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EFFECT OF THERMAL, MICROWAVE AND ULTRASONIC WAVE PROCESSING ON VIETNAMESE HONEY QUALITY

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Abstract

The aim of the present work is to find out if thermal, microwave and ultrasonic waves processing can affect some of the main honey quality parameters - reductive sugar (RS), hydroxyl-methyl-furfural (HMF) and diastase number (DN) or not. The results showed that RS concentration has been lightly fluctuated (not significantly), HMF increased (average 23.22% with thermal, 30.44% with microwave, 21.62% with ultrasonic waves processing) but still satisfied the limit of Codex Standard 12-1981, microwave processing was observed a significant decrease of DN (reduced to 93.09% after 30 seconds processing).

Introduction

It is well known that honey as a natural product may be processed by means of thermal treatment for two main reasons: first of all, to destroy the micro-organisms that may contaminate it and to modify its tendency to crystallization or delay the appearance of monosaccharide crystals (Tosi et al. 2002). During crystallization process that leads to phase separation, both liquid and non-liquid phases may coexist. Simultaneously, water activity of the remaining liquid phase begins to increase. This is the result of water release during

Key words: honey, thermal processing, microwave processing, ultrasonic wave, reductive sugar (RS), hydroxyl-methyl-furfural (HMF) and diastase number (DN).

crystallization and subsequent decrease of carbohydrates concentration in the liquid phase. This phenomenon makes the honey suitable for the growth of microorganisms like yeasts and fungi and leads to sensory properties modifications and quality damage (Tosi et al. 2004).

Microwave processing may be the solution for honey liquefaction without the loss of bioactivity. Microwaves as an example of volumetric heating will influence the state of aggregation and due to the microwave/matter interaction may be applied for a short time. It results in reduction of quality losses in honey (Kowalski, Lukasiewicz, Bednarz, & Panus, 2012). On the other hand it is well known that microwave processing can cause some damage to bioactive food components (especially enzymes) (Günes & Bayindirli, 1993; Matsui, Granado, de Oliveira, & Tadini, 2007).

Ultrasonic waves processing has become an alternative to many conventional food-processing steps, such as homogenization, milling, high shear mixing, pasteurization and solid/liquid separation. Moreover, it has shown to improve the efficiency of traditional processes such as filtration/screening, extraction, crystallization and fermentation (Patist A and Bates D., 2008). The different combinations of Ultrasonic waves processing (temperature and duration) can be used to achieve the main objective of honey deliquescence. Ultrasonic waves processing can be effectively used for thermal processing of honey, as it speeds up the liquefaction of honey in a temperature range of 40-50C without compromising its main quality parameters (Kabbani D, Sepulcre F, Wedekind J., 2011; Kabbani D, Wedekind J and Sepulcre F., 2011).

In this research, we aimed to evaluate the effect of thermal, microwave and ultrasonic waves processing on the honey quality.

Materials and Methods

Six samples of honey were obtained from different producers, includes: Thai Hoa Mat honey (M1), Trieu Chau honey (M2), Daklak honey (M3), Honey Boy honey (M4), Longan honey (M5) and Rambutan honey (M6).

Conventional heating of the honey samples (50 g) was conducted in a water bath (BS-11, Korean) at 90C for 20, 40, and 60 min (isothermal heating) without stirring.

Microwave processing of the honey samples (50 g) was performed without stirring in a microwave reactor operating with continues power for 10, 20, and 30 seconds.

Ultrasonic waves processing of the honey samples (50 g) was performed in a ultrasound reactor (S-3000, France; 20kHz 50 Hz) for 2, 4, and 6 min.

After all treatments and cooling of the samples to room temperature, reductive sugar, hydroxymethylfurfural (HMF) and diastase number (DN) were determined as a function of time.

RS can be investigated by the 3,5-dinitrosalicylic acid (DNS) method employing glucose as the standard. DNS reacts with free carbonyl group of the RS under alkaline condition, forming 3-amino-5-nitrosalicylic acid, an aromatic compound with maximum absorption at 540 nm, allowing a quantitative spectrophotometer measurement of the amount of RS present.

The determination of HMF content is based on the determination of UV absorbance of HMF at 284 nm. Accurately weigh approximately 5g of honey into a 50 ml beaker. Dissolve the sample in approximately 25 ml of water and transfer quantitatively into a 50 ml volumetric flask. Add 0.5 ml of Carrez solution I and mix. Add 0.5 ml of Carrez solution II, mix and make up to the mark with water (a drop of ethanol may be added to suppress foam). Filter through paper; rejecting the first 10 ml of the filtrate. Pipette 5.0 ml in each of two 2 test tubes (18 x 150 mm). Add 5.0 ml of water to one of the test tubes and mix well (the sample solution). Add 5.0 ml of sodium bisulphite solution 0.2% to the second test tube and mix well (the reference solution). Determine the absorbance of the sample solution against the reference solution at 284 and 336 nm.

The unit of Diastase Activity, the Gothe unit, is defined as that amount of enzyme which will convert 0.01 gram of starch to the prescribed end-point in one hour at 40^oC under the conditions of test. Results are expressed in Gothe units (or Schade units) per gram of honey.

Table 1: Changes in honeys RS, HMF and DN after thermal processing at 90^oC

Physicochemical composition	Time (min)	Sample					
		M1	M2	M3	M4	M5	M6
RS (mg/g)	0	$794,67^{a}\pm3,21$	$830,33^{a}\pm1,53$	$846,67^{a}\pm2,08$	$810,33^{a}\pm2,52$	$833,67^{a}\pm9,07$	$789,67^{a}\pm4,16$
	20	$837,33^{b}\pm3,06$	$835,33^{b}\pm2,08$	$834,00^{b}\pm2,00$	$822,67^{b}\pm2,52$	$818,33^{b}\pm1,15$	$803,00^{b}\pm1,00$
	40	$842,00^{b}\pm2,00$	$828,00^{a}\pm1,00$	$846,33^{a}\pm2,31$	$806,33^{c}\pm1,53$	$827,00^{ab}\pm2,00$	$794,33^{c}\pm1,53$
	60	$853,33^{c}\pm1,53$	$840,67^{c}\pm1,53$	$833,33^{b}\pm2,08$	$834,33^{d}\pm1,53$	$792,00^{c}\pm2,00$	$816,00^{d}\pm1,00$
HMF (mg/kg)	0	$4,05^{a}\pm0,09$	$1,90^{a}\pm0,06$	$1,22^{a}\pm0,09$	$3,21^{a}\pm0,04$	$1,53^{a}\pm0,04$	$1,79^{a}\pm0,04$
	20	$4,65^{b}\pm0,02$	$1,90^{a}\pm0,03$	$1,50^{b}\pm0,02$	$3,22^{a}\pm0,01$	$1,57^{b}\pm0,02$	$1,90^{b}\pm0,02$
	40	$4,50^{c}\pm0,02$	$2,12^{b}\pm0,02$	$1,65^{c}\pm0,03$	$3,24^{a}\pm0,02$	$1,65^{c}\pm0,02$	$2,25^{c}\pm0,01$
	60	$4,95^{d}\pm0,02$	$2,12^{b}\pm0,13$	$1,72^{c}\pm0,03$	$3,61^{b}\pm0,02$	$1,93^{d}\pm0,02$	$2,25^{c}\pm0,02$
Diastase (G)	0	$3,01^{a}\pm0,04$	$5,56^{a}\pm0,07$	$3,75^{a}\pm0,05$	$8,43^{a}\pm0,10$	$2,39^{a}\pm0,07$	$5,29^{a}\pm0,15$
	20	$2,56^{b}\pm0,03$	$4,92^{b}\pm0,04$	$3,24^{b}\pm0,05$	$7,21^{b}\pm0,07$	$1,92^{b}\pm0,05$	$4,12^{b}\pm0,03$
	40	$2,06^{c}\pm0,10$	$3,79^{c}\pm0,04$	$2,71^{c}\pm0,04$	$6,22^{c}\pm0,05$	$1,69^{c}\pm0,03$	$3,77^{c}\pm0,02$
	60	$1,78^{d}\pm0,05$	$3,16^{d}\pm0,06$	$2,31^{d}\pm0,05$	$5,94^{d}\pm0,08$	$1,36^{d}\pm0,02$	$2,85^{d}\pm0,06$

Note: Values in columns with the same letter do not differ significantly at $\alpha = 0.05$

Results and Discussions

After 60 min thermal processing at temperature 90^oC, we observed an increase of RS of four samples (M1 - 7.38%, M2 - 1.24%, M4 - 2.96%, M6 - 3.33%), a

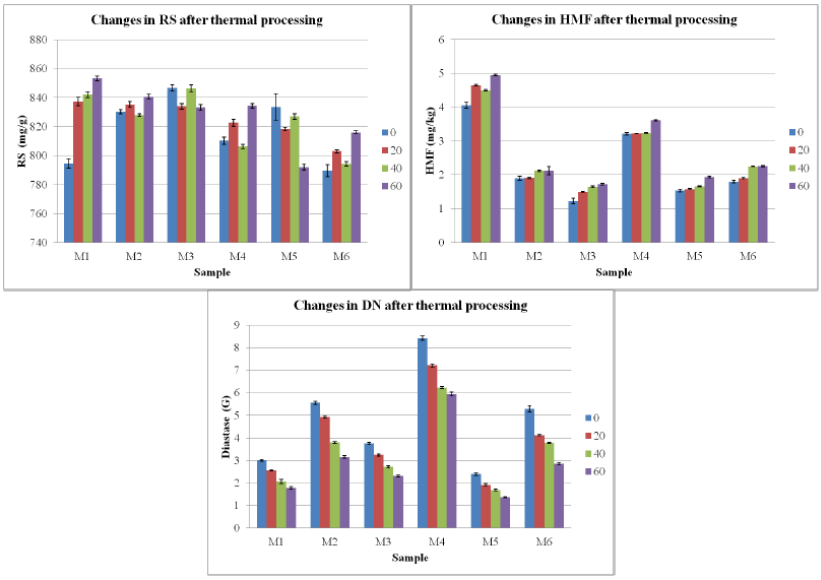

Figure 1: Changes in honeys RS, HMF and DN after thermal processing at 90^oC

decrease of RS of two samples (M3 - 1.57%, M5 - 5.00%). However, the RS of all the honey samples did not less than 600 mg/g (Codex Standard 12-1981).

Based on the statistical analysis, a statistically significant ($P<0.05$) was observed, an increase of HMF of four samples (M1, M3, M5, M6) after 20 min, an increase of HMF of the two samples (M2 - 11.95%, M4 - 12.34%) after 60 min. However, the HMF of all samples did not more than 40 mg/kg (Codex Standard 12-1981).

After 60 min, only two samples (M2 - 3.16 G, M4 - 5.94 G) would not reduce DN below the Codex Standard 12-1981 (not less than 3 G)

Our results showed that in honey with DN less than 5 G did not allowed to thermal processing at 90^oC.

After 6 min ultrasonic waves processing, we observed an increase of RS of four samples (M1 - 9.35%, M2 - 0.76%, M4 - 0.95%, M6 - 3.33%), a decrease of RS of two samples (M3 - 0.24%, M5 - 1.12%). However, the RS of all the honey samples did not less than 600 mg/g (Codex Standard 12-1981).

Based on the statistical analysis, a statistically significant (P¡0.05) was observed, an increase of HMF of two samples (M4 and M5) after 2 min, an increase of HMF of three samples (M1, M2 and M6) after 4 min, an increase of HMF of M3 sample after 6 min.

However, the HMF of all samples did not more than 40 mg/kg (Codex Standard 12-1981).

After 60 min, only two samples (M1 - 3.01 G, M5 - 2.39 G) would reduce

Table 2: Changes in honeys RS, HMF and DN after ultrasonic waves processing

Physicochemical composition	Time (min)	Sample					
		M1	M2	M3	M4	M5	M6
RS (mg/g)	0	$794,67^{a}\pm3,21$	$830,33^{a}\pm1,53$	$846,67^{a}\pm2,08$	$810,33^{a}\pm2,52$	$833,67^{a}\pm9,07$	$789,67^{a}\pm4,16$
	2	$863,33^{b}\pm4,16$	$834,67^{b}\pm2,08$	$834,00^{b}\pm1,00$	$803,33^{b}\pm1,53$	$820,67^{b}\pm2,08$	$783,33^{b}\pm1,53$
	4	$873,33^{b}\pm4,16$	$829,33^{a}\pm0,58$	$829,33^{c}\pm2,52$	$811,33^{a}\pm2,52$	$825,67^{ab}\pm2,08$	$792,67^{a}\pm1,53$
	6	$869,00^{b}\pm8,89$	$836,67^{b}\pm1,53$	$844,67^{a}\pm1,53$	$818,00^{c}\pm2,65$	$824,33^{b}\pm2,52$	$788,67^{a}\pm1,15$
HMF (mg/kg)	0	$4,05^{a}\pm0,09$	$1,90^{a}\pm0,06$	$1,22^{a}\pm0,09$	$3,21^{a}\pm0,04$	$1,53^{a}\pm0,04$	$1,79^{a}\pm0,04$
	2	$4,33^{b}\pm0,01$	$1,80^{b}\pm0,02$	$1,20^{a}\pm0,03$	$3,45^{b}\pm0,02$	$1,57^{b}\pm0,02$	$1,82^{a}\pm0,02$
	4	$4,34^{b}\pm0,01$	$1,81^{b}\pm0,02$	$1,27^{a}\pm0,02$	$3,59^{c}\pm0,01$	$1,72^{c}\pm0,01$	$1,92^{b}\pm0,02$
	6	$4,48^{c}\pm0,01$	$1,91^{a}\pm0,02$	$1,57^{b}\pm0,02$	$3,75^{d}\pm0,02$	$2,25^{d}\pm0,02$	$2,26^{c}\pm0,01$
Diastase (G)	0	$3,01^{a}\pm0,04$	$5,56^{a}\pm0,07$	$3,75^{a}\pm0,05$	$8,43^{a}\pm0,10$	$2,39^{a}\pm0,07$	$5,29^{a}\pm0,15$
	2	$2,92^{b}\pm0,02$	$4,76^{b}\pm0,04$	$3,73^{a}\pm0,02$	$8,09^{b}\pm0,02$	$2,24^{b}\pm0,02$	$4,98^{b}\pm0,02$
	4	$2,86^{c}\pm0,02$	$4,59^{c}\pm0,04$	$3,66^{b}\pm0,02$	$7,78^{c}\pm0,05$	$2,14^{c}\pm0,01$	$4,73^{c}\pm0,02$
	6	$2,58^{d}\pm0,03$	$4,33^{d}\pm0,03$	$3,60^{c}\pm0,02$	$7,54^{d}\pm0,03$	$1,99^{d}\pm0,02$	$4,49^{d}\pm0,02$

Note: Values in columns with the same letter do not differ significantly at $\alpha = 0.05$

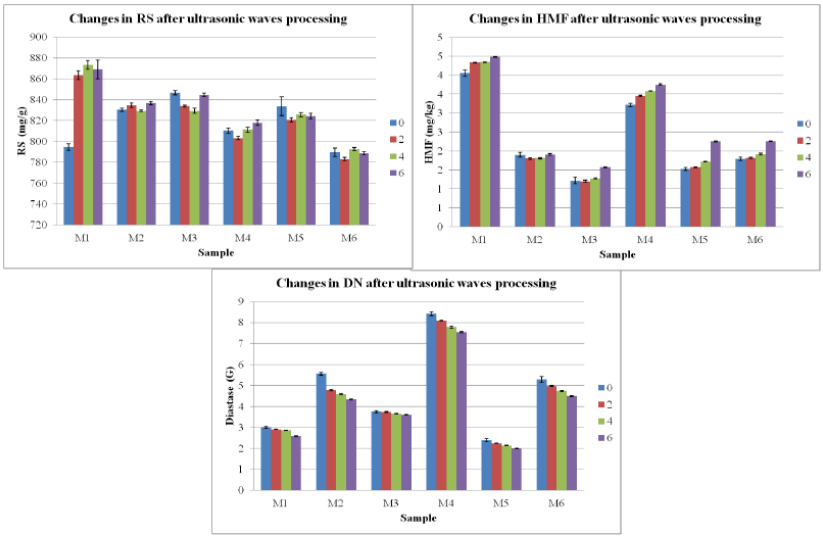

Figure 2: Changes in honeys RS, HMF and DN after ultrasonic waves processing

DN below the Codex Standard 12-1981 (not less than 3 G).

The results showed that ultrasonic waves processing did not influence the honey quality, for example, in M3 sample with the lower DN (3.75 G) dropped to 3.60 G (only 3.91%) after 6 min of ultrasonic waves processing.

Table 3: Changes in honeys RS, HMF and DN after microwave processing

Physicochemical composition	Time (sec)	Sample					
		M1	M2	M3	M4	M5	M6
RS (mg/g)	0	$794,67^{a}\pm3,21$	$830,33^{a}\pm1,53$	$846,67^{ab}\pm2,08$	$810,33^{a}\pm2,52$	$833,67^{a}\pm9,07$	$789,67^{a}\pm4,16$
	10	$843,00^{b}\pm2,00$	$830,33^{a}\pm1,53$	$841,00^{c}\pm1,00$	$816,00^{b}\pm1,00$	$786,33^{b}\pm1,53$	$805,33^{b}\pm1,53$
	20	$841,67^{b}\pm1,15$	$837,33^{b}\pm1,53$	$845,33^{a}\pm2,08$	$823,67^{c}\pm1,53$	$792,33^{bc}\pm0,58$	$812,00^{c}\pm1,00$
	30	$859,00^{c}\pm2,00$	$835,67^{b}\pm1,15$	$849,67^{b}\pm2,08$	$828,33^{d}\pm0,58$	$795,33^{c}\pm1,53$	$811,33^{c}\pm3,06$
HMF (mg/kg)	0	$4,05^{a}\pm0,09$	$1,90^{a}\pm0,06$	$1,22^{a}\pm0,09$	$3,21^{a}\pm0,04$	$1,53^{a}\pm0,04$	$1,79^{a}\pm0,04$
	10	$4,34^{b}\pm0,02$	$2,10^{b}\pm0,02$	$1,35^{b}\pm0,02$	$3,59^{b}\pm0,03$	$1,60^{b}\pm0,02$	$2,13^{b}\pm0,03$
	20	$4,36^{b}\pm0,02$	$2,12^{b}\pm0,02$	$1,52^{c}\pm0,02$	$4,34^{c}\pm0,02$	$1,75^{c}\pm0,03$	$2,27^{c}\pm0,02$
	30	$5,07^{c}\pm0,02$	$2,23^{c}\pm0,03$	$1,65^{d}\pm0,02$	$4,34^{c}\pm0,02$	$2,14^{d}\pm0,04$	$2,32^{d}\pm0,03$
Diastase (G)	0	$3,01^{a}\pm0,04$	$5,56^{a}\pm0,07$	$3,75^{a}\pm0,05$	$8,43^{a}\pm0,10$	$2,39^{a}\pm0,07$	$5,29^{a}\pm0,15$
	10	$2,30^{b}\pm0,02$	$4,48^{b}\pm0,04$	$3,03^{b}\pm0,06$	$6,47^{b}\pm0,02$	$1,81^{b}\pm0,02$	$4,32^{b}\pm0,03$
	20	$0,71^{c}\pm0,02$	$1,27^{c}\pm0,02$	$1,05^{c}\pm0,08$	$2,45^{c}\pm0,04$	$0,54^{c}\pm0,04$	$1,43^{c}\pm0,02$
	30	$0,26^{d}\pm0,03$	$0,38^{d}\pm0,04$	$0,24^{d}\pm0,01$	$0,54^{d}\pm0,04$	$0,13^{d}\pm0,02$	$0,40^{d}\pm0,02$

Values in columns with the same letter do not differ significantly at $\alpha = 0.05$.

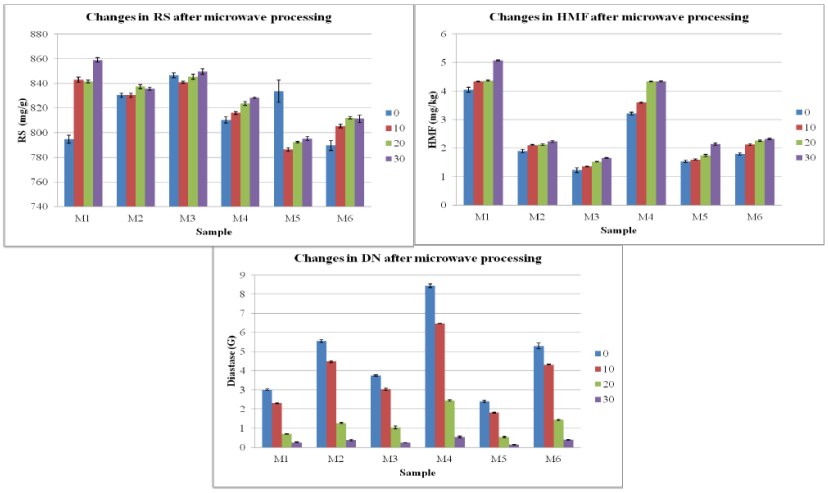

Figure 3: Changes in honeys RS, HMF and DN after microwave processing

After 30 seconds microwave processing, except M5 (decrease 4.60%), we observed an increase of RS of all samples. However, the RS of all the honey samples did not less than 600 mg/g (Codex Standard 12-1981).

Based on the statistical analysis, a statistically significant (P¡0.05) was observed, an increase of HMF of all samples after 10 seconds. However, the HMF of all samples did not more than 40 mg/kg (Codex Standard 12-1981).

We observed that a decrease of DN of all samples after 10 seconds. However, only two samples (M1 - 3.01 G, M5 - 2.39 G) would reduce DN below the Codex Standard 12-1981 (not less than 3 G).

The results showed that microwave processing did not influence RS and HMF but significant decrease of DN (93.09%).

Conclusion

The results received from this research showed that in some experimental conditions, there were statistically significant differences for the RS and HMF in honey after thermal, microwave or ultrasonic wave but still satisfied the limits of Codex Standard 12-1981.

We also observed a variable behavior of DN during treatment process. Going into details, DN dropped average 40.23% after 60 min of thermal processing, 93.09% after 30 seconds of microwave processing and 13.77% after 6 min of ultrasonic waves processing.

Such observation leads to the conclusion that a short ultrasonic wave processing of honey with a low power level did not influence on honey quality estimated by means of RS, HMF, DN and allowed to imagine the industrial processing of honey. However, the effect of ultrasonic wave treatment needs further examination.

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