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Physico-chemical characteristics of ripened honey as affected by processing time and storage stability

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Abstract
Background: Processing of honey is the practical means for preventing granulation and fermentation, otherwise it can easily deteriorate the quality. Heat processing of honey is essential to extend its shelf life, preventing granulation and arresting fermentation. However, uncontrolled heat processing of honey results into hydroxymethylfurfural formation which darkens colour of honey. Although raw is the best honey, but processing is needed to meet the market requirements. The research was conducted on ripened honey. Honey were processed at different time viz 12, 24, 36 and 48 hours respectively. The processed honey samples were than packed in glass jars, plastic jars and polpack pouches and analyzed fresh and at a storage interval of 3, 6, 9 and 12 months.
Results: Ripened honey was processed at different time for 12, 24, 36 and 48 hours and were packaged in glass jars, plastic jars and polpack pouches and analysed fresh and after 3, 6, 9 and 12 months of storage intervals. However, the mean values total sugars (66.74, 66.58 and 65.82 percent), fructose (35.02, 35.04 and 34.96 percent) and glucose (32.83, 32.82 and 32.79 percent), diastatic activity (18.24, 18.29, 18.27 Diastase Number) and energy (319.90, 319.97 and 320.03 Kcal/100g) for glass jars, plastic jars and polypack pouches respectively.
Conclusion: The results of the study revealed that total sugars, fructose, diastatic activity and energy decreased during storage and glucose content increased during storage. The quality of honey can be improved by processing honey for 12 to 36 hours.

Keywords: honey, ripened honey, total soluble solids, sugars, processing honey

Introduction
Honey, an important hive product since ancient time due to its nutritional and antimicrobial properties. In India, per capita consumption of honey is very low (8.4 g/year /person) as compared to other countries (120-1800 g) (Gulati and Kumari 2005) [6]. However, the demand for honey as well as awareness about its quality among consumers is now expanding. The quality of honey varies with floral sources, degree of sealing in comb at the time of harvest, storage period and processing techniques (Rahman *et al.*, 2013) [2].
Honey is valued not only as a food but also for some of its therapeutic attributes. It improves the resistance of the body by improving the biological processes of organs and systems. It facilitates proteins and fat digestion thus constitutes an excellent anti-dyspeptogenic factor (Alvrez-suarez *et al*., 2010) [1]. Honey has medicinal property neutralizes fatigue, compensatory hypotonia, as well as the adverse effects of the other substances added when used in the preparation of beverages (Buba *et al*. (2014) [4].
Honey is also mainly composed of simple sugars, fructose and glucose (Lawal *et al.*, 2009). Honey provides immediately available calories, which derives its energy value for healthy and sick people. Consumption of honey benefits such as digestive system, respiratory system, skin and wound healing and eye disorders. Honey is also good for diabetics and to normalize kidney function. Processing of honey is the practical means for preventing granulation and fermentation, but can easily deteriorate quality. Processing of honey is essential to extend its shelf life, prevents granulation and fermentation. Although raw is the best honey, but processing is needed to meet the market requirements. The present studies were therefore, undertaken to know the changes after processing and storage at different processing time.

Materials and methods
Ripened honey was procured from the local market and Bee Keeping Research Station, Nagrota Bhagwan. The other ingredients required for the research study were purchased from the local market.

Processing of honey

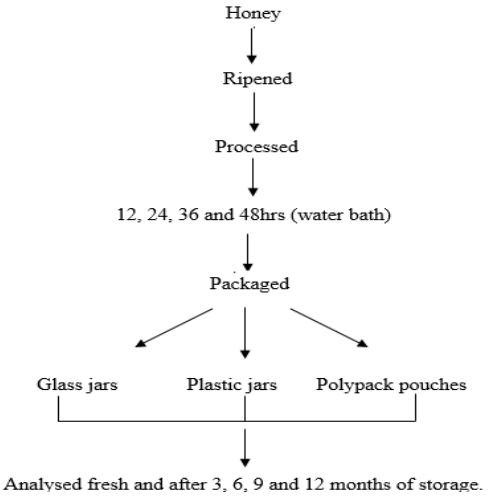

Fig 1: Steps involved for the processing of honey

Standardization of honey was done in Bee Keeping Research Station, Nagrota Bhagwan.

Ripened honey was processed at 12, 24, 36 and 48 hrs. The sample of processed honey were packaged in different packaging materials (glass jars, plastic jars and polythene pouches) and analysed fresh and after every 3.0, 6.0, 9.0 and 12.0 months of storage intervals for chemical evaluation. Figure 1 indicates the steps involved in processing of honey.

Results and Discussion

Sugars

Total sugars

The data pertaining to total sugars of honey packaged in glass jars, plastic jars and polypack pouches as affected by type of honey, processing time and storage intervals are given in Table 1 respectively. The ripened honey had significant effect on total sugars of honey packaged in glass jars and plastic jars with the mean values of 66.74 and 66.58 per cent, respectively. However, ripening of honey had non-significant effect on the total sugars of honey packaged in polypack pouches.

The processing time used for processing of honey had significant effect on total sugars packaged in glass jars and plastic jars. The mean values of total sugar of honey processed for 12 hours and packaged in glass jars and plastic jars were 66.20 and 66.15 per cent which increased slightly to 67.34 and 67.10 per cent of honey processed for 48 hours, respectively. The mean values of non-reducing sugars of honey processed for "12 and 24 hours", "24 and 36" hours and "36 and 48 hours" were varied critically non-significant of honey packaged in glass jars and plastic jars. However, the effect of processing time had non-significant effect on total sugars of honey packaged in polypack pouches. The values of total sugars of honey packaged for "12 and 24 hours", "24 and 36" hours and "36 and 48 hours" varied critically non-significant in case of honey packaged in glass jars and plastic jars.

Table 1: Physico-chemical analysis of total sugars (%) of honey packaged in glass jars, plastic jars and polypack pouches as affected by processing time and storage interval

Parameters	Packaging materials	Particulars	Storage interval (months)						CD(P≤0.05) Between
			Fresh	**3**	**6**	**9**	**12**	**Mean**	
Total sugars (%)	Glass jars	Ripened honey	68.17	67.81	66.82	65.83	65.05	66.74	Processing Time:0.52 Storage Interval:0.58
			Processing time (hrs)						
		12	67.59	67.26	66.29	65.31	64.54	66.20	
		24	67.95	67.45	66.66	65.66	64.88	66.52	
		36	68.32	67.97	66.99	66.01	65.21	66.90	
		48	68.80	68.58	67.36	66.35	65.59	67.34	
		Mean	68.17	67.81	66.82	65.83	65.05	66.74	
	Plastic jars		Fresh	3	6	9	12	Mean	Processing Time: 0.64 Storage Interval:0.72
		Ripened honey	68.17	67.83	66.52	65.57	64.85	66.58	
			Processing time (hrs)						
		12	67.59	67.08	66.02	65.32	64.77	66.15	
		24	67.95	67.70	66.29	65.31	64.54	66.36	
		36	68.32	68.09	66.66	65.66	64.88	66.71	
		48	68.80	68.45	67.12	66.01	65.21	67.10	
		Mean	68.17	67.83	66.52	65.57	64.85	66.58	
	Polypack pouches		Fresh	3	6	9	12	Mean	Processing Time: NS Storage Interval:1.84
		Ripened honey	68.17	66.75	65.97	64.41	64.31	65.82	
			Processing time (hrs)						
		12	67.59	66.86	66.35	64.78	63.74	65.86	
		24	67.95	67.37	66.44	64.92	64.09	66.16	
		36	68.32	64.41	67.02	62.28	64.55	65.32	
		48	68.80	68.38	64.07	65.65	64.87	66.36	
		Mean	68.17	66.75	65.97	64.41	64.31	65.92	

The storage intervals also had significantly decreasing effect on the total sugars of honey packaged in different packaging materials. The mean value of total sugars of fresh honey was 68.17 per cent which decreased to 66.74, 66.58 and 65.82 per cent after 12 months of storage of honey packaged in glass jars, plastic jars and polypack pouches, respectively. However, the values of total sugars of "fresh and 3 months" in glass jars and plastic jars, were varied critically non-significant. The values of total sugars of "fresh and 3 months", "3 and 6 months", "6 and 9 months" and "9 and 12 months" of honey packaged in polypack pouches varied critically non-significantly.

The results of present study revealed that total sugars of honey was higher in glass jars with mean value of 66.74 per cent, followed by honey packaged in plastic jars (66.58%) and polypack pouches (65.82%).

The results of the present findings are in agreement with the findings of Singh *et al.* (2006) [8] who reported the reducing sugars varied from 60.6 to 60.9 per cent and total sugars varied from 68.7 to 69.5 per cent. The sugars significantly increased with increase in storage period. Similar findings were also reported by Rahman *et al.* 2013 [2] who reported sugars 80.70 per cent which slightly increased to 80.95 per cent after 6 months of storage.

Fructose

The data pertaining to fructose content of honey packaged in glass jars, plastic jars and polypack pouches as affected by type of honey, processing time and storage intervals are given in Table 2, respectively. The ripened honey had non-significant effect on the fructose content of honey packaged in glass jars and polypack pouches. However, the ripened honey had significant on the fructose content packaged in plastic jars. The mean values of fructose content of ripened honey packaged in plastic jars was 35.05 per cent, respectively.

Table 2: Physico-chemical analysis of fructose (%) of honey packaged in glass jars, plastic jars and polypack pouches as affected by processing time and storage interval

Parameters	Packaging materials	Particulars	Storage interval (months)						CD(P≤0.05) Between
			Fresh	**3**	**6**	**9**	**12**	**Mean**	
Fructose (%)	Glass jars	Ripened Honey	35.68	35.47	35.18	34.44	34.35	35.02	Processing Time: NS Storage Interval:0.61
			Processing time (hrs)						
		12	35.62	35.40	35.13	34.39	34.29	34.96	
		24	35.66	35.45	35.16	34.43	34.33	35.01	
		36	35.70	35.49	35.20	34.46	34.36	35.04	
		48	35.74	35.53	35.25	34.50	34.40	35.08	
		Mean	35.68	35.47	35.18	34.44	34.35	35.02	
	Plastic jars		Fresh	3	6	9	12	Mean	Processing Time: NS Storage Interval:0.22
		Ripened Honey	35.68	35.42	35.15	34.54	34.39	35.04	
			Processing time (hrs)						
		12	35.62	35.45	35.16	34.42	34.30	35.01	
		24	35.66	35.38	35.13	34.55	34.40	35.02	
		36	35.70	35.49	35.20	34.46	34.32	35.04	
		48	35.74	35.36	35.12	34.74	34.53	35.07	
		Mean	35.68	35.42	35.15	34.54	34.39	35.04	
	Polypack pouches		Fresh	3	6	9	12	Mean	Processing Time: NS Storage Interval:0.54
		Ripened Honey	35.68	35.53	35.30	34.24	34.10	34.96	
			Processing time (hrs)						
		12	35.62	35.43	35.09	34.08	33.92	34.80	
		24	35.66	35.56	35.27	34.13	33.94	34.91	
		36	35.70	35.59	35.41	34.39	34.29	35.07	
		48	35.74	35.56	35.45	34.36	34.23	35.06	
		Mean	35.68	35.53	35.30	34.24	34.10	34.96	

Glucose

The processing time had non-significant effect on the fructose content of honey irrespective of different packaging materials. The fructose content of honey packaged in glass jars decreased significantly with the increase of storage period. However, the values of fructose content of honey "fresh and 3 months", "3 and 6 months", "6 and 9 months" and "9 and 12 months" were varied critically non-significant packaged in glass jars and polypack pouches. The mean values of fructose content of honey "9 and 12 months" were varied critically non-significant. Chua and Adnan (2014) and Buba *et al.*, (2014) [4] reported slightly higher values of fructose content as compared to present findings.

The storage also affected the fructose content and a decrease in fructose content was observed with the increase in storage period irrespective of different packaging materials.

Table 3 show the glucose content of honey as affected by type of honey, processing time and storage intervals packaged in glass jars, plastic jars and polypack pouches. The ripened honey had non-significant effect on glucose content of honey irrespective of packaging materials.

The processing time had non-significant effect on the fructose content of honey packaged in glass jars and plastic jars. However, the mean value of honey processed for "12 and 24 hours", "24 and 36 hours" and "36 and 48 hours" of honey packaged in polypack pouches varied critically non-significantly. The storage of honey had significant effect on the glucose content of honey packaged in plastic jars and polypack pouches. The mean value of glucose content of fresh honey was 32.62 which increased to 33.00, 33.01 and 32.97 per cent after 12 months of storage, in glass jars, plastic jars and polypack pouches. However, the mean values of "fresh and 3 months", "3 and 6 months", "6 and 9 months" and "9 and 12 months" of honey packaged in plastic jars and polypack pouches varied critically non-significantly. The mean values of honey packaged in glass jars had non-significant effect on the glucose content of honey.

Table 3: Physico-chemical analysis of glucose (%) of honey packaged in glass jars, plastic jars and polypack pouches as affected by processing time and storage interval

Parameters	Packaging materials	Particulars	Storage interval (months)						CD(P≤0.05) Between
			Fresh	**3**	**6**	**9**	**12**	**Mean**	
Glucose (%)	Glass jars	Ripened Honey	32.62	32.75	32.85	32.93	33.00	32.83	Processing Time: NS Storage Interval:NS
			Processing time (hrs)						
		12	32.57	32.70	32.80	32.89	32.96	32.79	
		24	32.59	32.74	32.84	32.92	32.99	32.82	
		36	32.64	32.77	32.87	32.94	33.01	32.84	
		48	32.69	32.81	32.89	32.96	33.02	32.87	
		Mean	32.62	32.75	32.85	32.93	33.00	32.83	
	Plastic jars		Fresh	3	6	9	12	Mean	Processing Time: NS Storage Interval:0.43
		Ripened Honey	32.62	32.72	32.84	32.93	33.01	32.82	
			Processing time (hrs)						
		12	32.57	32.62	32.77	32.90	33.00	32.77	
		24	32.59	32.76	32.87	32.96	33.04	32.84	
		36	32.64	32.74	32.84	32.92	32.99	32.82	
		48	32.69	32.77	32.87	32.94	33.01	32.81	
		Mean	32.62	32.72	32.84	32.93	33.01	32.82	
	Polypack pouches		Fresh	3	6	9	12	Mean	Processing Time: 0.12 Storage Interval:0.14
		Ripened Honey	32.62	32.69	32.79	32.90	32.97	32.79	
			Processing time (hrs)						
		12	32.57	32.62	32.71	32.83	32.90	32.72	
		24	32.59	32.68	32.78	32.87	32.94	32.77	
		36	32.64	32.72	32.83	32.94	33.01	32.83	
		48	32.69	32.73	32.85	32.96	33.05	32.86	
		Mean	32.62	32.69	32.79	32.90	32.97	32.79	

In present study, the values of glucose content (32.83 %) were higher of honey in glass jars, followed by glucose content (32.82%) of honey in plastic jars and glucose content (32.79%) of honey in polypack pouches. Chua and Adnan (2014) reported slightly higher values of fructose content as compared to present findings. The values of glucose content of honey are in agreement with the findings reported by Buba *et al.,* (2014) [4]. Gulati and Kumari (2005) [6] who reported that glucose content varied from 22.4 to 32.2 per cent. The values of ripened honey were higher as compared to unripened honey.

The increase in values might be due to early harvesting which resulted into incomplete inversion of sugar in unripened honey and thereby reducing the level of different reducing sugars as compared to ripened honey. However, Singh *et al.* (2006) [8] reported slightly lower values of glucose content of honey varing from 30.1 to 31.0 per cent. The glucose content increased with increase in storage period.

Diastatic activity

Table 4 indicate the diastatic activity of honey packaged in glass jars, plastic jars and polypack pouches as affected by type of honey, processing time and storage intervals. The ripened honey had significant effect on the diastatic activity of honey packaged in glass jars. The mean values of diastatic activity present in ripened honey was 18.24 DN, respectively. However, ripened honey had non-significant on the diastatic activity of honey packaged in plastic jars and polypack pouches.

The processing time had significant effect on the diastatic activity and slightly increased with the increase in processing time. The diastatic activity of honey processed for 12 hours and packaged in plastic jars was 18.19 DN which increased to 18.39 DN after 48 hours of processing time, respectively. However, the mean values of diastatic activity of honey processed for “12 and 24 hours” and “36 and 48 hours” of honey packaged in plastic jars varied critically non-significantly. The values of diastatic activity of honey processed and packaged in glass jars and polypack pouches had non-significant effect.

The storage of honey irrespective of packaging materials also had significant effect on the diastatic activity. The mean values of fresh honey was 20.62 which decreased to 16.85, 16.92

Table 4: Physico-chemical analysis of diastatic activity (Diastase Number) of honey packaged in glass jars, plastic jars and polypack pouches as affected by processing time and storage interval

Parameters	Packaging materials	Particulars	Storage interval (months)						CD(P≤0.05) Between
Diastatic Activity (Diastase Number)	Glass jars		**Fresh**	**3**	**6**	**9**	**12**	**Mean**	Processing Time: NS Storage Interval:0.47
		Ripened Honey	20.62	18.82	17.77	17.12	16.85	18.24	
			Processing time (hrs)						
		12	20.55	18.74	17.70	17.06	16.81	18.17	
		24	20.59	18.79	17.75	17.09	16.84	18.21	
		36	20.65	18.85	17.80	17.14	16.87	18.26	
		48	20.70	18.91	17.84	17.18	16.90	18.30	
		Mean	20.62	18.82	17.77	17.12	16.85	18.24	
	Plastic jars		Fresh	3	6	9	12	Mean	Processing Time: 0.12 Storage Interval:0.13
		Ripened Honey	20.62	18.96	17.79	17.16	16.92	18.29	
			Processing time (hrs)						
		12	20.55	18.76	17.71	17.06	16.81	18.19	
		24	20.59	19.05	17.76	17.10	16.84	18.28	
		36	20.65	19.04	17.80	17.14	16.87	18.31	
		48	20.70	19.01	17.90	17.34	17.14	18.39	
		Mean	20.62	18.96	17.79	17.16	16.92	18.29	
	Polypack pouches		Fresh	3	6	9	12	Mean	Processing Time: NS Storage Interval:0.31
		Ripened Honey	20.62	18.85	18.11	17.02	16.75	18.27	
			Processing time (hrs)						
		12	20.55	18.79	17.95	16.94	16.63	18.17	
		24	20.59	18.13	18.09	16.96	16.70	18.10	
		36	20.65	19.20	18.17	17.06	16.81	18.38	
		48	20.70	19.27	18.23	17.10	16.84	18.43	
		Mean	20.62	18.85	18.11	17.02	16.75	18.27	

and 16.75 after 12 months of storage of honey, respectively. However, the mean values of storage for "9 and 12 months" of honey packaged in glass jars and polypack pouches varied critically non-significant.

In the present study the diastatic activity of honey ranged 18.07-18.40 DN. Sahinler *et al.* (2004) [7] reported diastatic activity of honey ranged from 1.5-13.7 DN. The storage of honey had significantly decreasing effect on the diastatic activity of honey.

Energy

The data pertaining to the energy content of honey as affected by type of honey, processing time and storage intervals packaged in glass jars, plastic jars and polypack pouches are given in Table 5 respectively.

The ripened honey had significant effect on the energy content and mean values of energy were found in honey packaged in plastic jars and polypack pouches with mean values of 319.97 and 320.03 Kcal/100g, respectively. However, the mean values of types of honey had non-significant effect in case of honey packaged in glass jars.

The processing time also had significant effect on the energy content and slightly increased with the increase in processing time. The energy content of honey processed for 12 hours and packaged in glass jars, plastic jars and polypack pouches were 312.05, 312.38 and 331.70 Kcal/100g which increased to 327.60, 327.59 and 349.79 Kcal/100g after 48 hours of processing time, respectively. The storage of honey irrespective of packaging materials had non-significant effect on the energy content.

The energy content were higher in glass jars with mean values of 320.03 Kcal/100g, followed by plastic jars (319.97 Kcal/100g) and polypack pouches (319.90 Kcal/100g). Buba *et al.* (2014) [4] reported slightly higher values of energy content as compared to present findings.

Table 5: Physico-chemical analysis of energy (Kcal/100g) of honey packaged in glass jars, plastic jars and polypack pouches as affected by processing time and storage interval

Parameters	Packaging materials	Particulars	Storage interval (months)						CD(P≤0.05) Between
Energy (K cal/100g)	Glass jars		**Fresh**	**3**	**6**	**9**	**12**	**Mean**	Processing Time: 0.76 Storage Interval: NS
		Ripened Honey	320.08	320.08	320.08	319.91	319.37	319.90	
			Processing time (hrs)						
		12	312.49	312.49	312.49	312.27	310.51	312.05	
		24	317.52	317.52	317.52	317.30	317.16	317.40	
		36	322.64	322.64	322.64	322.51	322.38	322.56	
		48	327.67	327.67	327.67	327.55	327.44	327.60	
		Mean	320.08	320.08	320.08	319.91	319.37	319.90	
	Plastic jars		Fresh	3	6	9	12	Mean	Processing Time: 0.63 Storage Interval: NS
		Ripened Honey	320.08	320.08	320.08	319.87	319.76	319.97	
			Processing time (hrs)						
		12	312.49	312.49	312.49	312.29	312.17	312.38	
		24	317.52	317.52	317.52	317.28	317.17	317.40	
		36	322.64	322.64	322.64	322.43	322.29	322.52	
		48	327.67	327.67	327.67	327.49	327.43	327.59	
		Mean	320.08	320.08	320.08	319.87	319.76	319.97	
	Polypack pouches		Fresh	3	6	9	12	Mean	Processing Time: 0.63 Storage Interval: NS
		Ripened Honey	320.08	320.08	320.08	319.76	319.64	320.03	
			Processing time (hrs)						
		12	318.55	306.11	312.33	295.48	309.82	331.70	
		24	323.52	311.22	317.37	297.95	316.06	338.10	
		36	328.65	316.33	322.49	301.96	322.70	342.80	
		48	335.77	319.27	327.52	306.22	326.55	349.79	
		Mean	326.62	313.23	319.93	300.40	318.78	340.60	

Conclusion

The storage of honey had significantly decreasing effect on the total sugars, fructose content, diastatic activity and energy content of honey and slightly increase the glucose content of honey. Among the different processing time, the overall acceptability of honey heated for 24 and 36 hour were more acceptable as compared to other combinations.

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