3(2): 67-74 (2017) doi: 10.3153/JFHS17009

Journal of Food and Health Science

E-ISSN 2149-0473

ORIGINAL ARTICLE/ORİJİNAL ÇALIŞMA

FULL PAPER TAM MAKALE

THE FACILITIES OF SPRAY DRIED HONEY POWDER USE AS A SUBSTITUTE FOR SUGAR IN COOKIE PRODUCTION

Mehmet Kılınç[1], Mustafa Kürşat Demir[2]

[1] Afyon Kocatepe University, Faculty of Engineering and Architecture, Depertment of Food Engineering, Afyonkarahisar, Turkey

[2] Necmettin Erbakan University, Faculty of Engineering and Architecture, Department of Food Engineering, Konya, Turkey

Received:.01.01.2017

Accepted: 06.02.2017

Published online: 21.03.2017

Corresponding author:

Mustafa Kürşat DEMİR, Necmettin Erbakan University, Faculty of Engineering and Architecture, Department of Food Engineering, Konya, Turkey

E-mail: mkdemir@konya.edu.tr

Abstract:

The cookie stands out as a high sugar content product. Recently, with the discussion of the adverse effects of sugar on health, a high number of food materials have been used as a sugar substitute. One of these is honey which was also used as sweeteners in the past. Honey might be regarded as a good alternative due to its natural origin, and its high content of vitamins, minerals and antioxidants. In this study, the mixture of honey maltodextrin (60/40%) resulting from spray-drying was incorporated in different proportions (0, 20, 40, 60, 80, 100%) instead of sugar, so the target was both to minimize the negative effect of sugar on health and to create a functional food product, enriched by nutrients. In the cookies produced, some physical, sensory, chemical and nutritional properties were investigated. With the substitution of honey powder, the diameter of the cookies and spread ratio decreased, it was found that the thickness values did not change. In addition, the hardness and $a*$ values have increased and $L*$ and $b*$ values have decreased. In terms of chemical properties; moisture, ash, mineral, total phenolic contents increased with the increasing amount of honey powder but there were not significant changes in water activity, crude protein, crude fat values of cookie samples. Thus, energy values were decreased. Consequently, it was found that substitution of sugar with 100% honey powder is suitable to improve cookies chemical and nutritional characteristics and up to 60% is suitable to protect sensory and physical properties.

Keywords: Honey powder, Nutrition, Cookie, Substitution, Sugar

Introduction

Biscuits and cookies have amazingly become one of the most desirable desserts for both youth and old people owing to low manufacturing cost, more convenience, variety in taste, crispiness, digestibility and longer shelf life (Akubor, 2003; Hooda and Jood, 2005; Hussain *et al*., 2006; Jayasena and Nasar- Abbas, 2011; Demir, 2014). Most bakery products can basically be enriched and fortified (Indrani *et al.,* 2007). A large variety and quantity of materials is produced industrially in powder form (Fitzpatrick *et al*., 2004; Fitzpatrick *et al*., 2007). Recently, additives have come into common usage in the baking industry. Lots of artificial sweeteners, which are sweeter than sucrose and nontoxic, have been developed and identified to substitute of sugar. During development of sugar-free formulations, the use of both an alternative sweetener and a bulking agent is employed (Savitha *et al*., 2008).

Honey, a natural biological product evolved from nectar and of great benefit to human beings both as food and medicine (Hebbar *et al*., 2003), contains high sugar such as fructose and glucose (80-90%) (Bogdanov, 2011; Satvihel *et al*., 2013), and water, in addition to small quantities of proteins, minerals, organic acids, and vitamins (Hebbar *et al*., 2003). It is consumed due to its unique aroma and taste as well as its numerous health-promoting properties (Alvarez-Suarez *et al*., 2010; Samborska *et al*., 2015). Honey in its natural form has several disadvantages as a result of high density and viscosity which cause difficulties in transportation and dosage (Cui *et al*., 2008; Hebbar *et al*., 2008; Samborska *et al*., 2015), and also leading to problems in mass production operations (Cui *et al*., 2008; Samborska and Czelejewska, 2014). It can change its properties as a result of cristalization (Shi *et al*., 2013), which may contribute to the development of osmophile yeast and fermentation (Bhandari *et al*., 1999; Hebbar *et al*., 2008; Samborska *et al.,* 2015).

Production of honey dry powder is difficult mainly because of the high content of sugars and organic acids (Truong *et al*., 2005; Rodriguez-Hernandez *et al*., 2005; Zareifard *et al*., 2012; Murugesan and Orsat, 2012; Samborska *et al*., 2015). Dried honey, like the powders can be used for direct consumption, applied as an additive to a range of food products such as beverages, yogurts, snacks, sauces, edible coatings, as well as dietary supplements. The use of dried honey as an additive for some bakery products enhance their attractiveness, improves their flavour, aroma, color, texture and helps to maintain high product quality (Samborska and Bienkowska, 2013). The honey powder is frequently produced by adding ingredients such honey, anti-caking agent, emulsifier, and filler materials of high molecular weight to increase glass transition temperature of a mixture and to minimize the problem during drying (difficult to dry and sticky) (Bhandari and Howes, 1999). The filler materials used are carbohydrate group such as starch, maltodextrin, carboxy methyl cellulose, arabic gum, and protein group such as gelatin (Barbosa-Cánovas *et al*., 2005). Honey powder with its low moisture content has the capability to be easily mixed with other ingredients apart from other advantages including convenience, ease of handling, reduced storage space, sanitation and storage for a longer period. Various methods of drying honey have been used such as spray drying, vacuum drying, tunnel drying and solidification into blocks by crystallization (Cui *et al*., 2008). Nevertheless, drying of honey poses many problems such as low recovery rates because of its high sugar content (Wang and Langrish, 2009) and also utilization of at least 50-70% of additives to obtain a dried powder (Cui *et al*., 2008). Spray drying of high sugar content liquids like honey involves the use of additives that serve as drying agents such as maltodextrin and gum Arabic (Cano-Chauca *et al*., 2005; Wang and Langrish, 2009). The conversion of liquid honey into powder form by spray drying may have the problems of hygroscopicity and stickiness which is mainly because of the presence of a high proportion of low-molecular-weight sugars in honey (Adhikari *et al*., 2007). The sticky problem leads to important economic loss and operating problems during drying, and so limits the application of spray drying for food and pharmaceutical materials (Maa *et al*., 1998; Boonyai *et al*., 2004).

Honey, which is one of widely consumed foods, has considerable nutritional properties with respect to sugar. In this study, honey, a natural source of sugar, was used in the production of cookies as a replacement of sugar. For this purpose, honey was produced in granulated form and the experiment was carried out with mixture of the granulated form of honey and maltodextrin as a carrier (60-40% v/w) using a spray-dryer unit. Then, the obtained honey powder (HP) was used as a replacement of sugar in different levels (0, 20, 40, 60, 80 and 100%) for the production of cookies. With the present study, it was aimed to determine the effect of HP addition on the physical, chemical, nutritional and sensory properties of the cookies.

Materials and Methods

Materials: Wheat flour, sodium bicarbonate and ammonium bicarbonate were obtained from Golda Biscuit and Food Industry A.Ş. (Karaman, Turkey). All-purpose shortening, skimmed milk powder, salt, sugar and flower honey were procured from local market in Konya, Turkey. High-fructose corn syrup (HFCS-F55) and maltodextrin (Dry MD-01915) were purchased from Cargill (Turkey). The samples were kept at +4°C till the analysis.

Honey powder production: Honey and maltodextrin (as a carrier) (60-40% v/w) was spray dried by Niro-Atomizer laboratory type pilot drying unit in the plant of Enka Dairy and Food Products Co., Konya, Turkey. The procedure took 60 min with an inlet air temperature of 200ºC and an outlet air temperature not exceeding 70ºC. Particles sizes were in the range of 5-25 µm.

Production of cookies: The cookies were prepared by modifying method 10-54.01 of AACCI (AACCI, 2000). Following recipe was used for the preparation of cookies in Table 1. HP was used as a replacement of sugar in different levels (0, 20, 40, 60, 80 and 100%) for the production of cookies. All ingredients used for cookie preparation were kept at room temperature. Cookie dough was mixed in Kenwood mixer (Kenwood KMX-50, United Kingdom). The dough was sheeted to a thickness of 5 mm and cut into round shapes using a 55 mm diameter dough cutter. The dough was transferred to aluminum trays and placed in a baking oven (LG MP-9485S, Seoul, Korea). These were baked at 160ºC for 10 min. Afterwards the cookie samples were allowed to cool at room temperature (22ºC) and these samples were packaged in polyethylene bags, until used.

Analysis methods: The AACC International methods were used for the determination of moisture (method 44-19.01), ash (method 08-01.01), crude protein (method 46-12.01) and crude fat (30-25.01) contents (AACCI, 2000). Water activity was measured with an Aqualab apparatus (Decagon Devices Inc., Model series 3TE, USA). Pure water (1.000 ± 0.003%) was used as standard for equipment calibration.

A digital micrometer (0.001 mm, Mitutoyo, Minoto-Ku, Tokyo, Japan) was used to measure the dimensions (diameter and thickness) of the cookie samples (AACCI method 10-54.01). The spread ratio was found using the following formula;

Spread ratio = Diameter (D) / Thickness (T)

The hardness of cookie samples after baking was measured in Newton's by a texture analyzer (TA-XT plus, Stable Microsystems, UK) equipped with 3-point bend ring. Three cookies were selected randomly and applied to the base of analyzer. Settings included pre-test speed of 1mm/s, test speed of 3mm/s, post-test speed 10mm/s, distance 5 mm, trigger force 50g and load cell: 30 kg.

Carbohydrate values are calculated; CHO %=100 – (moisture % + crude protein % + crude fat % + ash %). Energy values are calculated; energy (kcal/100 g) = [4 x (CHO % + crude protein %) + 9 x (crude fat %)] (Karaağaoğlu *et al*., 2008).

Table 1. Formulation of cookies

Ingredients	Control Weight (g)	20% HP	40% HP	60% HP	80% HP	100% HP
Wheat flour	100					
Sugar	42.0	33.6	25.2	16.8	8.4	0
Honey powder (HP)	0	8.4	16.8	25.2	33.6	42
All- purpose shortening	40.0					
High fructose corn- syrup	1.5					
Salt (NaCl)	1.25					
Skimmed milk power	1.0					
Sodium bicarbonate	1.0					
Ammonium bicarbonate	0.5					
Deionized water	Variable (13-17 mL)					

Color measurement was performed using Hunter Lab Color Quest II Minolta CR 400 (Konica Minolta Sensing, Inc., Osaka, Japan). The color measurements were determined according to the CIELab color space system (Francis, 1998). Color was expressed as *L** (100 = white ; 0 = black), *a** (+, redness ; -, greenness), and *b** (+, yellowness ; -, blueness).

The mineral (Ca, Fe, K, Mg, Mn, P and Zn) contents of the raw materials and cookie samples were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES) (Vista series, Varian International AG, Switzerland) with an automatic sampler system. Approximately 0.5 g of the sample was put into a burning cup, and 5 mL of HNO_3 +5 mL H_2SO_4 was added. The samples were incinerated in a microwave oven (Mars 5, CEM Corporation, USA). The solution was diluted to 100 mL with water. Concentrations were determined by ICP-AES (Bubert and Hagenah, 1987).

Total phenolic content (TPC) was determined using the Folin-Ciocalteau method (Singleton and Rossi 1965). The TPC was used a Hitachi-U1800 spectrophotometer (Hitachi High-Technologies, Tokyo, Japan). The results were expressed as µg gallic acid equivalents per g sample.

Sensory evaluation of cookies: The sensory evaluation was performed by a panel of panelists, consisting of scientific staff of the department of Food Engineering, Faculty of Engineering and Architecture, University of Necmettin Erbakan, chosen for their experience in the sensory analysis of food. Cookie samples were evaluated by ten panelists, who are familiar with the characteristics of cookies. Ages ranged from 21 to 55. Seven of them were females. All panelists were non-smokers. Instructions were given in full to panelists beforehand. The samples were brought to room temperature before testing. The samples were coded with letters and the order of sample presentation was completely randomized for serving to the panelists to guard against any bias. The panelists cleansed their palates with water before rating each sample. The panelists were asked to score the cookie in terms of color, taste odor, appearance and overall acceptability using a hedonic scale. Each feature, a score between 1 and 5 (5: very good; 4: good; 3: moderate; 2: poor; 1: very bad) to be evaluated over 5points.

Statistical analysis: A commercial software program (Tarist, version 4.0; Izmir, Turkey) was used to perform statistical analyses. Data were assessed by analysis of variance. Means that were statistically different from each other were compared using Tukey-Q tests at 5% confidence interval. Standard deviations were calculated using the same software.

Results and Discussion

Analytical results: The investigated characteristics of honey powder were: *L** values 93.37 ±0.47, *a** values -0.68 ±0.03, *b** values 9.80 ±0.14, moisture 3.47 ±0.05%, ash 0.23 ±0.01%, water activity 0.30 ±0.01, total phenolic content 0.58 ±0.01 µg GAE/g, calcium 24.93 ±0.6 mg/100g, iron 1.57 ±0.04 mg/100g, potassium 76.52±1.26 mg/100g, magnesium 12.71 ±1.70 mg/100g, manganese 0.25 ±0.01, phosphorus 122.63 ±3.49 mg/100g and zinc 0.54 ±0.01 mg/100g. Also, the approximate composition of wheat flour used in this study was *L*, a*, b* values* 93.14 ±1.42, -0.72 ±0.17, 9.20 ±0.35 respectively, moisture 12.15 ±1.07%, ash 0.59 ±0.01%, crude protein 10.48 ±0.11%, crude fat 0.45 ±0.08%, water activity 0.51 ±0.04 and total phenolic content 0.66 ±0.03 µg GAE/g.

Physical properties of cookies: The effect of HP on physical characteristics of cookies including diameter, thickness, spread ratio, hardness and color (*L**, *a** and *b**) were given in Table 2. According to the Table 2, the addition of HP to the cookie samples resulted in a slight increase in the product thickness values. However, the cookie samples did not have any significant effect ($P < 0.05$) thickness values. Also, cookie diameter values decreased as levels of HP and this led to a reduction in spread ratio. The lowest spread ratio (7.24 ± 0.12) and the highest hardness (45.17 ± 0.16) values were obtained for the cookies made up with 100% HP. The lowest hardness values were determined for control group. According to these results, the use of HP led to more compact cookie dough and cookies with harder characteristics. Demir (2014) reported that pekmez powder increased hardness of cookies. Color values of cookies were presented in Table 2. According to the Table 2; the brightness (*L**) values of cookies produced with 100% S (control group) were found higher. There were slightly decrease *L** values and increase *a** values with HP addition, but the differences were not statistically significant. Also, the lowest *b** values were determined in the cookies made with 100% HP. Demir (2014) reported that *L** (brightness) values of cookies declined and *a** (redness) and *b** (yellowness) values raised after the replacement of sugar with pekmez powder.

Table 2. Physical, textural and color properties of cookie samples (mean values±SD)[1].

Samples[2]	Diameter (D) (mm)	Thickness (T) (mm)	Spread ratio (D/T)	Hardness (N)	Color values		
					L*	a*	b*
Control (100% S)	64.72±0.40[a]	8.38±0.24[a]	7.72±0.17[a]	28.27±7.14[c]	70.52±1.30[a]	3.49±0.13[b]	27.25±0.28[a]
80% S : 20% HP	63.56±0.54[ab]	8.29±0.29[a]	7.67±0.20[ab]	30.73±1.03[c]	66.32±0.96[b]	4.82±0.18[a]	27.14±0.44[a]
60% S : 40% HP	62.57±0.83[bc]	8.51±0.16[a]	7.36±0.24[abc]	32.98±5.04[bc]	65.86±0.36[b]	4.88±0.19[a]	27.09±0.91[a]
40% S : 60% HP	62.97±0.21[bc]	8.31±0.08[a]	7.58±0.10[abc]	33.48±1.54[abc]	65.75±0.74[b]	4.97±0.76[a]	26.59±0.64[ab]
20% S: 80% HP	62.13±0.49[c]	8.62±0.10[a]	7.21±0.14[c]	41.31±2.43[ab]	64.77±1.10[b]	5.00±0.24[a]	26.08±0.89[ab]
100% HP	62.09±0.01[c]	8.57±0.14[a]	7.24±0.12[c]	45.17±0.76[a]	64.01±0.94[b]	5.16±0.16[a]	25.23±0.70[b]

[1] The means with the same letter in column are not significantly different (*P<0.05*). [2]S: Sugar, HP: Honey Powder

Table 3. Some chemical characteristics of cookie samples (mean values±SD)[1].

Samples[2]	Moisture %	Water activity (aw)	Ash (%)	Crude Protein (%)	Crude Fat (%)	Carbohydrate (%)	Energy (kcal/ 100g)	Total phenolic content (µg GAE/g)
Control (100% S)	2.99±0.02[d]	0.24±0.05[a]	1.09±0.01[f]	6.32±0.06[a]	18.46±0.49[a]	71.15±0.56[a]	475.97±2.38[a]	0.65±0.02[e]
80% S : 20% HP	3.68±0.25[c]	0.20±0.03[a]	1.12±0.01[e]	6.34±0.06[a]	18.05±0.64[a]	70.81±0.84[a]	471.01±2.19[ab]	0.85±0.02[d]
60% S : 40% HP	3.99±0.01[b]	0.21±0.03[a]	1.18±0.01[d]	6.33±0.08[a]	18.22±0.28[a]	70.29±0.35[a]	470.40±1.44[ab]	0.92±0.02[c]
40% S : 60% HP	4.16±0.07[ab]	0.22±0.01[a]	1.22±0.01[c]	6.35±0.06[a]	18.33±0.42[a]	69.94±0.41[a]	470.14±2.42[ab]	1.00±0.02[b]
20% S: 80% HP	4.33±0.04[a]	0.20±0.01[a]	1.26±0.01[b]	6.34±0.08[a]	18.27±0.69[a]	69.81±0.63[a]	468.99±3.30[ab]	1.07±0.03[ab]
100% HP	4.49±0.01[a]	0.22±0.01[a]	1.31±0.01[a]	6.34±0.05[a]	18.34±0.78[a]	69.52±0.81[a]	468.50±3.96[b]	1.17±0.03[a]

[1] The means with the same letter in column are not significantly different (*P<0.05*). Values are dry weight basis. [2]S: Sugar, HP: Honey Powder

Table 4. Mineral content (mg/100g) of cookie samples (mean values±SD)[1].

Samples[2]	Ca	Fe	K	Mg	Mn	P	Zn
Control (100% S)	31.28±1.4[f]	1.58±0.01[f]	149.89±0.78[f]	28.90±1.03[f]	0.60±0.01[f]	216.04±7.17[f]	0.95±0.01[f]
80% S : 20% HP	33.66±0.1[e]	1.87±0.01[e]	159.18±0.66[e]	31.06±0.26[e]	0.66±0.01[e]	238.08±0.89[e]	1.03±0.03[e]
60% S : 40% HP	37.68±0.2[d]	2.05±0.03[d]	175.21±1.48[d]	32.89±0.80[d]	0.73±0.01[d]	262.54±4.12[d]	1.15±0.01[d]
40% S : 60% HP	41.73±0.3[c]	2.24±0.02[c]	188.96±0.72[c]	35.73±0.21[c]	0.79±0.01[c]	278.22±1.52[c]	1.28±0.04[c]
20% S : 80% HP	44.32±0.7[b]	2.45±0.03[b]	213.83±2.08[b]	37.96±0.16[b]	0.91±0.01[b]	304.77±0.91[b]	1.42±0.02[b]
100% HP	47.99±0.7[a]	2.58±0.02[a]	226.73±1.47[a]	40.80±0.12[a]	1.03±0.02[a]	328.50±4.81[a]	1.58±0.04[a]

[1] The means with the same letter in column are not significantly different (*P<0.05*). Values are dry weight basis. [2]S: Sugar, HP: Honey Powder

Chemical properties of cookies: Moisture and water activity of cookie samples were given in Table 3. Moisture and water activity values of the cookie samples ranged between 2.99 ±0.02 - 4.49 ±0.01 and 0.20 ±0.01 - 0.24 ±0.05 respectively. According to Table 3, there were not statistically significant changes in water activity, while moisture values significantly changed when sugar was replaced by HP (P<0.05). The moisture content of cookies in control group produced with only sugar (100% S) as sweetener were higher than the other cookie samples, and moisture content of the cookies increased when HP was used instead of sugar.

Also, some chemical properties of cookie samples were given Table 3. Ash values of cookie samples ranged between 1.09 ±0.01 and 1.31 ±0.01 respectively. Ash values significantly changed when HP incorporated to the cookies. The highest ash values were determined in the cookies made with 100% HP, while cookies of control group had the lowest ash content. This was an expected result, because honey is a very rich nutrient product. Crude protein, crude fat and carbohydrate content were not statistically significant changes. Honey protein values are low, but protein quality is high (Alvarez-Suarez *et al.*, 2010).

Carbohydrate content of the cookie samples ranged between 69.52 ±0.81 and 71.15 ±0.56. Also energy values were changed from 468.50 ±3.96 to 475.97 ±2.38. The highest energy values were determined in the cookies made with 100% S (control group). Total phenolic content were changed ranged from 0.65 ±0.02 to 1.17 ±0.03. There were statistically significant changes (P< 0.05). The highest total phenolic content was determined in the cookies made with 100% HP, while cookies of control group had the lowest total phenolic content. However, honey powder has high total phenolic content, but in the spryer dryer, some phenolic content may effect from temperature.

Mineral content of cookies: The changes in mineral content in cookie samples as a result of HP addition are given in Table 4. According to Table 4, depending on HP addition levels Ca, Fe, K, Mg, Mn, P and Zn showed increasing trend. In other words, the replacement of S with HP and increasing the ratios of this replacement raised mineral content of the cookie samples. Cookie samples containing 100% S (control) had the lowest values of Ca, Fe, K, Mg, Mn, P and Zn minerals. According to the control, Ca, Fe, K, Mg, Mn, P and Zn contents (mg/100g) increased from 31.28 ±1.40, 1.58 ± 0.01, 149.89 ± 0.78, 28.90 ±1.03, 0.60 ± 0.01, 216.04 ±7.17 and 0.95 ±0.01 to 47.99 ±0.70, 2.58 ±0.02, 226.73 ±1.47, 40.80 ±0.12, 1.03 ±0.02, 328. 50 ±4.81 and 1.58 ±0.04 in cookie sample containing 100% HP, respectively. This was an expected result. It was reported by many studies that honey is a very rich source of major and minor minerals (Alvarez-Suarez *et al.*, 2010).

Sensory properties of cookies*:* The sensory scores of cookie samples were presented in Table 5. The highest addition level of HP (100% HP) decreased all sensory scores of cookie samples compared to control group (100% S). According to the results, the cookies containing 80% S:20% HP combination had the highest scores for taste. HP addition decreased odor score of cookie. But this decrement was not found significant (P< 0.05). Also, the samples containing HP levels more than 60% had lower scores. Overall acceptability score of cookie containing high HP was assessed with lower sensory scores than containing high S by the panelist. In conclusion, the most preferred cookies in terms of sensory properties were the ones containing 60% HP and 40% S.

Table 5. Sensory properties of cookie samples (mean values±SD)[1].

Samples[2]	Taste	Color	Odor	Appearance	Overall Acceptability
Control (100% S)	4.50±0.45^{ab}	4.50±0.50^{a}	4.20±0.50^{a}	4.90±0.22^{a}	4.60±0.42^{a}
80% S : 20% HP	5.00±0.45^{a}	4.80±0.45^{a}	4.70±0.45^{a}	4.80±0.45^{ab}	4.70±0.45^{a}
60% S : 40% HP	4.60±0.55^{a}	4.90±0.22^{a}	4.20±0.45^{a}	4.50±0.50^{ab}	4.70±0.45^{a}
40% S : 60% HP	4.00±0.45^{bc}	4.00±0.71^{a}	4.20±0.45^{a}	4.20±0.45^{ab}	4.10±0.74^{ab}
20% S : 80% HP	3.90±0.55^{c}	2.90±0.55^{b}	4.00±0.71^{a}	4.10±0.55^{b}	3.50±0.87^{b}
100% HP	3.90±0.55^{c}	2.40±0.55^{b}	4.00±0.71^{a}	4.10±0.55^{b}	3.10±0.74^{b}

[1] The means with the same letter in column are not significantly different (*P<0.05*). [2]S: Sugar, HP: Honey Powder

Conclusion

Sugar-free or reduced-sugar foods are very popular in the World. Cookies contain large amounts of sugar and fat and are usually avoided by dieters. Therefore the creation of low-fat and/or sugarless cookies is a challenge for the bakery industry. In this study, the use of powdered form of honey instead of sugar in cookies was investigated. According to the results, moisture, ash, mineral, total phenolic contents increased with the increasing amount of honey powder but there were not significant changes in water activity and crude fat values of cookie samples. Also, carbohydrate values decreased, descriptively. Thus, energy values were decreased. As a result, HP was successfully incorporated in to cookie formulation. It was found that substitution of sugar with 100% honey powder is suitable to improve cookies chemical and nutritional characteristics and up to 60% is suitable to protect sensory and physical properties.

Acknowledgements

This research was summarized from *Master Thesis (*Necmettin Erbakan University the Graduate School of Natural and Applied Science Department in Food Engineering) by Mehmet KILINÇ.

References

AACCI (2000). Approved methods of the American Association of Cereal Chemists, AACC International, St. Paul MN, USA.

Adhikari, B., Howes, T., Shrestha, A.K. & Bhandari, B.R. (2007). Development of stickiness of whey protein isolate and lactose droplets during convective drying. *Chemical Engineering and Processing: Process Intensification,* 46*,* 420-428.

Akubor, P.I. (2003). Functional properties and performance of cowpea/plantain/wheat flour blends in biscuits. *Plant Foods for Human Nutrition*, 58, 1-8.

Alvarez-Suarez, J.M., Tulipani, S., Romandini, S., Bertoli, E. & Battino, M. (2010). Contribution of honey in nutrition and human health: A review. *Mediterranean Journal of Nutrition and Metabolism*, 3, 15-23.

Barbosa-Canovas, G.V., Ortega-Rivas, E., Juliano, P. & Yan, H., (2005). Food Powders: Physical Properties, Processing, and Functionality. New York, Kluwer Academic/Plenum Publishers.

Bhandari, B., D'Arcy, B. & Chow, S. (1999). Rheology of selected Australian honeys. *Journal of Food Engineering*, 41, 65-68.

Bhandari, B.R. & Howes, T. (1999). Implication of glass transition for the drying and stability of dried food. *Journal of Food Engineering*, 40, 71-79.

Bogdanov, S. (2011). Honey as nutrient and functional food: A review. *Journal Bee Product Science*, 1-31.

Boonyai, P., Bhandari, B. & Howes, T. (2004). Stickiness measurement techniques for food powders: A review. *Powder Technology*, 145, 34-46.

Bubert, H. & Hagenah, W.D. (1987). Detection and measurement. In P.W.J.M. Boumans (Ed.), *Inductively coupled plasma emission spectroscopy*, (pp. 536-567). NewYork, Wiley-Interscience Publishers.

Cano-Chauca, M., Stringheta, P.C., Ramos, A.M. & Cal-Vidal, J. (2005). Effect of the carriers on the microstructure of mango powder obtained by spray drying and its functional characterization. *Innovative Food Science and Emerging Technologies*, 6, 420-428.

Cui, Z.W., Sun L.J., Chen, W. & Sun, D.W. (2008). Preparation of dry honey by microwave–vacuum drying. *Journal of Food Engineering*, 84, 582-590.

Demir, M.K. (2014). Effect of the replacement of sugar with spray dried grape pekmez (pekmez powder) on some properties of cookies. *Quality Assurance and Safety of Crops and Foods*, 6, 229-235.

Fitzpatrick, J.J., Iqbal, T., Delaney, C., Twomey, T. & Keogh, M.K. (2004). Effect of powder properties and storage conditions on the flowability of milk powders with different fat contents. *Journal of Food Engineering*, 64, 435-444

Fitzpatrick, J.J., Hodnett, M., Twomey, M., Cerqueira, P.S.M., O'Flynn, J. and Roos, Y.H. (2007). Glass transition and the flowability and caking of powders containing amorphous lactose. *Powder Technology*, 178, 119-128.

Francis, F.J. (1998). Colour analysis. In S.S. Nielsen (Ed.), *Food analysis*, (pp. 599-612). Maryland, GAithersnurg, USA, An Aspen Publishers.

Hebbar, H.U., Nandini, K.E., Lakshmi, M.C. & Subramanian, R. (2003). Microwave and infrared heat processing of honey and its quality. *Food Science and Technology Research,* 9, 49-53.

Hebbar, H.U., Rastogi, N.K. & Subramanian, R. (2008). Properties of dried and intermediate moisture honey products: A review. *International Journal of Food Properties*, 11, 804-819.

Hooda, S. & Jood, S. (2005). Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. *Food Chemistry*, 90, 427-435.

Hussain, S., Anjum, F.M., Butt, M.S., Khan, M.I. & Asghar, A. (2006). Physical and sensoric attributes of flaxseed flour supplemented cookies. *Turkish Journal of Biology*, 30, 87-92.

Jayasena, D. & Nasar-Abbas, S.M. (2011). Effect of lupin flour incorporation on the physical characteristics of dough and biscuits. *Quality Assurance and Safety of Crops and Foods,* 3, 140-147.

Indrani, D., Prabhasankar, P., Rajiv, J. & Venkateswara Rao, G. (2007). Influences of whey protein concentrate on the rheological characteristics of dough, microstructure and quality of unleavened flat bread (Parotta). *Food Research International*, 40, 1254-1260.

Karaağaoğlu, N., Karabudak, E., Yavuz, S., Yüksek, O., Dinçer, D., Tosunbayraktar, G. & Eren, H.F. (2008). Protein, fat, moisture, carbonhyrate and energy values of different type of breads. *The Journal of Food*, 33, 19-25.

Maa, Y.F., Nguyen, P.A.T. & Hsu, S.W. (1998). Spray drying of air-liquid interface sensitive recombinant human growth hormone. *Journal of Pharmaceutical Sciences*, 87, 152-159.

Murugesan, R. & Orsat, V. (2012). Spray drying for the production of nutraceutical ingredients-a review. *Food and Bioprocess Technology,* 5, 3-14.

Rodríguez-Hernández, G.R., González-García, R., Grajales-Lagunes, A., Ruiz-Cabrera, M.A. & Abud-Archila, M. (2005). Spray-drying of cactus pear juice (Opuntia streptacantha): effect on the physicochemical properties of powder and reconstituted product. *Drying Technology*, 23, 955-973.

Samborska, K. & Bieńkowska, B. (2013). Physicochemical properties of spray dried honey preparations. *Zeszyty Problemowe Postępów Nauk Rolniczych*, 91-105.

Samborska, K. & Czelejewska, M. (2014). The influence of thermal treatment and spray drying on the physicochemical properties of Polish honeys. *Journal of Food Processing and Preservation*, 38, 413-419.

Samborska, K., Gajek, P. & Kamińska-Dwórznicka, A. (2015). Spray drying of honey: the effect of drying agents on powder properties. *Polish Journal of Food and Nutrition Sciences*, 65, 109-118.

Sathivel, S., Ram, A.K., Espinoza, L., King, J., Cueto, R. & Solval, K.M. (2013). Application of honey powder in bread and its effect on bread characteristics. *Journal of Food Processing and Technology*, 4, 1-9.

Savitha, Y.S., Indrani, D. & Prakash, J. (2008). Effect of replacement of sugar with sucralose and maltodextrin on rheological characteristics of wheat flour dough and quality of soft dough biscuits. *Journal of Texture Studies*, 39, 605-616.

Shi, Q., Fang, Z. & Bhandari, B. (2013). Effect of addition of whey protein isolate on spray-drying behavior of honey with maltodextrin as a carrier material. *Drying Technology*, 31, 1681-1692.

Singleton, V.L. & Rossi, J.A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American journal of Enology and Viticulture,* 16, 144-158.

Truong, V., Bhandari, B.R. & Howes, T. (2005). Optimization of co-current spray drying process of sugar-rich foods. Part I-moisture and glass transition temperature profile during drying. *Journal of Food Engineering*, 71, 55-65.

Wang, S. & Langrish, T. (2009). A review of process simulations and the use of additives in spray drying. *Food Research International*, 42, 13-25.

Zareifard, M.R., Niakousari, M., Shokrollahi, Z. & Javadian, S. (2012). A feasibility study on the drying of lime juice: the relationship between the key operating parameters of a small laboratory spray dryer and product quality. *Food and Bioprocess Technology*, 5, 1896-1906.