Evaluation on the effects of hydrocolloids on sensory, texture and color properties of mulberry pastille

Nosrat Azimi[1], Shadi Basiri[2*], Ali Mortazavi[3]

(1. *MSc of Food Science and Technology, Sabzevar Branch, Islamic Azad University*;
2. *Assistant professor, Agricultural Engineering Research Department , Khorasan Razavi Agricultural and Natural Resources Research Center, AREEO, Mashhad, Iran*;
3. *Professor, Food Science and Technology Department, Faculty of Agriculture, Ferdowsi University of Mashhad, Iran*)

Abstract: White mulberry is a fruit with high nutritional quality. The shelf life of Mulberry is short due to high moisture content. In this research, a new product from white Mulberry called pastille was formulated. Two hydrocolloid ingredients: guar (0%, 0.5% and 1%) and gelatin (0%, 1% and 2%) were used for pastille formulations. Parameters such as color parameters (L^* a^* b^*), sensory evaluations and texture profile analysis (TPA) of samples were investigated. The results of texture evaluation showed that springiness, chewiness, adhesiveness and hardness increased by increasing gelatin, while cohesiveness decreased. Hardness and adhesiveness decreased by addition of the guar. Hardness and adhesiveness decreased with adding guar. Sensory evaluation showed that increasing of the hydrocolloids led to the decrease of acceptability scores. The parameters of a^* and b^* of pastille samples increased with increasing hydrocolloids concentration, however L^* values decreased when the amount of hydrocolloids increased. Mulberry pastille including 1% guar and 1% gelatin having the lowest amount of hardness, adhesiveness, chewiness and suitable color characteristics, was determined as the best formulation among the other investigated samples.

Keywords: Hydrocolloid, Mulberry pastille, Sensory Characteristics, Texture Properties

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1 Introduction

Mulberry is a kind of nutritious fruit which belongs to the *Morus* genus of the *Moraceae* family (Voutilainen et al., 2006). It grows under different climate conditions. It is also found in East, West and South East Asia, the South Europe, South of North America, Northwest of South America and some parts of Africa (Datta, 2002). Generally, there are three types of mulberry, including white (Morus alba), black (M. nigra) and red (M. rubra).White mulberry is originates from Western Asia, including Turkey, red mulberry from North and South America, and black mulberry from Southern Russia. Its leaves are used as foods for silkworms. Mulberries fruits are very sweet and perishable. They can be eaten fresh or dried. They are also processed into syrup, vinegar, concentrate, fruit juice, jam, jellies, pulp and ice-cream (Gundogdu, 2011, Minh and Dong, 2013). In Turkey, several traditional products such as pekmez and kome are made from mulberry (Yogurtçu & Kamisli, 2006).

Mulberries contain a very good variety of vitamins (vitamin B complex, vitamin K, vitamin B-6, niacin, riboflavin and folic acid), minerals (K, Mg, Mn, and Fe) (Lukinac et al., 2009). Recently done studies have revealed that mulberries have essential effects on human diet and health with the help of its compounds such as organic acids, phenolic compounds, including flavonoids, anthocyanins, carotenoids, and sugar contents (Pawlowski et al., 2008, Ozgen et al., 2009, Bae and Suh, 2007). Due to the various and well balanced composition

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*** Corresponding author: Shadi Basiri,** Assistant professor, Agricultural Engineering Research Department, Khorasan Razavi Agricultural and Natural Resources Research Center, AREEO, P.O. Box 91735-488 Mashhad, Iran. Email: shbasiri35@yahoo.com. Tel and Fax: +98-511-3822373.

of white mulberries; they have the potential to prevent from cancers and the treat sore throat, fever, hypertension and anemia (Gong and Zhu, 2008). Mulberries are not easy to store for a long time after harvest so instead of being consumed fresh, employing preservation methods, in order to increase its shelf-life, seems necessary because of its high level (more than 80%) of moisture content (Yamamoto et al., 2006).

When white mulberries are converted into new products with high durability, their added value will be increased and also their waste could be prevented to some extent. In this study, the formulation of a new product based on white mulberry which comprised of white mulberry puree, hydrocolloids were tried. This product is somewhat similar to common pastilles. Due to having multiple nutrients, organic acids and desirable flavor, white mulberries seem to be used as one of the major ingredients within the formulation of this category of foods. Fruit products made of pureed fruits have been the subject of many researches in which high amount of hydrocolloid gels and other additives have been used (Khazaiy et al., 2013). Hydrocolloids are a heterogeneous group of long chain polymers (polysaccharides and proteins) characterized by their property of forming viscous dispersions and/or gels when it is dispersed in water (Shalini and Laxmi, 2007, Saha and Bhattacharya, 2010). Food hydrocolloids are used in fruit snack formulations to create a new texture, increase stability for their water-holding capacity, improve texture and have an impact on flavor release and other structural and sensory properties in the respective products (Ben-zion and Nussinovitch, 1997, Rodge et al., 2012). Agar is a hydrophilic colloid extracted from certain marine algae of the class *Rhodophyceae*. Agar has been used for many centuries as a high performance gelling agent (Stanley, 2006). Its ability to produce clear, colorless, odorless, and natural gels without the support of other colloids has long been exploited by the food industry not only as a stabilizer and gelling agent but also as the manufacturing of confectionery (Barrangou et al., 2006). Guar gam is a kind of long-chain galactomannan with high molecular weight, obtained from endosperm of guar plant (Williams and Phillips, 2000). Gelatins have typical amino acid compositions containing large amounts of proline, hydroxyl proline, alanine and glycine; the latter constitutes approximately one third of the molecule (Mitchell, 1976). Gelatin gels are quite soft and flexible, but their textural properties are, in general, very narrow (Lau et al., 2000).

The aim of this research is to study the effects of different concentrations of gelatin and guar on the physicochemical, textural, color and sensory properties of white mulberry pastille.

2 Materials and methods

2.1 Materials

The materials included white mulberry, hydrocolloids (Agar, gelatin and guar) and citric acid. For uniformity, the berries fruits were collected from a tree in the city of Mashhad in Iran. Chemicals such as guar, agar, gelatin and citric acid were reagent grade.

2.2 Method

2.2.1 Preparation of sample

Components of formulation were mulberry puree (80% w/w), gelatin at three levels (0%, 1% and 2 %) and guar levels (0%, 0.5% and 1% w/w).

For mulberry puree production, fresh mulberry was used as raw material. First, mulberry is placed to boiling vessels after cleaning. Then, some water was added to mulberry. After adding water, the mixture is completely stirred and is boiled by stirring for some minutes. After that, the mixtures were poured into the chopper and were crushed to produce mulberry puree. The prepared fruit puree was stored in the freezer –18°C, for further test. Gelatin was created as a soluble form in distilled water at 65°C. Then it was added to the fruit mixture (Bourne, 2002). Guar was mixed with sugar powder and then was added to fruit mixture to prevent clouding. After measuring pH (pH meter of Hana model made in Portugal) and moderating to pH=4.3 by adding acid citric 40% (W/V) and control the percent of soluble solids of fruit mixture (optical refract meter of Carlze model) to constant Brix of 45, the mixture was prepared. Then the prepared mixture was poured into a steel mold (1.9×1.9×1.9 cm). The molds were held in the refrigerator (4°C) for 2 hours for hydration. After that, the obtained gel was taken out of the mold. The samples were dried at 60°C in a hot air cabinet drier for

6 hours.

2.2.2 Physicochemical analysis

2.2.2.1 Moisture and water activity

Moisture and water activity (a_w) of mulberry pastille were determined. Association of Official Analytical Chemistry methods were used to analyze the moisture content of the product (AOAC, 1990). The moisture content was determined by drying 2gr of sample in an oven drying (model Memert, Germany) for at least 18 h at 105°C.

The water activity was determined by using a water activity meter (model Novasina, Switzerland) with an accuracy of +/– 0.001. The units of pastille were cut in crosswise and both halves were placed in the sample holder to perform the measurements. All measurements were done at 25°C and in triplicate. Three minutes was used as stabilization time before the measurements were made.

2.2.3 Color parameters

In this paper, the color was of the white mulberry pastille samples were measured by using software Image J 1.40 g analysis system.

2.2.3.1 Image acquisition

Performing image acquisition in image processing has always been the first step. For this purpose, white mulberry pastilles were scanned with a Flatbed Scanner (HP Scan G3010). After the removing of Scanner lid, during image acquisition, the scanner was held in a black box, in order to exclude surrounding light and external reflections. All images were scanned at the same conditions, by positioning the mulberry pastilles coming from each repetitions and treatments on the scanner. The scanner was connected to the USB port of a PC provided with scanning it to Pro Software to visualize and acquire the digitalized images directly from the computer with high resolution. The scanned images were saved in 200×200 dpi resolution in JPG format and color mode. Finally, images were analyzed in the Image J software (version 1.40 g) environment to investigate the RGB channels after the color back ground had been ignored. Three parameters, L^* (lightness), a^* (redness) and b^* (yellowness), were used to study color changes in the $L^*a^*b^*$ color model. L^* refers to the lightness of the samples and ranges from black (L^*=0) to white (L^*=100). A negative value of a^* indicates green, while a^* positive one indicates red-purple. Positive b^* value indicates yellow and negative b^* indicates blue (Lukinac et al., 2009).

2.2.4 Measurement of texture parameters

The Texture Profile Analysis “TPA” test was performed by using the QTS-25 Texture Analyzer (CNS Farnell, England) equipped with the Texture-Pro program. The samples were compressed twice with a flat cylindrical probe (3.5 mm in diameter), which allowed the sample to be deformed without being penetrated. The testing conditions were the room temperature of 24°C; the samples were compressed twice to 30% of their original height. Cross-head moving at a constant speed of 60 mm/min and a trigger point of 0.05 N. The TPA attributes were determined as defined by Mochizuki (2001), Bourne and Comstock (1981), Rahman and Al-Farsi (2005). The size and irregular shape of confectionery gels may affect their TPA values, so it is important to prepare standardized samples (Teratsubo et al., 2002).

The textural parameters considered in the present study were defined as: Hardness was necessary force to attain the given deformation; Adhesiveness means the work necessary to overcome the attractive forces between the surface of the food and the surface of the other materials with which the food come in contact, Cohesiveness was the strength of the internal bonds in the sample, Springiness was elastic recovery that occurred when the compressive force was removed, Chewiness meant the energy required to chew a solid food into a state ready to be swallowed (Civille and Szczesniak, 1973).

2.2.5 Sensory analysis

Sensory analysis was performed by panelists consisting of nine people trained to evaluate the texture, taste and aroma properties of mulberry pastilles using a 5-point Hedonic scale. The following texture attributes including hardness, springiness, adhesiveness, aroma and overall acceptance were determined by the panelists. A three-digit code was assigned to every pastille sample and the samples were presented in random order. The panelists determined the perceived intensity of texture attributes using 5-point hedonic scale points (in values range between 1-unacceptable to 5-most acceptable).

2.2.6 Statistical analysis

The analysis of variance was performed by ANOVA procedures (SPSS 19 for Windows). Significant differences between means were determined by Duncan's Multiple Range tests. P values <0.05 were regarded as significant.

3 Results and discussion

3.1 Physical parameters

Moisture is the amount of free water sample that comes out due to drying. Table 1 shows the moisture content and water activity (a_w) of mulberry pastille.

Guar had statistically a significant effect on the moisture of mulberry pastille (p<0.05). The increasing of gelatin concentration caused mulberry pastille samples had higher moisture content; guar gum singly also decreased the moisture content of mulberry pastilles (Table 1). The lowest moisture content was in sample 6, and samples 4, 7 had the highest moisture content.

Table 1 Physicochemical characteristics of white mulberry pastille

Sample	Guar (%)	Gelatin (%)	Water activity	Moisture (% dry basis)
1	0	0	0.45±(0.003)^{b}	25.56±(0.69) ^{a}
2	0.5	0	0.43±(0.017) ^{ba}	26.02±(0.06) ^{ba}
3	1	0	0.41±(0.009) ^{a}	25.82±(1.21)^{a}
4	0	1	0.42±(0.001)^{a}	28.42±(0.77)^{cb}
5	0.5	1	0.41±(0.018) ^{a}	26.04±(1.63) ^{ba}
6	1	1	0.42±(0.004) ^{ba}	25.24±(0.88) ^{a}
7	0	2	0.43±(0.007)^{ba}	29.02±(0.67) ^{c}
8	0.5	2	0.40±(0.004) ^{a}	27.06±(0.27) ^{cba}
9	1	2	0.41±(0.000)^{a}	25.63±(0.22) ^{a}

Note: Values in parenthesis are standard deviations; Numbers in column followed by the same letter are not significantly different (p<0.05).

Guar gum is a galacto mannan long chain with high molecular weight and, due to the nature of hydrogel and water absorption, has the structure with the ability of bonding with water (Williams and Phillips, 2000). Guar gum based on functional properties as stabilizers and good moisture preserver, is used for food formulations (Goldstein et al., 1973). It seems that guar gum, due to hydrophilic structure is able to maintain a high amount of water which leads to the increase in the moisture of samples.

Water activity is an important parameter in understanding the taste and texture of food (Hansson et al., 2001). Guar and gelatin show a significant effect on the water activity (p<0.05). The parameter of a_w decreased by increasing the concentration of hydrocolloids. Water activity value of mulberry pastilles ranged from (0.41±0.411)% to (0.45±0.003)%. The lowest value of a_w was sample 9 and sample 1 had the highest a_w value (Table 1). The presence of water in the food can be expressed as moisture content and water activity. Moisture content shows the absolute amount of water contained in food as a component of food (Kusnandar, 2010 and Barbosa-Cánovas et al., 2007).

3.2 Color parameters

In food understanding, certain factors play an important role such as structure, smell and color. When a food product is evaluated for consumption, all senses play an important part for a food product to be accepted or rejected. The color is one of the main characteristics of food quality. Most consumers associate gel with a bright and mainly light color (Kronberga et al., 2011). The color variables have been related to the types and quantities of some components present in foods (Ameny and Wilson, 1997). The results of the surface color measurements of pastille samples are presented in Table 2.

L* value represents the lightness index of a product. The statistical analysis showed that guar has a significant effect (p<0.05). By increasing the guar ratio in pastilles, samples obtained a lighter color than the gelatin mixture. It occurred because water-holding capacity of the gums was high. The lower L* values, which connects to darker colors, could create when gelatin concentration ranged from 1 up to 2%. The lowest L* values was sample 4, and sample 3 had the highest L* value.

Index of a* represents greenness and redness of the product. Statistical analysis showed that gelatin had statistically a significant influence on a* values (p<0.05). By increasing gelatin from 0 to 2% in samples, Index of a* increased compared to guar gum samples. The lowest a* value was in sample 3, and sample 4 had the highest a* value (Table 2). The b* values represent yellowness and blueness of a product. The guar gum had statistically a significant effect on b* values of pastille samples (p<0.05). Based on table 2, b* values of pastille samples decreased in all samples with increasing the concentration of guar, while gelatin concentrations produced higher b* values. The lowest b* value was in sample 3, and sample

8 had the highest *b** value. The present results are similar to those obtained by Azoubel et al., (2011).

Table 2 The effects of the used hydrocolloids on color parameters

Sample	Gelatin (%)	Guar (%)	L*	a*	b*
1	0	0	29.35±(2.09) c	10.12±(1.08) ba	27.37±(2.90) c
2	0	0.5	31.13±(1.45) c	11.68±(1.13) cba	23.42±(2.02) cb
3	0	1	31.89±(2.28) a	9.56±(0.64) a	17.91±(0.95) a
4	1	0	23.81±(1.66) c	15.66±(1.98) d	25.14±(1.47) cb
5	1	0.5	31.19±(0.76) c	13.12±(2.65) dcba	25.08±(1.79) cb
6	1	1	31.46±(0.88) c	10.48±(1.06) ba	20.31±(2.55) ab
7	2	0	24.24±(0.64) ba	14.77±(1.15) dc	23.48±(2.31) cb
8	2	0.5	29.98±(0.88) c	12.67±(0.45) dcba	28.48±(0.82) c
9	2	1	28.16±(1.76) cb	13.64±(0.94) dcb	25.59±(0.84) cb

Note: Values in parenthesis are standard deviations; Numbers in column followed by the same letter are not significantly different (p<0.05).

3.3 Measurement of texture parameters

3.3.1 Hardness

The results of the texture parameters of pastille samples are shown in Table 3. The statistical analysis showed that guar and gelatin had significant effects on the texture parameters (p<0.05).

As far as the effect of hydrocolloid levels on the texture of samples, was concerned results showed, by increasing levels of guar gum from 0% to 1%, the softness of white mulberry pastilles was increased. Hardness increased with the addition of gelatin. This might be due to the high protein content, improving the structural bonding of the gelatin (Table 3). These results were similar to the findings of Collar et al., (2001), Shafiur and Mahrouqi (2009). De Mars and Ziegler, (2001) studied gelatin/pectin-based gummy confections and observed that hardness decreased with the increasing of pectin concentration.

3.3.2 Adhesiveness

Adhesiveness increased with increasing the level of guar gum from 0% to 1% and then decreased with adding gelatin. In general, the adhesiveness of pastille samples decreased significantly as the concentration of hydrocolloids was increased (p<0.05). Possibly by the increasing of hydrocolloids in formulations, a higher amount of bonding water and components of the formulation were placed together as a denser structure and finally reduced adhesiveness of the product (Table 3). Jain and Babbar (2011) stated that, in the gel mixed agar and guar, the adhesiveness decreased with the increase of agar whereas the firmness, strength and gel resistance increased. Gelatin also showed great influence on stringiness and adhesiveness. Decrease in gelatin concentration resulted in stringy and adhesive gels (Fonkwe et al., 2003). Gelatin gels provided elasticity, while the addition of starch increased the gel strength and hardness of gelatin-based gummy confections (Marfil et al., 2012).

3.3.3 Cohesiveness

Guar and gelatin gels showed significant differences on cohesiveness (p<0.05). Cohesiveness increased with the increase of gelatin and guar of mixed gels at 1% and 0.5%, respectively. Then it decreased with the increase in hydrocolloids concentration. It could be seen that, there was a synersis effect between the ratings of mixed hydrocolloids. The lowest cohesiveness was seen in sample 4, and the sample 5 had the highest cohesiveness (Table 3).

Fruit quantity in pastille formulations influenced the concentration of used hydrocolloids, so, in this study, it had a negative effect on cohesiveness texture (Hernandez et al., 1999).

3.3.4 Springiness

Springiness was significantly (p<0.05) affected by the addition of guar and gelatin. Springiness increased with the addition of gelatin, gelatin at 1% showed the highest springiness values, while guar at 1% showed the lowest springiness values (Table 3). When springiness is high, it requires more mastication energy in the mouth. High springiness was resulted when the gel structure was broken into few large pieces during the first compression TPA whereas low springiness resulted from the gel breaking into many small pieces.

Less springy gels, such as low methoxy pectin, carrageenan and agar gels broke down more easily than a firm and springy gelatin gel during mastication (Lau et al., 2000, Marshall and Vaisey, 1972).

Lau et al., (2000) reported that Springiness was the highest at a ratio of 0.4% gellan –1.2% gelatin without adding calcium, and the lowest level was at a combination of 0.8% gellan –0.8% gelatin and a high level of calcium.

3.3.5 Chewiness

Gelatin showed higher chewiness compared with guar

(p<0.05). Chewiness as a function of water activity was measured and chewiness was found to increase with the increase of solids content (Bourne and Comstock, 1981). In the literature, it is mentioned that gumminess should be used for semi-solid foods and chewiness should be used for solid foods (Bourne, 2002).

Gelatin directly and significantly affects the chewiness, texture and assessment (Hernandez et al., 1999). The lowest chewiness value observed was sample 3, and sample 9 had the highest chewiness value (Table 3).

Table 3 Texture profile analysis of white mulberry pastille

Sample	Gelatin (%)	Guar (%)	Hardness (N)	Adhesiveness (N.s)	Cohesiveness	Springiness (mm)	Chewiness (N mm)
1	0	0	26.70±(0.69)^{cba}	–1.94±(0.36)^{edc}	1.61±(0.86)^{cb}	1.53±(0.05)^{e}	68.24±(39.14)^{cba}
2	0	0.5	23.20±(6.38)^{ba}	–1.55±(0.51)^{ed}	0.73±(0.07)^{ba}	1.22±(0.02)^{b}	20.30±(4.15)^{ba}
3	0	1	11.56±(2.31)^{a}	–1.19±(0.22)^{e}	0.91±(0.06)^{ba}	1.11±(0.02)^{a}	11.55±(1.80)^{a}
4	1	0	78.81±(3.58)^{d}	–7.49±(0.11)^{a}	0.54±(0.02)^{a}	1.69±(0.01)^{f}	72.27±(0.88)^{cb}
5	1	0.5	42.03±(3.56)^{c}	–3.77±(0.91)^{bc}	2.13±(0.15)^{c}	1.42±(0.00)^{c}	126.31±(1.78)^{c}
6	1	1	33.35±(3.89)^{cb}	–1.83±(0.23)^{edc}	1.29±(0.59)^{cba}	1.50±(0.03)^{ed}	67.30±(35.68)^{cba}
7	2	0	14.65±(0.72)^{a}	–4.36±(0.01)^{b}	0.79±(0.01)^{ba}	1.56±(0.01)^{e}	18.25±(0.69)^{ba}
8	2	0.5	103.18±(14.06)^{f}	–4.47±(1.21)^{b}	0.75±(0.27)^{ba}	1.21±(0.02)^{b}	88.51±(19.51)^{c}
9	2	1	89.98±(6.59)^{fd}	–3.51±(1.53)^{dcb}	0.96±(0.15)^{ba}	1.44±(0.02)^{dc}	126.43±(26.97)^{c}

Note: Values in parenthesis are standard deviations; Numbers in column followed by the same letter are not significantly different (p<0.05).

3.4 Sensory analysis

The results of the organoleptic assessment of the pastille samples are represented in Table 4.

Guar and gelatin were not significantly different (p< 0.05) on sensory parameters of mulberry pastilles. The flavor and aroma of samples 1, 2 and 6 had significantly higher acceptability scores compared to other samples (p<0.05). It seems that increasing the concentration of hydrocolloids leads to the decrease in acceptability scores.

The aroma of products results from volatile substances in the fresh food such as esters, ketones, terpenes, aldehydes and others. The loss of these volatiles leads to a decrease in aroma detection (Okilya *et al*., 2010).

Hollowood et al., (2002) reported that texture firmness was effective on the understanding of taste. Renard et al.(2006) stated that, with decreasing hardness gel, the understanding of the flavor increased. Samples 8 and 9 had the lowest acceptability for hardness and were generally disliked (score<5). The results showed the ratings of the acceptability of the pastille samples decreased with the increase in concentration of hydrocolloids. The highest acceptability rating for hardness was observed in sample 1, 2, and 7 (Table 4). The highest acceptability rating for Springiness was seen in sample 1, 2 and 4, while sample 8 and 9 received the lowest rating. Probably, it could be due to the increase in the concentration of gelatin.

Table 4 The acceptability scores of sensory attributes of white mulberry pastille

Sample	Gelatin (%)	Guar (%)	Flavor and aroma	Hardness	Springiness	Adhesiveness	Acceptability
1	0	0	4.22±(0.66)^{b}	4.11±(0.60)^{dcba}	4.44±(0.52)^{c}	4.44±(0.52)^{a}	4.33±(0.70)^{b}
2	0	0.5	3.78±(0.83)^{ba}	4.44±(0.52)^{d}	4.33±(0.70)^{cb}	4.22±(0.60)^{a}	4.33±(0.60)^{b}
3	0	1	3.11±(0.92)^{a}	3.89±(0.92)^{dcba}	4.11±(0.78)^{cba}	4.00±(0.86)^{a}	3.78±(0.97)^{ba}
4	1	0	3.44±(0.88)^{ba}	4.33±(0.70)^{dc}	4.33±(0.50)^{cb}	4.22±(0.66)^{a}	4.00±(0.70)^{ba}
5	1	0.5	3.44±(0.72)^{ba}	3.67±(0.50)^{cba}	4.11±(0.60)^{cba}	4.11±(0.78)^{a}	3.56±(0.72)^{ba}
6	1	1	3.78±(0.83)^{ba}	3.56±(1.01)^{ba}	4.11±(0.60)^{cba}	4.22±(0.66)^{a}	3.89±(0.92)^{ba}
7	2	0	3.00±(0.86)^{a}	4.22±(0.44)^{dcb}	4.11±(0.60)^{cba}	4.11±(0.78)^{a}	3.56±(0.88)^{ba}
8	2	0.5	3.44±(0.52)^{ba}	3.44±(0.52)^{a}	3.56±(0.52)^{a}	4.22±(0.44)^{a}	3.33±(0.50)^{a}
9	2	1	3.33±(0.70)^{b}	3.56±(0.72)^{ba}	3.67±(0.86)^{ab}	4.00±(0.86)^{a}	3.22±(0.66)^{a}

Note: Values in parenthesis are standard deviations; Numbers in column followed by the same letter are not significantly different (p<0.05).

The acceptability for adhesiveness was not significantly different (p<0.05). The sample 1 had the highest acceptability in terms of adhesiveness. The results showed that overall acceptability of the mulberry pastille was the highest in the samples 1, 2 and 4, and it was the lowest in sample 8 and 9. The obtained results were similar to those obtained for all the other sensory attribute rates. It is reported that the acceptability of fruits and vegetables is influenced by their aroma (Okilya et al., 2010). In this study, the results of overall acceptability were significantly (p<0.05) positively correlated with the acceptability of all the tested sensory attributes (Table 4).

4 Conclusion

As an important food additive, hydrocolloids are increasingly applied in several food products as the thickening and gelling agents. The present study revealed that white mulberry pastilles could be made by adding hydrocolloids to improve texture characteristics of gel suitable for pastille samples making.

The results showed that the moisture content increased with the increasing of guar and gelatin levels in formulations, while the water activity decreased by increasing the concentration of hydrocolloids. The indexes of a* and b* increased by adding gelatin, while L* values decreased. Instrumental results of texture samples showed that springiness, chewiness, adhesiveness and hardness increased with adding gelatin, while cohesiveness decreased. Hardness and adhesiveness decreased due to adding guar. Generally, sensory valuation showed that increasing the concentration of hydrocolloids led to the decrease in acceptability scores. The pastille quality was improved by all the used hydrocolloids; however, the highest improvement in overall quality of pastilles due to about adding guar gum and gelatin 1% and 1% to fruit formulation respectively.

References

Ameny, M. A., and P. W. Wilson. 1997. Relationship between hunter color values and beta carotene contents in white-fleshed African sweet potatoes (*Ipomoea batatas* Lam.). *Journal of the Science of Food and Agriculture,* 73: 301–306.

AOAC. 1990. *Official methods of analysis.* (17th ed.). Washington, DC: Association of Official Analytical Chemists.

Azoubel, P. M., A. J. B. Araujo, S. B. Oliveira, and M. R. Amorim. 2011. Restructuring passiflora cincinnata fruit pulp: influence of hydrocolloids. *Science and Technology Aliment. Campinas,* 31(1): 160–166.

Bae, S. H., and H. J. Suh. 2007. Antioxidant Activities of Five Different Mulberry Cultivars in Korea. LWT – *Food Science and Technology,* 40(6): 962–955.

Barbosa-Cánovas, G. V., A. J. Fontana Jr, S. J. Schmidt, T. P. Labuza. 2007. Water Activity in Foods: Fundamentals and Applications. Blackwell Publishing and the Institute of Food Technologists.

Barrangou, L. M., C. R. Daubert, and E. A. Foegeding. 2006. Textural properties of agarose gels. I. Rheological and fracture properties. *Food Hydrocolloids,* 20: 184–195.

Ben-zion, O., and A. Nussinovitch. 1997. A prediction of the compressive deformabilities of multilayered gels and texturized fruit, glued together by three different adhesion techniques. Food Hydrocolloids, 11(3): 253–260.

Bourne, M. C. 2002. Food texture and viscosity. Concept and measurement. (2nd ed.). London: Academic Press.

Bourne, M. C., and S. H. Comstock. 1981. Effect of degree of compression on texture profile parameters. *Journal of Texture Studies,* 12: 201–216.

Civille, G. V and A. S. Szczesniak. 1973. Guidelines to training a texture profile panel. *Journal of Texture Studies.* 4: 204–223.

Collar, C., J. C. Martinez, and C. M. Rosell. 2001. Lipid binding of fresh and stored formulated wheat breads: Relationships with dough and bread technological performance. Food Science and Technology International. 7: 501–510.

Datta, R. K. 2002. Mulberry cultivation and utilization in India. FAO Electronic Conference on mulberry for animal production (Morus1-L):19–21. Srirampura, Mysore 570 008, India. http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/FRG/MULBERRY/DEFAULT.HTM

DeMars, L. L., and G. R. Ziegler. 2001. Texture and structure of gelatin/pectin – base gummy confections. *Food Hydrocolloids,* 15: 643– 653.

Fonkwe, L. G., G. Narsimhan, and A. S. Cha. 2003. Characterization of gelation time and texture of gelatin and gelatin–polysaccharide mixed gels. *Food Hydrocolloids,* 17: 871–883.

Gong, S. X., and J. P. Zhu. 2008. Mulberry relieving nutritional anemi. *Journal Zhejiang University Traditional Chinese,* 32: 350–352.

Goldstein, A. M., E. N. Alter, and J. K. Seaman. 1973. *Guar gum*. In: whistler RL, (Eds), Industrial gums, (2nd edition.). New York: Academicl Press, 303–321.

Gundogdu, M., F. Muradoglu, R. I. Sensoy, and H. Yilmaz. 2011. Determination of fruit chemical properties of *Morus nigra* L., *Morus Alba* L. and *Morus rubra* L. by HPLC. *Scientia Horticulturae,* 132(5): 37–41.

Hansson, A., J. Andersson, and A. Leufven. 2001. The effect of sugars and pectin on flavour release from a soft drink related model system. *Food Chemistry,* 72: 363–368.

Hernandez, M. J., L. Duran, and E. Costell. 1999. Influence of composition on mechanical properties of strawberry gels. Compression test and texture profile analysis. *Food Science and Technology International,* 5: 79–87.

Hollowood T. A., R. S. T. Linforth, and A. J. Taylor. 2002. The effect of viscosity on the perception of flavor. *Chemical Senses,* 27: 583–591.

Jain, R., and S. B. Babbar. 2011. Evaluation of belends of altenative gelling agents with agar and development xanthagar, a gelling mix, suitable for plant tissue culture media. *Asian journal of biotechnology,* 3(2): 153– 164.

Khazaiy Pool, E., F. Shahidi, A. Mortazavi. 2013. *Mathematical modeling of drying kinetics of the kiwifruit pastille, 1st International e-conference on novel food processing (IECFP 2013). Ferdowsi University of Mashhad.* 2013- 02-26.

Koyuncu, F. 2004. Organic acid composition of native black mulberry fruit. *Chemistry of Natural Compounds,* 40(4), 367–369.

Kronberga, M., D. Karklina, I. Murniece, and Z. Kruma. 2011. Changes of agar-agar gel properties after replacing sucrose by inulin syrup. In *6th Baltic Conference on Food Science and Technology "Innovations for Food Science and Production"* , 137–142. FOODBALT-2011 Conference Proceedings Jelgava, LLU..

Kvaal, K., J. P. Wold, U. G. Indahi. 1998. Multivariate feature extraction from textural images of bread. *Chemical and Intelligent Laboratory Systems,* 42: 141–158.

Kusnandar, F. 2010. Food Chemistry: Macro Component. Dian Rakyat. Jakarta.

Lau, M. H., J. Tang, and A. T. Paulson. 2000. Texture profile and turbidity of gellan/gelatin mixed gels. *Food Research International*, 33: 665 – 671.

Lukinac, J., C. Jokic, M. Planinic, D. Magdic. 2009. An Application of Image Analysis and Colorimetric Methods on Color Change of Dehydrated Asparagus (*Asparagus maritimus* L.). *Agriculture Conspectus Scientifics*, 74(3): 233–237.

Marfil, P. H. M., A. C. B. M. Anhê, and V. R. N. Telis. 2012. Texture and microstructure of gelatin/corn starch-based gummy confections. *Food Biophysics,* 7: 236–243.

Marshall, S. G., and M. Vaisey. 1972. Sweetness perception in relation to some textural characteristics of hydrocolloid gels. *Journal of Texture Studies*, 3: 173–185.

Minh, N. P., T. A. D. Dong. 2013. Investigation of Saccharomyces Cerevisiae in Fermented Mulberry Juice. *Middle-East Journal of Scientific Research*, 17(6): 814–820.

Mitchell, J. 1976. Rheology of Gels. *Journal of Texture Studies*, 7, 313–339.

Mochizuki, Y. 2001. Texture profile analysis. In *Current protocols in food analytical chemistry*, ed. R. E. Wrolstad, H2.3.1.–H2.3.7). New York, NY: John Wiley and Sons Inc.

Okilya, S., L. M. Mukisa, and A. N. Kaaya. 2010. Effect of solar drying on the quality and acceptability of jack fruit leather, *Electronic journal of environmental, agricultural and food chemistry*, 9(1): 101–111.

Ozgen, M., S. Serce, and C. Kaya. 2009. Phytochemical and antioxidant properties of anthocyanin-rich Morus nigra and Morus rubra fruits. *Scientia Horticulturae,* 119: 275–279.

Pawlowski, M. A., W. Oleszek, and A. Braca. 2008. Quali-quantitative analyses of flavonoids of Morus nigra L. and Morus Alba L. (Moraceae) fruits. *Journal of Agricultural Food Chemistry,* 56, 3377–3380.

Rahman, M. S., and S. A. Al-Farsi. 2005. Instrumental texture profile analysis (TPA) of date flesh as a function of moisture content. *Journal Food Engineering*, 66: 505–511.

Renard, D., F. Van De Velde, and R. W. Vischers. 2006. The gap between food gel structure, texture and perception. *Food Hydrocolloids*, 20: 423–431.

Rodge, A. B., S. M. Sonkamble, R. V. Salve, and S. I. Hashmi. 2012. Effect of Hydrocolloid (guar gum) Incorporation on the Quality Characteristics of Bread. *Journal food Processing & Technology,* 3: 136.

Saha, D., and S. Bhattacharya. 2010. Hydrocolloids as thickening and gelling agents in food, a critical review. *Journal Food Science and Technology*. 47(6), 587–597.

Shafiur Rahman, M., and A. I. Mahrouqi. 2009. Instrumental texture profile analysis of gelatin gel extracted from grouper skin and commercial (bovine and porcine) gelatin gels. *International Journal of Food Sciences and Nutrition.* 1–14.

Shalini, K. G., and A. Laxmi. 2007. Influence of additives on rheological characteristics of whole-wheat dough and quality of Chapatti (Indian unleavened Flat bread) Part I-hydrocolloids. *Food Hydrocolloids,* 21: 110–117.

Stanley, N. F. 2006. Agars. *In: Food Polysaccharides and Their Applications*, Eds A. M., Stephen, G. O., Phillips, P. A., Williams. New York: CRC Press, 217–238.

Teratsubo, M., Y. Tanaka, and S. Saeki. 2002. Measurement of stress and strain during tensile testing of gellan gum gels: Effect of deformation speed. Carbohydrate Polymers, 47(1): 1–5.

Voutilainen, S., T. Nurmi, J. Mursu and T. H. Rissanen. 2006. Carotenoids and cardiovascular health. *American Journal Clinical Nutrition*, 83: 1265–1271.

Williams, P. A., and G. O. Phillips. 2000. *Handbook of hydrocolloid, Introduction to food hydrocolloids.* Oxford Cambridge New Delhi: Wood head Publishing Limited and CRC Press LLC..

Yamamoto, J., A. Naemura, M. Ura, Y. Ijiri, T. Yamashita, A. Kurioka, and A. Koyama. 2006. Testing various fruits for anti-thrombotic effect: I. *Mulberries Platelets,* 17(8): 555–564.

Yogurtçu, H., and F. Kamisli. 2006. Determination of Rheological Properties of Some Pekmez Samples in Turkey. Journal Food Engineering, 77: 1064–1068.