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Study the properties of honey powder produced from spray drying and vacuum drying method

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Abstract: In this study, honey powder produced from vacuum and spray drying method were characterized for their yield, chemical and physical properties (moisture content, pH, total and reducing sugar content, sugar composition, HMF content, DN, a_w, color and glass transition temperature), hygroscopic rate and hygroscopicity and hedonic test. The destruction effect of heating is more prominent on honey powder of vacuum drying than that of spray drying and is markedly reduced by the addition of Arabic gum in both drying methods. The honey powder yield of vacuum drying is higher than that of spray drying (72.985 – 73.745% versus 9.72 – 36.596%). The addition of arabic gum increase the higroscopicity of the honey powder compared to the addition of maltodextrin. In adition, Arabic gum increases the wetability and dispersing time of the honey powder. The panelist indicated their preferences for the honey powder produced by vacuum drying due to its aroma and taste and that the hedonic scale of the honey powder is within the range of neutral to like.

Keywords: Honey, vacuum drying, spray drying, honey powder

Introduction

The processing of liquid honey into honey powder is difficult as the high sugar content contributed to the stickiness of the dried honey (Canovas *et al*., 2005). The honey powder is usually produced by adding ingredients such honey, emulsifier, anti caking agent and filler materials of high molecular weight to increase glass transition temperature of a mixture and to minimize the problem during drying (sticky and difficult to dry) (Bhandari and Howes, 1999). The filler materials used are carbohydrate group such as starch, carboxy methyl cellulose, Arabic gum, maltodextrin and protein group such as gelatin (Canovas *et al*., 2005).

The stickiness problem of honey during drying can be addressed by applying the concept of glass transition temperature (Tg) through two approaches; low drying temperature (if possible lower than honey's Tg) and addition of high molecular weight filler material (Bhandari and Howes, 1999), as the addition of filler to honey could increase its Tg and also encapsulate the honey itself. Pure honey powder might be impossible to produce even through freeze drying method. Honey powder be produced by freeze drying methodt could not be stored at ambient temperature because it can easily becomes sticky and rubbery. Hence, mixed honey powder is usually produced by spray drying and drum drying method which are more costly. The use of foam mat drying method is a less efficient process due to the small drying capacity per batch.

With regards to the vacuum drying method, based on ideal gas law, at lower absolute pressure (vacuum condition), the water can evaporate at lower temperature than that at the normal condition (ambient pressure, 1 atm). Furthermore, the addition of filler to honey could increase its Tg and thus by combining these two method, it is hoped that the drying proces could be achieved at a lower cost and can be applied to small and medium scale industry. Thus, the objective of this research is to produce honey powder using a simple vacuum drying method and to compare the characteristic of the honey powder produced from vacuum and spray drying method.

Materials and Methods

Liquid honey (Perhutani's honey from Bandung Indonesia), Maltodekstrin and Arabic gum (Bratachem), liquid soy lecithin (CV. Jebsen and Jessen Chemical Indonesia) and Calcium stearate (CV. WMK Indonesia) were used in this study. The measurement of glass transition temperature was done at the food engineering laboratory of Bogor Agricultural University (IPB), Bogor-Indonesia, whereas HMF and DN evaluation were carried out at the Agro industrial board (BBIA), Bogor.). The determination of the sugar composition was was

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done at the CV. Saraswati Indo Genetech Bogor, Indonesia by the HPLC method. The honey powder were obtained by the from spray and vacuum drying method with filler to honey ratio of 50:50. The filler materials used were maltodextrin and arabic gum. Four treatments approach were carried out: mixture of spray dried honey and maltodextrin dried; mixture spray dried honey and arabic gum; mixture of vacuum dried honey and maltodextrin; and mixture of spray dried honey and arabic gum. Honey powder of Plant Lipids (USA) was used as a control. The parameters for the spray drying method were: inlet temperature of 180°C, outlet temperature of + 80°C, ratio of honey and filler to water 1:3-3.6, and sampel weight of + 700 gram. The oven vacuum conditions were as follows: drying room of 26 cm x 23 cm x 23 cm, drying temperature of 60°C, P_{vacuum} 25 in Hg ($P_{absolute}$ = 4.921 inHg), sampel weight of + 200 gram and drying time of + 1 hour.

The liquid honey used as sample is stabilized by storing it in a chamber filled with silica gel for about one week, before being used in the experiment. Liquid honey was analyzed for moisture content by the refractive method (AOAC, 1999), total and reducing sugar content were analysed according to Sudarmadji (1996), sugar composition were determined by HPLC, HMF and DN (BSN, 2004), and glass transition temperature was determined unsing the (Shimadzu-60. Filler materials were analyzed for moisture content (destilation method), a_w (aw meter), and DE value (only for maltodextrin by determining its reducing sugar content ratio to its total solid content) (Chapkin, 2006). Honey powder was analyzed for moisture content by destilation method (Sudarmadji, 1996), color by chromameter CR-400, measurement of wetability by the time needed for powder sample to be fully wetted after pourinf from a funnel. The hygroscopic rate was measured by determining a slope of weight change of honey powder at 4 hours storage while higrocopicity is determined by measuring the amount of equilibrium moisture absorbed by a sample after storaged in condition of RH 79.5% (Gea Niro Research Laboratory, 2005), the dispersing time is determined by measuring the time needed for sample being fully dispersed (Ranggana, 1977) and the hedonic test was carried out according to Soekarto (1985).

Result and Discussion

The properties of honey and filler materials

The liquid honey used as raw material has moisture content that comply with the Indonesian standard with a maximum value of 22% (the moisture content 19.6 – 20%) (BSN, 2004), and a_w value in the range of 0.57 – 0.64. Honey is categorized as a stable food due to its low a_w value. Honey with a_w value higher than 0.6 is susceptible to attacked by osmophilic yeast such as *Saccharomyces rouxii* and some molds such as *Aspergillus echinulatus* and *Monascus bisporus* (Fennema and Tannenbaum, 1996), which may result in the changes to the quality of honey. The stabilization honey during storage requires a decrease of its a_w value to less than 0.6 and Table 1 shows that the a_w value for the honey was 0.59 with a moisture content of 18.4% and reducing sugar content complied with the standard of minimal 65%. The pH value of the honey stabilized within the range of 3.7 – 3.9 and the main organic acid of honey are citric and gluconic acid (Chmelewska, 2004). The decreasing values of the pH of the honey during storage are an indication that there may be microbial growth that ferments the sugar content into organic acid.

Table 1. Chemical and physical properties of honey and filler material

	Moisture (% wb)	pH	aw	Reducing sugar (%wb)	Total Sugar (% wb)	Tg (°C)	DE
Honey	19.9	3.8	0.62	72.1	82.8	-47.5 (-53.5 - -35.5)	
Honey after Stabilization	18.4	3.8	0.59	70.5	80.3	-44.5 (-58.0 - -40.0)	
Maltodextrin	8.6		0.65			205.5 (178-232.5)	17.8
Arabic Gum	10.4		0.39			194.5 (160-232)	

wb = wet basis; DE=Dextrose Equivalent; Tg= Glass Transition Temperature

The filler materials, maltodextrin and Arabic gum, was used as drying aid of the honey. The physical and chemical properties of the filler are presented in Table 1. It can be seen that the Arabic gum has moisture content higher than maltodextrin but its a_w value is lower than maltodextrin. The Maltodextrin used has high dextrose equivalent (DE) value (maximum value 20, Linden and Lorrent, 1999). The DE value is obtained from the ratio of reducing sugar content to its solid total content (Chapkin, 2006).

From Table 1, the glass transition temperature is presented as mid point of temperature and also presented in the temperature range of DSC curve which show glass transition phenomena. The glass transition temperature of Arabic gum is lower than maltodextrin which is 194.5°C compared to 205.5°C. This result contradicts with the report published by Araujo *et al.* (2009), who reported that glass transition temperature of Arabic gum is higher than maltodextrin. It is suspected that the higher moisture content of Arabic gum depress its glass transition to be lower than maltodextrin. On the other hand, the glass transition of maltodextrin is higher than what have been reported by Bhandari and Howes Finding (1999), with a Tg of 52.4°C. However according to Bhandari dan Howes (1999), maltodextrin with same DE value or the same molecular weigth could have different Tg. The Tg range of the maltodextrin and Arabic gum are wide (Table. 1) and this are in agreement with Roos in Kaletung (2009) which reported that compound with high molecular weight and complex (such as protein, starch, etc) tend to have wide range of Tg.

The glass transition temperature of liquid honey is strongly affected by its moisture content. Water has very low glass transition temperature (about -138°C or 135 K) and act as plasticizer and decreasing Tg's mixture (Okos *et al*., 2007). From Table 1, it can be seen that liquid honey with moisture content of 19.9% has glass transition phenomena at lower temperature than that of liquid honey with lower moisture content of 18.4%. Table 1 showed that the glass transition temperature range of the liquid honey is less than the filler materials (maltodextrin and Arabic gum), an observation that was in agreement with the findings of Roos in Kaletung (2009), who reported that higher and more complex molecule has wider range of glass transition than that of lower and more simple compound.

Yield

The yield of honey powder is affected by the dryer type and filler materials used. The loss of product can occur during drying due to sticking to the drying chamber/container, spilled off container and during grinding. As can be seen in Figure 1, the vacuum drying resulted in higher yield than that of spray drying. This can be attributed due to the addition of water to the mixture (honey + filler) during spray drying which tend to decrease its Tg that may cause the mixture to stick to the drying chamber.

The addition of the Arabic gum addition gave higher yield than maltodextrin for both type of drying. On spray drying method, a significant difference of yield was obtained for honey powder produced containing maltodextrin and Arabic gum. Eventhough maltodextrin has higher glass transition temperature but its ability to cover or encapsulate honey is not as good as the Arabic gum. As a result, the yield of honey powder containing Arabic gum addition is higher than honey powder containing maltodextrin. Meanwhile for the vacuum drying, the yield difference of honey powder from the addition of the two filler was not significant.

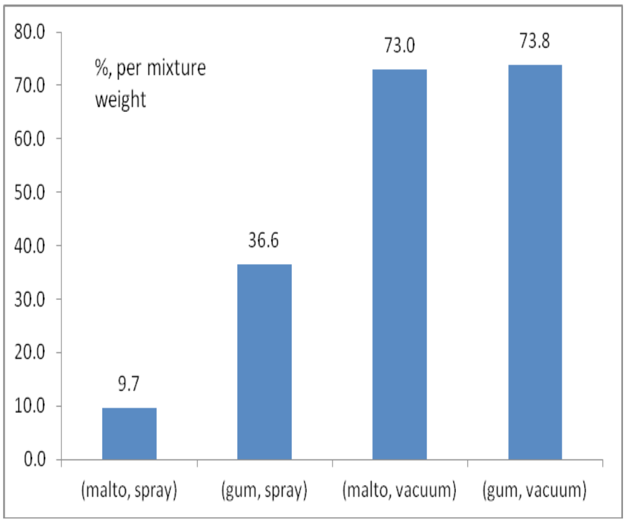

Figure 1. Honey powder yield produced from spray and vacuum drying method

It might be due to the high viscosity of the mixture (honey+filler) that prevent separation of honey from the filler materials. This situation is very different from the spray drying method. The addition of water (about three times mixture of honey and filler) to the mixture contributed to the lower yield when compared to the yield from the mixture obtained using the vacuum drying method.

The properties of honey powder

Chemical properties

The honey powder produced with maltodextrin addition has lower moisture content than that of Arabic (Table 2). This observation is supported by Gabas *et al*. (2007) who found that the addition of maltodextrin to the pineapple powder produced a lower moisture content than that of Arabic gum addition. This may be caused by the difference of hydrophylic and hidrofobic balance due to the filler addition (Gabas *et al*., 2007). From Table 2, the sugar composition of honey powder from each treatment are almost similar and it is difficult to see its tendency in relation to the effect of heat destruction to honey. However, the hydroxyl methyl furfural (HMF) content and diastase number (DN) could be used as indication to see the destruction effect of heating during drying process on honey powder for each treatment.

From Table 2, it can be seen that the liquid honey sample has higher HMF content than the standard which is 53.6 mg/kg compared to 50 mg/kg (BSN, 2004). Hydroxyl methyl furfural is a derivative compound of glucose and fructose as a result of excessive heating of honey (Chmielewska, 2004).

Table 2. Chemical properties of honey powder

	Moisture (%, wb)	aw	Fructose (%)	Glucose (%)	Sucrose (%)	Maltose (%)	HMF (mg/kg)	DN
Honey (Liquid)	18.4	0.59	38.89	33.08	0.29	0.27	53.6	8.3
Honey Powder (malto, spray)	2.3	0.40	22.17	19.32	0.45	0.10	22.7	1.8
Honey Powder (gum, spray)	4.4	0.40	20.68	17.67	0.14	0.14	0	12.4
Honey Powder (malto, vacuum)	1.1	0.32	21.80	19.02	0.46	0.12	30.4	0
Honey Powder (gum, vacuum)	2.0	0.29	21.64	18.93	0.14	0.16	0	7.2
Control of Honey Powder	1.1	0.48					584.0	0

Table3. The color properties of honey powder of spray and vacuum drying method

	Color		
	L	a	b
Honey Powder (malto, spray)	94.6	-0.3	6.9
Honey Powder (gum, spray)	98.1	-0.1	2.1
Honey Powder (malto, vacuum)	95.4	-0.2	7.9
Honey Powder (gum, vacuum)	94.3	-0.2	10.5
Control of Honey Powder	92.6	-0.6	9.5

Table 4. The instant properties of honey powder

	Hygroscopic rate (g H2O/ min)	Hygroscopic level (%)	Wettability (min)	Dispersing time (min)
Honey Powder (malto, spray)	2.0×10^{-4}	13.2	0.05	0.55
Honey Powder (gum, spray)	3.3×10^{-4}	20.3	> 5	4.21
Honey Powder (malto, vacuum)	2.4×10^{-4}	12.0	0.07	1.08
Honey Powder (gum, vacuum)	2.5×10^{-4}	13.7	0.40	3.29
Control of Honey Powder	2.8×10^{-4}	13.0	0.26	1.50

Meanwhile the DN value of sample comply with the standard (minimal 3) (BSN, 2004). Based on the DN and HMF content (Table 2), it can be seen that the destruction effect of heating occurred higher on honey powder produced from vacuum drying than spray drying for both filler materials. The HMF content of honey powder of vacuum drying is higher than that of spray drying, but the diastase number is lower than that of spray drying. From Table 2, the HMF content and DN of honey powder produced from spray drying method are 0-22.7 mg/kg and 1.8-12.4, respectively. On the other hand, the HMF content and DN of honey powder produced from vacuum drying method are 0-30.4 mg//kg and 0-7.2. The addition of Arabic gum resulted in honey powder with lower destruction effect of heating than that of maltodextrin for both types of dryer. Thus it can be assumed that the Arabic gum provided better protective ability than maltodextrin with DE 17.8. From Table 2, it can be concluded that for honey powder used as the control, its HMF content is very high and there is a possibility that invert sugar may have been added to the honey. Its HMF content is the highest which is 584 mg/kg. The invert sugar has HMF content of 1700 to 6500 mg/kg and that value is very high compared to the genuine honey with HMF content of 12 – 200 mg/kg (Chmielewska in Tomasik, 2004).

Color properties

Honey powder produced from vacuum drying possessed strong yellow color, indicating a higher b value (Table 3), however, we cannot deny the fact that the yellow color could also be the effects of heating during the drying process. The b value of honey powder of spray drying and vacuum drying are 2.16 – 6.94 and 7.93 – 10.47, respectively. From the Table 3, the color of honey powder from each treatment does not differ much when compared to the control, while for lightness index, their value is a bit higher than the control.

Instant properties

From Table 4, the hygroscopic rate and level of honey powder of spray drying method is higher than that of vacuum drying method. The addition of Arabic gum produced honey powder with higher level and rate of hygroscopic rate. Hence, the honey powder produced from Arabic gum addition and dried with spray drying method was very hygroscopic (its hygroscopic level more that 20%) while for other treatment they are classified as slightly hygroscopic (Gea Niro Research Laboratory, 2005). It seemed that the glass transition temperature of Arabic gum is lower than maltodextrin thus resulted in more hygroscopic product.

For wettability and dispersing time, honey powder produced from Arabic gum addition was more difficult to be wetted and need longer time to diperse in water. It could be due to the fact that Arabic gum contain more hydrophobic site than maltodextrin making it more difficult to be wetted (Wiliams and Philips, 2000). The higher the DE value of maltodekstrin, the more soluble maltodextrin is in water. The maltodextrin used has high DE value (17.76) which makes its honey powder quicker to disperse in water than that of Arabic gum.

Table 5. Hedonic Score of honey powder of spray and vacuum drying method.

	Color		Aroma		Taste	
	Score		Score		Score	
Honey Powder (malto, spray)	3.7	ab	3.0	b	3.5	ab
Honey Powder (gum, spray)	4.0	a	3.1	ab	3.1	b
Honey Powder (malto, vacuum)	4.1	a	3.6	a	3.9	ab
Honey Powder (gum, vacuum)	3.0	b	3.7	a	3.7	ab

Note :The average score indicated by different letters show significanta different according to Duncan's Multiple test

Sensory properties

The hedonic test result of the honey powder produced from the addition of maltodextrin and Arabic gum are presented in Table 5. For aroma and taste, honey powder produced by vacuum drying method is more preferred than that of spray drying. The exception for aroma occurred on honey powder with Arabic gum addition which showed no significant different of hedonic score with that produced from vacuum drying. It might be caused by the characteristic of Arabic gum which has a good aroma protective barrier (Wiliams and Philips, 2000). The taste of maltodextrin is a bit of sweet which make its product scores almost the same for both types of dryer. On the other hand, the color of honey powder produced by Arabic gum addition and dried by vacuum method was least preferred by panelist.

Conclusion

Processing of the liquid honey using the vacuum drying method produced higher yield of honey powder, higher destruction effect of heating (lower value of DN and higher value of HMF) and better sensoric characteristic than that of spray drying. When compared to Arabic gum, the use of maltodextrin could decrease the hygroscopicity of honey powder, wetting time, dispersing time and increase the sensoric acceptance of honey powder by the panelist.

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