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Potential of Twin Key Management Practices: Higher Colony Strength and Lower Honey Extraction Frequency in Improving Honey Quality of *Apis mellifera*

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***Abstract*:** Present study signifies the benefits of scientific management practices which eventually will earn more returns to beekeepers in India. Colonies with initial 10 frames strength and two extractions in the seasons were observed to produce honey of good quality and most economical. In 5 frame colonies moisture remained well below (17.91%) the maximum standards (20%) set for "special" grade honey and was still lower (17.80%) in medium strength (10 frames) and the strongest (15 frames) colonies (17.43%). However, under regular honey extraction, the moisture content was maximum in colonies of lowest strength (20.02%) compared to in 10 and 15 frame colonies. Other quality parameters like F: G ratio, sucrose, hydroxy methyl furfural (HMF) was observed above standards in 10 frame and two extraction colonies. Total reducing sugars was highest (82.23 %) in 15 frame single extraction colonies and 80.24 % in 10 frame colonies with similar extraction frequencies. Present findings clearly support the role of extraction frequencies in improving honey quality as we decrease frequency quality improves remarkable even in low strength colony. Strength is also a very important factor in deciding honey quality.

Keywords: Honey quality, Extraction, Quality Parameters, Moisture, Honey sugars

Beekeepers desire to make beekeeping more and more profitable and keep on extracting honey at regular intervals during honey flow season. Scientific knowledge of beekeeping to beekeepers is a major constraint and they follow either traditional or own developed non-scientific practices which degrades quality of honey. Regular extraction of honey at fixed interval of 7-10 days and extraction of un-ripened honey from brood chamber and reluctant to use supers for honey production are some causes of quality degradation. In India winter is the major honey flow season from mustard crop followed by few minor seasons up to early summer (December to May) followed by a long dearth from summer through rainy season till November (Chaudhary 2005). The Bureau of Indian Standards (BIS) standard (No. IS: 4941-1974), now Food Standard and Safety Authority of India (FSSAI 2010) through its regulation (No. 5.7.4) also recommends extracting honey from ripe and sealed honey combs and by default present Indian honey does not confirm to these standards. Besides poor quality, such practices are the root cause of low colony productivity. The production of honey and growth of colony is dependent over colony strength & honey extraction frequency. Right colony strength and extraction frequency gives better economical returns in beekeeping enterprise (Bhusal 2011, Saini et al 2018b, 2022). Honey quality parameters contain moisture content, ash content, total soluble solids (TSS), acidity, reducing & non-reducing, fructose: glucose ratio and HMF content (Codex 2001). Beekeeping now days facing four major problems *viz*. low colony productivity, colony debilitation / mortality, extremely poor honey quality and ever increasing cost of production (labor and migration) resulting in non-stability of the beekeeping enterprise. Present study on colony strength and honey extraction frequencies was conducted to formalize some practices for beekeeping that improves colony health and honey quality.

MATERIAL AND METHODS

Present investigations were carried out on western honey bee, *A. mellifera* L. colonies at beekeeper's apiary during major honey flow season of mustard crop. Initial colony strength (ICS) and for equalization of colonies standard protocol were followed Delaplane et al (2013) and Saini et al (2022). After equalization colonies were migrated to the experimental site at RDS Farm of CCS Haryana Agricultural University, Hisar on the mustard crop which was about to flowering. Each colony with specified frame strength was labeled and placed in diamond orientation at 10 feet row and 5 feet colony distance. Bee colony with 5, 10 and 15 frames strength were the treatments, these colonies were then extracted at different frequencies (once, twice and regular) considering single colony as one replication and four

replications were kept in each treatment, total 36 colonies were under experiment (12 in each colony strength)

Honey extraction frequencies: To determine the effect of honey extraction frequencies on honey quality four colonies in each colony strength of 5, 10 and 15 frame were extracted once for honey in the season, four were extracted twice and remaining four in each strength were extracted regularly or following beekeeper's practice. During the experiment, 36 colonies (Colony strength and honey extraction frequencies) were used.

Collection of sample: Samples of honey for each treatment were collected in wide mouth food grade plastic bottles (Cello) on the day of honey extraction in the field, specific number were given to each sample and stored in a closed big plastic box at home under favorable temperature condition so that any change in property could be avoided before going for physio-chemical analysis. All precautions were taken care to keep the quality unaltered during storage.

Preparation of sample before processing: Samples for quality testing, were placed in hot water bath at 40^0C for liquefaction, strained through muslin cloth and stored in clean containers. Three honey sub samples from each treatment were drawn, then mixed together and a composite sub sample of 50 g was made for further processing. Honey left in the containers after making composite sample was again sealed in air tight jars. Three sets (replications) were made from the composite sample and subjected to testing for different honey quality parameters.

Physio-chemical characteristics of honey: The sub samples (in triplicate) were prepared from different treatments were analyzed as per standard procedures prescribed by the Bureau of Indian standard (IS4941:1994) unless specified in text. Standard procedures specified in FAO Manuals of Food Quality Control (FAO 1984), ISI Hand book of Food Analysis (Part II), and in testing manual of food safety and security authority of India (FSSAI 2010) were followed for honey quality testing.

RESULTS AND DISCUSSION

Honey quality in different colony strengths under different honey extraction regimes: In regular honey extraction, the moisture content was maximum in colonies of lowest strength (19.33%) compared to in 10 and 15 frame colonies where values were significantly lower but at par with each other (Table 1). The honey from lowest colony strength had least specific gravity (1.407) compared to the stronger colonies with similar values (1.409). On the contrary total reducing sugars was minimum in the lowest strength colonies 78.48 percent and increased progressively with increase in colony strength (79.22 and 79.43%). Colony

Table 1. Comparison of honey quality parameters in colonies with varied frame strength under different honey extraction regime

Quality parameters	Regular extraction in colony strengths (frames/colony)				2 extractions in colony strengths (frames/colony)				1 extraction in colony strengths (frames/colony)			
	5	10	15	CD (p=0.05)	5	10	15	CD (p=0.05)	5	10	15	CD (p=0.05)
Moisture (%)	19.33	19.05	19.05	0.06	19.10	18.80	19.00	0.06	18.60	18.40	17.40	0.07
Total reducing sugar (%)	78.48	79.22	79.43	0.20	78.96	79.65	79.78	0.05	79.87	80.24	82.23	0.05
Fructose (%)	40.06	41.18	40.85	0.07	40.60	40.80	41.07	0.02	40.66	41.15	41.89	0.04
Glucose (%)	38.42	38.04	38.59	0.16	38.36	38.85	38.71	0.06	39.21	39.09	40.34	0.08
Sucrose (%)	2.56	2.23	2.00	0.06	2.57	2.25	2.23	0.03	2.00	1.87	1.40	0.07
Acidity (%)	0.076	0.066	0.075	0.004	0.077	0.084	0.084	0.002	0.070	0.086	0.080	0.012
Ash (%)	0.091	0.082	0.093	0.005	0.088	0.095	0.094	0.003	0.086	0.095	0.090	NS
F/G ratio	1.042	1.082	1.059	0.005	1.058	1.051	1.061	0.002	1.036	1.053	1.038	0.003
H.M.F.	6.91	7.00	7.00	NS	7.103	7.038	7.000	0.048	7.107	7.190	7.190	NS
Specific gravity	1.407	1.409	1.409	0.000	1.408	1.410	1.409	0.001	1.410	1.411	1.414	0.001

strength under regular honey extraction had no effect on HMF content in the honeys. The moisture content was lowest in 10 frame colonies (18.80%) followed by 15 frames (19.00%). The increase in TRS was significant with increase in colony strength (78.96, 79.65 and 79.78%) from 5, 10 and 15 frame strengths, respectively. Fructose content also increased with colony strength while the glucose content was least in 5 frame colonies (38.36%) and maximum in 10 frame colonies (38.85%). The acidity and ash content was lowest in the weakest colonies (0.077 and 0.088%) that increased significantly in higher strength colonies.

Honey quality in different colonies strengths under different honey extraction regimes: In 15 frame colonies lowest moisture content 17.43%, signifying the highest honey quality in 15 frame colonies in the single honey extraction regime (Table 2). The specific gravity also had an increasing trend with increase in colony strength. TRS content increased from 80.38 percent in 5 frame colonies to 81.89% in 10 frame colonies and was the maximum in the strongest colonies (82.04%). The fructose content also exhibited similar increase from 40.90 to 41.71% while the glucose content was minimum in 5 frame (39.48%) to become maximum (40.57%) in 10 frame colonies. The sucrose exhibited reverse trend with colony strength being maximum in 5 frame (1.88%) and reducing in 10 (1.81) to become the least (1.26%) in strongest colonies. Acidity observed high in 5 frame colony (0.173) which decreases with increase in colony strength became minimum in 15 frame (0.076) and ash content where maximum in 15 frame colonies (0.093%) then 10 and 5 frame colonies (0.085 and 0.081, respectively).

Under twice honey extraction regimes, sucrose content was higher in 5 frame colonies which indicate un-ripened honey or nectar. F:G ratio showed pattern that was highest in the strongest colonies and lowest in weakest colony. Under regular honey extraction, the moisture content was maximum in colonies of lowest strength (20.02%) compared to in 10 and 15 frame colonies where values were significantly lower and varies significantly with each other. The honey from lowest colony strength had least specific gravity (1.405) compared to the stronger colonies which had value higher (1.409) than this. The total reducing sugars was minimum in the lowest strength colonies 78.54 percent and increased progressively with increase in colony strength (79.01 and 79.38%). Sucrose content was least in the strongest colonies (1.699%), increased to 2.01 % in 10 and 2.44 percent in 5 frame colonies. Ash content in honey was observed maximum in strongest colony (0.094%) which decreases significantly in 10 frame (0.089) and minimum in 5 frame colonies (0.082). The results for all the honey quality

Table 2. Comparison of honey quality parameters in colonies with varied frame strength under different honey extraction regime

Quality parameters	Regular extraction in colony strengths (Frames/colony)				2 extractions in colony strengths (Frames/colony)				1 extraction in colony strengths (Frames/colony)			
	5	10	15	CD (p=0.05)	5	10	15	CD (p=0.05)	5	10	15	CD (p=0.05)
Moisture (%)	20.022	19.809	19.652	0.016	19.860	19.697	19.345	0.021	17.907	17.807	17.433	0.115
Total reducing sugar (%)	78.542	79.011	79.384	0.049	78.433	79.385	79.597	0.019	80.387	81.897	82.047	0.025
Fructose (%)	40.051	40.931	41.241	0.034	40.183	40.713	40.879	0.021	40.900	41.390	41.713	0.060
Glucose (%)	38.492	38.080	38.144	0.037	38.248	38.675	38.718	0.028	39.487	40.573	40.333	0.146
Sucrose (%)	2.447	2.019	1.699	0.015	2.363	1.692	1.505	0.023	1.887	1.810	1.267	0.045
Acidity (%)	0.109	0.112	0.097	0.002	0.109	0.085	0.082	0.004	0.173	0.083	0.076	0.006
Ash (%)	0.082	0.089	0.094	0.002	0.079	0.085	0.079	0.002	0.081	0.085	0.093	0.004
F/G ratio	1.040	1.075	1.082	0.002	1.051	1.053	1.056	0.001	1.035	1.020	1.034	0.005
Hydroxy methyl furfural (mg/kg)	6.888	6.872	6.663	0.018	7.222	7.175	7.055	0.020	7.073	6.937	6.990	0.049
Specific gravity	1.405	1.408	1.409	0.001	1.399	1.404	1.410	0.001	1.412	1.413	1.415	0.001

Annexure 1. Various honey standards by agencies

Characteristics	P.F.A	BIS (4941-1994)			AGMARK (2008)			CODEX (2001)
		Special	"A"	Standard	Special	"A"	Standard	
Specific gravity at 27 C (Min)	-	1.37	1.37	1.37	1.40	1.37	1.35	--
Moisture % (Max)	25	20	22	25	20	22	25	21
Reducing sugars % (Min)	65	70	65	65	70	65	65	65
Sucrose % (Max)	5	5	5	5	5	5	5	5
Ratio L/D (Min)	0.95	1	1	1	1	0.95	0.95	--
Ash% (Max)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.6
Acidity as formic acid % (Max)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	40
Fiehe 's test		Negative				Negative		
Aniline Chloride test	-	-	-	-		Negative		
Total pollen count and plant elements / g A Apiary honey (Max)	-	50,000	50,000	50,000	50,000 50,000	50,000 50,000	50,000 50,000	-
H.M.F. mg / Kg (Max)	-	80	80	80	80	80	80	40
Optical density % (Max)	-	0.3	0.3	0.3	0.3	0.3	0.3	-
Diastase (Min)	-	-	-	-	3	3	3	3
Water insoluble matters % (Max) for pressed honeys	-	- -	- -	- -	0.50 0.10	0.50 0.10	0.50 0.10	0.1 0.5

BIS -If Fiesh's test is Positive and HMF content is more than 80 mg/kg then L/D ratio should be more than1.00
Agmark:
1.If the pollen count is higher than 50,000/gm. Then honey may be categorized as squeezed honey.
2.If the Fiehe's test is positive but Hydroxyl Methyl Furfural (HMF) content is below 80ppm then honey may be accepted.
If granulated, it should be warmed at 60 till the crystals have dissolved completely

parameters were remarkable under single and two honey extractions over regular extractions regime. Similar high quality of honey was recorded in strongest (15) and 10 frame colonies over the weakest 5 frame colonies. The moisture content which is major quality criteria even in 5 frame colonies (17.91%) remained well below the maximum standards (20%) set for "special" grade honey and was still lower in medium (17.80%) and the strongest colonies (17.43%). The specific gravity, total reducing sugars, fructose, glucose, ash content (0.081 to also increased with increase in colony strength. The acidity and HMF content were least in these honeys and confirm to best quality honey. Reports of Szabo et al (1992) and Szabo & Lefkovitch (1990) about the effects of the frequency of honey extraction (4, 2 and 1 times) quantity and quality of honey on A. mellifera colonies indicating higher moisture content in colonies with applications of 5 supers and 4 honey removals (19.0%) and the lowest with 2 honey removals and 12 supers (16.7%), highest diastase (amylase) numbers for honey removed once (28.6) followed by that removed twice (26.5) and 4 times (23.2) amply support the present findings.

There is significant role of extraction frequencies in improving honey quality as we decrease frequency quality improves remarkable even in low strength colony. Strength is also a very important factor in deciding honey quality. In spite improving honey quality less number of honey extractions increases economic returns to the farmers (Saini et al 2022). The results for all the honey quality parameters were remarkable under single and two honey extractions over regular extractions. Colonies with initial 10 frames strength and two extractions in the seasons were observed to produce honey of good quality and most economical as per findings of the study. The moisture content which is major quality criteria even in 5 frame colonies (17.91%) remained well below the maximum standards (20%) set for "special" grade honey and was still lower in medium (17.80%) and the strongest colonies (17.43%). However, under regular honey extraction, the moisture content was maximum in colonies of lowest strength (20.02%) compared to in 10 and 15 frame colonies. If beekeepers in India want to improve honey quality and to earn more returns from this enterprise honey extraction should be limit to one or two in the season leaving enough food stores for bee to survive dearth period.

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