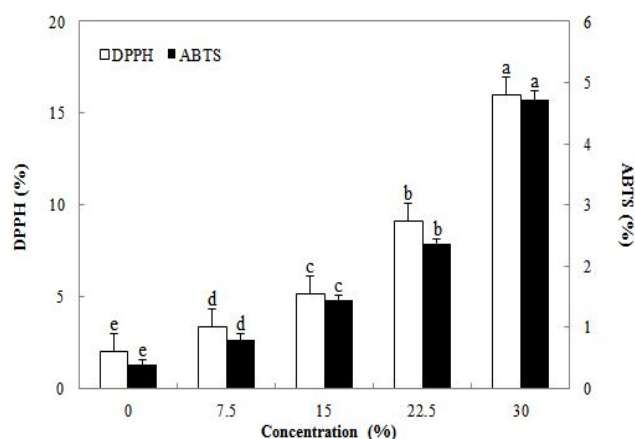
**Fig. 1. Appearance of jellies with different concentrations of apricot juice concentrate (AJC).**

supplemented with corn concentrate (13). These results suggest that the color of jellies can be easily controlled based on the concentration of AJC according to consumer and/or manufacturer preferences.

### Free radical scavenging activities

Antioxidant activities were investigated based on DPPH radical scavenging activity and ABTS radical cation assay. The addition of AJC in the jelly formulation enhanced antioxidant activities (Fig. 2), which can be attributed to

the abundant antioxidant capacities of AJC. There were significant increases in electron-donating ability (EDA) values of bound phenolic extracts in samples containing AJC compared to the control sample ( $p < 0.05$ ). The EDA increased as ABTS values increased, and these values increased significantly with increasing concentration of AJC ( $p < 0.05$ ), showing that higher concentrations of AJC in the sample resulted in higher antioxidant potential. Data also showed a positive correlation between the antioxidant capacities of the various samples.



**Fig. 2. DPPH and ABTS radical scavenging activities of jellies with different concentrations of apricot juice concentrate (AJC).**

Means within the same activity with a different letter (a-e) are significantly different ( $p < 0.05$ ).

### Sensory evaluation

Color, aroma, taste, texture, and overall acceptance of the control and the AJC-supplemented jellies were evaluated (Table 2). When evaluated by untrained panelists, statistically significant differences in the all tested attributes were detected among samples ( $p < 0.05$ ). The sensory panelists rated the samples enriched with 22.5% AJC as having the highest scores for all tested attributes compared to others ( $p < 0.05$ ), although there were no significant differences between samples enriched with 22.5% and 30% AJC with respect to aroma, taste, or texture attributes. However, further increasing the AJC concentration had undesirable sensorial effects, especially for color and overall acceptance. On a nine-point hedonic scale, 22.5% AJC samples received mean scores of 6.38–7.10. It is noteworthy that the mean score of 7.10 was

for overall acceptance. The 22.5% AJC sample received the highest overall acceptance score and therefore seems satisfactory.

As mentioned previously, apricots have a high potential usage as a functional ingredient in the food processing industry rather than only being directly consumed. As the demand for convenient foods such as jelly is rising steadily, the development of AJC-supplemented jellies is a valuable alternative to increase the overall consumption of apricots which may have positive human health effects. Based on our study, jelly containing 22.5% AJC is recommended for developing AJC-added jellies with improved overall qualities without sacrificing consumer acceptability.

**Table 2. Sensory findings of jelly incorporated with different concentrations of apricot juice concentrate (AJC)**

Attribute	AJC (%)				
	0	7.5	15	22.5	30
Color	6.76±2.01 <sup>a</sup>	5.44±2.00 <sup>b</sup>	6.28±1.67 <sup>a</sup>	6.38±1.92 <sup>a</sup>	4.92±2.47 <sup>b</sup>
Aroma	3.84±1.48 <sup>d</sup>	5.02±1.63 <sup>c</sup>	5.78±1.76 <sup>b</sup>	6.88±1.69 <sup>a</sup>	6.84±2.12 <sup>a</sup>
Taste	2.98±1.87 <sup>d</sup>	4.74±1.84 <sup>c</sup>	5.78±1.63 <sup>b</sup>	6.88±2.16 <sup>a</sup>	6.72±2.11 <sup>a</sup>
Texture	5.26±2.66 <sup>b</sup>	5.66±1.67 <sup>ab</sup>	5.58±1.68 <sup>ab</sup>	6.40±1.85 <sup>a</sup>	6.20±2.59 <sup>a</sup>
Overall acceptance	3.48±1.93 <sup>d</sup>	5.10±1.80 <sup>c</sup>	5.66±1.52 <sup>bc</sup>	7.10±1.93 <sup>a</sup>	6.12±2.19 <sup>b</sup>

Means within the same row without a common letter (a-d) are significantly different ( $p < 0.05$ ).

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