Characteristics of forest honey from several areas in Riau Province, Indonesia

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~~Characteristic~~ Characteristics of forest honey from several areas in Riau Province, Indonesia

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Abstract

Honey quality is influenced by several factors, including transportation conditions and length of storage. ~~The~~ This study aimed to investigate ~~both~~ the composition, characteristics, and quality of honey from several regions in Riau and ~~the composition of~~ Riau honey sent to Java Island ~~and to determine the characteristics and quality of honey samples.~~. Honey samples were obtained from ~~5~~five districts in Riau Province, namely, Inderagiri Hulu, Kuantan Singingi, Pelalawan, Bengkalis, and Kampar Regencies. ~~Honey~~The honey parameters observed were based on the Indonesia National Standard (SNI) of honey. Data were analyzed descriptively by comparing the characteristics of honey samples from Riau Province. ~~The results~~Results showed a significant difference between honey sent and those not sent between islands. Significant differences were mainly ~~seen~~observed in ~~Hydroxymethylfurfural~~hydroxymethylfurfural (HMF) levels. Almost all honey samples sent ~~between islands have~~to Java Island had HMF levels above 50 mg/kg, ~~while~~. Meanwhile, all Riau honey samples ~~that were not sent between islands have~~from the five regions had HMF levels below 50 mg/kg. The diastase enzyme activity was slightly higher in the honey samples ~~that were not sent to Java island.~~from the five regions. Land transportation ~~between islands~~to the island decreased the quality of honey as indicated by

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~~Keyword~~

Keywords

diastase enzyme activity, forest honey, HMF levels, ~~transportation~~

Commented [A1]: Remark: Generally, abbreviations are not allowed as keywords.

1. Introduction

Honey is a natural product with a sweet taste produced by honeybees from flower nectar and consumed ~~because it has a~~due to its high nutritional value and ~~has an influence on~~ health benefits, such as antioxidants, anti-inflammatory, antimicrobial, and ~~also its effect on~~ wound healing. The composition of honey depends on the type of flower, ~~the~~ season, environmental factors, and ~~post-harvest~~postharvest treatment by beekeepers (1,2).

Riau ~~province~~ Province is one of the largest honey producers ~~compared to the others~~ in Indonesia. ~~Honeybees~~Honeybee cultivation is prospective enough to be developed in Riau Province because ~~there is a~~ of the gap between ~~the~~ supply and demand for honey production. The ~~supply's~~supply of honey is about 8,000 tons/year, ~~while~~and the demand for honey is 20,000 tons/year. ~~The fulfillment of~~Honey shortage ~~of honey production is generally imported~~is addressed by importing from other countries ~~by~~and domestic industries. Problems often faced by honeybee farmers include simple technology,

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unsustainable honey harvesting, and inability of the ~~honey produced has not met~~product to meet the standards or criteria set by the market (3).

Land transportation is a ~~transportation~~necessary route ~~that must be taken~~ for the delivery of honey outside Riau Province. Mileage that takes days, especially when shipping between the islands of Sumatra and Java, can ~~result in a decrease in~~reduce the quality of honey. ~~The influence of packing~~Packing and high temperatures during ~~the~~ land trip ~~using land transportation~~ can also damage the ~~honey~~ composition of honey, thereby reducing ~~honey~~ its quality~~,~~ and consequently ~~decreasing~~ its health efficacy. For instance, ~~hidroxymethylfurfural~~hydroxymethylfurfural (HMF) and diastase ~~enzyme~~ activity are commonly used as ~~parameter~~parameters of honey quality~~. These parameters~~, and both are greatly affected by temperature and storage conditions (4.5).

~~There has been no~~No data ~~showing~~are available on the quality of Riau honey samples and the differences in the quality and composition of honey from Riau Province sent by land transportation ~~between~~to islands in Sumatra and Java with 1ose of honey that only circulates in Riau Province. ~~The purpose of~~Therefore, this study ~~was~~aimed to ~~know~~determine the characteristics and quality of Riau honey samples, and compare the composition of honey from several regions in Riau Province with ~~the composition~~that of ~~Riau~~ honey sent to Java Island.

2. Materials and Methods

~~This study used a~~A descriptive method was used to determine the characteristics of Riau honey and the effect of inter-island transportation on the ~~changes in the~~ composition of honey samples from ~~Riau Province. Honey samples originated from 5~~five districts in Riau Province, namely, Indragiri Hulu (Inhu), Kuantan Singingi (Kuansing), Pelalawan, Bengkalis, and Kampar. ~~The study~~This research was conducted from March to June 2019.

Forest honey ~~tested consists~~samples consisted of ~~1 (~~one~~) sample honey~~ from Indragiri Hulu (Inhu) District, ~~1 (~~one~~) sample~~ from Kuantan Singingi (Kuansing), ~~1 (~~one~~) sample~~ from Bengkalis, ~~2 (~~two~~) samples~~ from Pelalawan, ~~1 (~~and one~~) sample~~ from honey farms in Kampar (kelulut honey). The honey sample from Pelalawan consisted of ~~1 (~~one~~)~~ sample from the Sorek area and ~~1 (~~one~~)~~ commercial honey sample.

In the first phase ~~of the study~~, honey samples from five districts in Riau Province ~~was~~were packaged in plastic bottles and sent to the Riau Provincial Trade Office for quality analysis. Testing ~~method for all~~ parameters ~~used~~were adopted from SNI (Indonesia National Standard) 3545:2013.

In the second ~~stage~~phase, honey samples from the five districts in Riau Province were sent to Java Island using land expedition services for ~~four~~4 days. Honey ~~is~~was packaged in plastic bottles and ~~packed with~~then in boxes made of pieces of wood. Honey testing was conducted at the Agro-Industry Center (BBIA), Bogor. Testing ~~methods~~ for ~~parameters of~~ diastase ~~enzyme~~ activity, ~~hidroxymethylfurfural (~~HMF~~),~~, water, and acidity ~~using~~was conducted following SNI 3545:2013. ~~For the parameters~~Analysis of reducing sugar, sucrose sugar, total insoluble solids, and ash content ~~using~~was performed as per SNI 01-2892-1992. For metal contamination, ~~lead, cadmium uses the~~ MU/MO/10 (AAS) ~~method. For mercury uses~~was adopted for lead and cadmium, MU/MO/12 (AAS~~). Arsenic testing uses~~) for mercury, MU/MO/13 (AAS~~), copper uses~~) for arsenic, AOAC.999.11 (9.1.09.2005~~), calcium uses~~) for copper, and AOAC 985.35 (50.1.14.2005~~).~~) for calcium. Total plate ~~numbers~~

were number (TPN) was tested using the METHODS following ISO 4833:2003(E) and ISO 7218:2012. Coliform Coliforms were tested with the 2002 BAM method, as well as and mold and yeast were examined using BAM 2001. Both The laboratories where were accredited for honey sample testing is accredited laboratory.

Honey The honey samples tested consist were examined in terms of thirteen 13 parameters such as diastase enzyme activity, HMF, water content, reducing sugar (glucose), sucrose, acidity, total insoluble solids, ash, metal contamination (Pb and Cd), microbial contamination (total plate count, coliform, mold, and yeast), and calcium levels tested at BBIA using SNI Parameter in 2013. For Each sample was measured twice to ensure the validity and reproducibility of the data, each sample was measured twice. Data analysis was obtained. The results were qualitatively analyzed to describe the characteristics of several honey samples in Riau and to determine the changes in HMF levels and diastase enzyme activity of after th 5 oney was sent to Java.

The This study was approved by the ethical clearance committee of the Faculty of Public Health Universitas Indonesia (No.: 332/UN2.F10/PPM.00.02/2019, date of issue: May16, 2019).

3. Results and Discussion

3.1. Characteristics of Riau Forest Honey

Riau is one of a province in Indonesia and is located on Sumatra Island. The climate is tropical with a maximum temperature of 35.1 0 -1 °C and a minimum temperature of 21.8 0 -8 °C. The average annual rainfall ranges between 1,700 mm to and 4,000 mm (6).

Honey The honey samples were analyzed at the Riau Provincial Trade Office using SNI 2013 parameters. The characteristics of some Riau honey samples are present presented in Table I. Table I shows that the The highest diastase enzyme activity was found in the Kuansing honey sample (8.16), while and an average of 0 was obtained for the honey samples samples from other regions averaged 0. The requirement for diastase enzyme activity according to SNI is a minimum of 3 DN. Diastase The diastase enzyme activity of the honey in this present study was lower than that of the honey from India and Ethiopia varied varying from 36.7 DN to 57.5 DN and from 3.91 DN to 13.6 DN, respectively (7,8). Otherwise, it but was higher than that of the honey from Malaysia ranged ranging between 0 to and 0.75 DN (9). The variation of diastase enzyme activity could be caused by the different types of honey's floral origin.

Table 1. Characteristics Of Riau Honey Samples.

Charasteristics Characteristics	Kuansing	Inhu	Bengkalis	Kampar	Sorek	Commercia
Diastase Enzyme Activity (DN)	8.16	0	0.38	0.34	0.86	0
Hidroxiimethylfurfural (Mg/Kg)	0.49	9.05	11.94	0.58	9.44	27.84
Moisture (% B/B)	> 25	24.2	20.6	> 25	24.6	19.4
Reducing Sugar (% B/B)	63.86	64.18	63.37	37.77	67.14	63.37
Sucrose (% B/B)	0	2.53	6.38	0.35	0	6.14
Acidity (1 N/Kg)	42.65	49.70	94.73	198.47	39.86	82.04
Total Insoluble solid (% B/B)	0.81	1.02	0.37	1.54	1.08	1.90
Ash (% B/B)	0.48	0.20	0.54	0.44	0.20	0.42

Commented [A2]: Remark: For all tables and figures, the full forms of all acronyms/abbreviations should be used only once or at first mention (with the abbreviations or initialisms indicated in a parentheses); use the abbreviations or initialisms in subsequent mentions. Note that the instruction of most journals is that tables and figures should be able to stand on their own (without need for reference to the text).

Commented [A3]: Remark: Correct spelling is: hydroxymethylfurfural.

Metal Contamination: Lead (Mg/Kg) Cadmium (Mg/Kg)	< 0.34 < 0.16	< 0.34 < 0.16	< 0.34 < 0.16	< 0.34 < 0.16	< 0.34 < 0.16	< 0.34 < 0.16
Microbial Contamination: Total Plate Count (Col/G) Coliform (Apm/G) Mold And Yeast (Col/G)	1.0×10^6 < 3.0 2.8×10^2	2.5×10^3 < 3.0 3.0×10^1	6.2×10^2 < 3.0 2.0×10^1	2.8×10^3 < 3.0 1.0×10^2	6.9×10^3 < 3.0 7.0×10^1	3.7×10^3 < 3.0 2.0×10^1

~~Diastase enzyme~~The diastase activity in honey is affected by several factors. The temperature and heating process may decrease the diastase ~~enzyme~~ content. Biological differences among species of bees also affect the diastase ~~enzyme~~ content of honey (10).

The enzyme content in honey is one of the characteristics that are considered beneficial for health. The main enzymes found in honey are invertase (saccharase), diastase (amylase), and glucose oxidase. ~~The diastase enzyme~~Diastase activity is an essential factor that determines the quality of honey. Although enzymes are a small part of honey's composition, their presence is associated with health ~~benefits~~advantages, including nutritional benefits, carbohydrate digestion, and ~~potential as an~~ antimicrobial activity (11,12).

For HMF level parameters, all Riau honey samples ~~meet~~met SNI ~~requirements, which are~~ requirement of below 50 mg/kg (from 0.49 mg/kg to 27.84 mg/kg~~.~~). The lowest HMF level was found in Kuansing honey sample at 0.49 mg/kg. The average ~~of~~ HMF ~~levels~~level in this study was lower than that of Tunisian honey (12.07 mg/kg to 27.43 mg/kg) (13) and higher than that of Ethiopian honey (0 to 3.~~37mg~~37 mg/kg) (8). The high water content of honey could increase ~~the~~its HMF level.

HMF is a cyclic aldehyde produced from the breakdown of sugar through the Maillard reaction (a non-enzymatic browning reaction) during food processing or long storage ~~honey~~. The content of simple sugars (glucose and fructose), acidic compounds, and minerals can increase the production of HMF. ~~The concentration of HMF is known as a parameter that~~HMF affects the freshness of honey because freshly harvested honey ~~does not~~ contain minimal and even no HMF ~~or is present in slight amounts.~~. HMF concentrations tend to increase during processing or storage (4). High acid content, moisture content, sugars, amino acids, and minerals~~,~~ could increase HMF level (14).

The moisture content of Riau honey samples ranged from 19.4% to >~~-~~25%. The maximum water content according to SNI is 22. ~~It is proved by~~The honey samples from Bengkalis ~~with~~had a moisture content of 20.6, and commercial honey ~~with~~had a water content of 19.4. The Bengkalis honey sample has undergone ~~a dehumidifier process or~~dehumidification, a process of decreasing water content~~, while commercial~~. Commercial honey is also suspected to have undergone ~~a process of decreasing water content.~~this procedure.

The moisture content of Riau honey samples was higher than ~~those from~~ that of Tunisia honey (~~ranged from~~ 17.27% to 19.80%) and Turkish honey (15.1% and 20.4%) (13,15). The ~~higher~~ high moisture content in Riau honey samples can be caused by honey harvesting in the rainy season~~, thus affecting their moisture contents~~.

Honey contains water, fructose, and acidic compounds. Mold can grow in honey ~~if~~when the water content of honey is high. Fermentation is a problem in honey. If the water content ~~increased,~~increases, then fermentation and decomposition could rapidly occur

Commented [A4]: Remark: The point of comparison is usually indicated for comparative modifiers or terms. When the basis cannot be provided, the positive form of the terms is typically adopted.
This comment applies to all other similar cases in this paper.

faster (16). Water content in honey is affected by plant species, geographical origin, season at harvest time, and post-harvestpostharvest processing, such as honey extraction, processing, and storage conditions (14).

The highest reducing sugar content was detected in Sorek honey samples at 67.14 with a (minimum SNI requirement of 65, while). The honey samples from other regions havehad reducing sugar levels below 65. These resultsvalues were lower than the reducing sugar fromcontent of Saudi honey (72.36 ± 0.32 g/100 g) (1), while and Croatian honey had reducing sugar with an average of 67.69 ± 7.05 g/100 g for accaciaacacia honey and 77.82 ± 12.25 g/100 g for chestnut honey (17). The reducing sugar content wasis determined by the duration of storage and honey collection time (18).

Honey is rich in reducing sugars, notably fructose (38%) and glucose (31%). Both types of sugar do not require hydrolysis by enzymes in the digestive tract to directly be absorbed in the small intestine. Fructose may lower hyperglycemia or sugar levels in experimental mice, healthy subjects, and patients with diabetes. Therefore, fructose does not enhance blood glucose. Furthermore, its metabolism does not require insulin. Glucose also increases fructose absorption in the gut (11).

The requirement for sucrose content in honey is a maximum of 5 accordingly% according to SNI. HoneyThe honey from Kuansing, Inhu, Kampar, and Sorek can achieve these requirements. Whileachieved this requirement. However, the honey from Bengkalis and Pelalawan (commercial) did not reach the SNI standard and had sucrose contents of 6.38% and 3.14%, respectively. Tunisian honeys hadhoney has a sucrose level below 5% (0.20% to 4.60%) (13). Multifloral honey from Poland and Slovakia hadhas a sucrose level of 4.40% ± 1.95% and 4.47% ± 2.15,%, respectively (19). Source of plant, immaturity of honey, and artificial feeding of bees affectedaffect the high sucrose content in honey (14).

The sucrose in honey is turned into glucose and fructose. High levels of sucrose indicate premature honey harvesting. Hence, invertase cannot fragment sucrose has not been fragmented into glucose and fructose by the enzyme invertase.. Sugar content in honey is affected by the ratio of fructose–glucose and sucrose content. Crystallized honey suggests a high level of glucose. Because of thisTherefore, the glucose in honey is hardly soluble in water. In addition, honeyHoney also contains other types of sugar that can impede crystallization (13,20).

Commented [A5]: Remark: The en dash (–) is often used to link items of equal rank.

Acidity levelsThe maximum acidity level in honey is 50 N/Kg according to SNI 2013 is maximum 50 N/Kg.. Bengkalis, Kampar, and Commercial honey havesamples had a high acidity above 50 N/kg. Acidity in Sudan honey from Sudan was found athas an acidity of 51.80 ± 1.95 meq/kg for *Apis melifera* honey and 98.40 ± 1.82 meq/kg for *Apis florea* honey (21). HowerMeanwhile, Tunisian honey had lowerhas a low acidity ranging from 0.0071 N/kg to 0.0272 N/kg. Different levels of acidity in honey may be caused by the varied botanical origin or the difference in harvest season (13).

The characteristics of flower nectar sucked by bees affect the difference in acidity in honey. Low acidity indicates freshness, whileand high acidity indicates the fermentation of glucose into organic acids. The consistency of honey also affects its acidity. Liquid texture has a higher acidity than solid texture sincebecause the production of free acid from fermentation is easier to occureasily occurs in liquid honey texture. In addition, acidity is affected by the length of storage. Free acids formation produced by fermentation during storage will increase the acidity of honey. (20).

~~Total~~The total insoluble ~~solid~~solids in this study ranged from 0.37% to 1.90%. ~~According to~~ SNI 3545:2013~~, it is~~ imposed a maximum of 0.5~~% and is~~%, which was only achieved by Bengkalis honey. ~~In~~By contrast, Turkish honey ~~had~~has a weak total insoluble solid content between 0.001% ~~-~~and 0.080% (22), and Ethiopian honey ~~had water~~ has a total insoluble solid ~~at~~content of 0.005~~% – %~~–0.22%. Honey ~~needs~~requires a proper procedure to avoid contamination with insoluble solids (23). A high number of insoluble solids in honey ~~like~~, such as impurities or other particles, could indicate ~~a~~ poor ~~hygienic post-harvest~~hygiene during postharvest honey process.

All honey samples ~~meet~~met the maximum ash content according to SNI (not more than 0.5~~%). Except~~%), except for ~~honey from~~ Bengkalis~~, which has~~ honey that had a slightly ~~higher~~high ash content (0.54%). ~~Honey from~~ Sudan ~~contained~~honey contains 0.26% (*Apis melifera*) and 1.16% (*Apis florea*) ash content (21), ~~while honey from~~and Brazil ~~have contents~~honey has an ash ~~constituent~~content between 0.11% and 0.95% (24).

Ash levels indicate mineral content and are affected by honey extraction methods and~~ also by~~ bee food (21,25). Other factors can influence ash content in honey, such as environment, geography, and vegetation (24).

For metal contamination, all ~~samples of~~ Riau honey ~~meet~~samples met the SNI requirements (<2.0 mg/kg for lead and <0.2 mg/kg for cadmium). ~~Honey samples from~~ Turkey ~~had lower~~honey has low lead (mean of 0.04 ± 0.09) and cadmium ~~with a~~ (mean of ~~lead content 0.04 ± 0.09 and mean of cadmium content~~ 0.0002 ± 0 contents. In ~~China~~Chines honey, the average contents of lead and cadmium ~~in the honey samples were~~are 1.34 ~~µg/kg~~ and 33.98 µg/kg, respectively (26,27). Most of Riau honey samples were derived from multifloral honey or forest honey distant from industrial areas. For this reason, the concentration of heavy metals was low in Riau honey samples.

Bees can fly up to a radius of 4 km from the hive ~~so that they can~~, allowing them to access an area of 50 km^2. Contact of bees with air, soil, and water cause their honey to contain heavy metals. The level of heavy metals in honey can indicate the number of heavy metals found in the environment. Contaminated air, water, and soil ~~as well as~~and honey processing ~~influenced~~influence the composition of heavy metals in honey (11,28).

Although ~~the amount of~~ heavy metals ~~is~~constitute a small part of honey, ~~it determines~~they are crucial in the quality of honey. Honey can contain heavy metals such as lead and cadmium that can damage health (11). Furthermore, heavy metals such as Pb, Cd, Hg, Cr, Cu, Mn, Ni, and Zn are ~~non- biodegradable~~nonbiodegradable substance that can accumulate in the human body and cause health problems~~. For example,~~, including metabolic and respiratory disorders, headaches, nausea, and vomiting (28).

~~Total Plate Number (~~The maximum TPC~~)~~ according to SNI ~~maximum~~ is <5 x 10^3 cfu/g. Kuansing honey and Sorek honey ~~have~~had TPC above SNI, namely, 1.0 x 10^6 and 6.9 x 10^3 cfu/g, respectively. Similarly, ~~TPC in honey from~~ Nigeria ~~ranged~~honey has a TPC ranging from 1.0 x 10^4 cfu/ml to 1.2 x 10^5 cfu/ml~~-~~, and ~~honey from~~ Ghana ~~was found~~honey has a TPC between 6.0 x 10^4 and 1.1 x 10^5 cfu/ml (29,30).

~~Total Plate Number (~~TPC~~)~~ indicates the number of microorganisms ~~of both~~ (pathogenic and ~~non-pathogenic~~nonpathogenic) in honey. For example, *Bacillus* sp., *Clostridium* sp., *Micrococcus* sp., ~~Lactic Acid Bacteria~~lactic acid bacteria, yeast, and fungi ~~were~~are present in honey. These microorganisms could originate from the air, soil, water, dust, pollen, and nectar. In addition, unhygienic conditions ~~when~~during honey extraction, processing, and packaging may cause ~~honey~~microorganism contamination ~~by microorganisms~~in honey (30,31).

Honey can load microorganisms, such as bacteria, mold, and yeast. Contamination in honey can occur either through primary sources (pollen, flower nectar, dust, soil, body, and digestive tract of bees) or secondary sources ~~of post-harvest~~during postharvest processing ~~with sources of contamination~~, such as ~~from~~ humans and equipment (32,33).

All honey samples ~~fulfill Coliform~~fulfilled coliform requirements ~~i.e~~i.e.,~~.,~~ <3 APM/g~~. All Riau honey samples have not met~~ but failed to meet the requirements for mold and yeast because ~~of~~ they ~~have~~ exceeded SNI requirements, ~~which are~~ i.e., <1 x 10^1 APM/g. Similarly, the amounts of mold and yeast found in Croatian honey ~~were~~ are above the accepted standard for ~~yeast and~~ mold~~. The molds were~~ at 18~~ to ~~182 cfu/g and ~~the yeasts were~~for yeast at 18~~ to ~~1,300 cfu/g. The ~~presence of~~ molds in Croatian honey ~~came~~originated from primary sources such as the digestive tract of bees (34). Microorganisms are found in honey ~~since~~because they can survive in high sugar solutions~~,~~ and acid conditions~~, and antimicrobial properties of honey~~ (29).

Most microorganisms in honey are not harmful to health. ~~Antimicrobial~~The antimicrobial properties in honey can inhibit the growth of microorganisms. However, honey may contain *Clostridium botulinum*, which leads to infant botulism. Consequently, honey is not recommended ~~being given to~~for children under ~~one~~1-year-old (31).

Table II shows ~~resume of~~ the honey quality test ~~result~~results with 13 ~~test~~ parameters based on SNI 3545:2013. ~~Based on table II, it appears that none~~None of the Riau honey samples ~~can meet~~met all the honey requirements based on SNI in 3545:2013. Honey samples from Kuansing, Inhu, and Sorek ~~can meet 8~~met eight SNI requirements, ~~while~~and honey samples from Bengkalis, Kampar, and commercial honey samples ~~can~~met only ~~meet~~ ~~7~~seven SNI 3545:2013 requirements ~~2013~~.

Table 2. ~~Resume Of~~ Honey Quality Test Results.

Honey Samples	Test Parameters												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Kuansing	√	√	X	X	√	√	X	√	√	√	X	√	X
Inhu	X	√	X	X	√	√	X	√	√	√	√	√	X
Bengkalis	X	√	√	X	X	X	√	X	√	√	√	√	X
Kampar	X	√	X	X	√	X	X	√	√	√	√	√	X
Sorek	X	√	X	√	√	√	X	√	√	√	X	√	X
Komersial	X	√	√	X	X	X	X	√	√	√	√	√	X

√ = Qualified
X = Not Qualified
1 = Diastase ~~Enzyme~~ Activity
2 = HMF
3 = Total Moisture
4 = Reduced Sugar Content
5 = Sucrose Content
6 = Acidity
7 = Total insoluble solid
8 = Ash
9 = Lead Contamination
10 = Cadmium Contamination
11 = Total Plate Count
12 = Coliform
13 = Mold and yeast

Commented [A6]: Remark: Use English term, i.e., commercial.

Each of the three honey samples that achieved the eight SNI requirements had priorities. ~~Such as~~ Kuansing honey samples ~~containing~~showed high ~~activity of~~ diastase ~~enzymes~~activity, Sorek honey samples ~~containing~~had high levels of reducing sugar, and Inhu honey samples ~~containing~~contained low total plate numbers.

3.2. Changes in Riau Honey Composition after Inter-Island Shipping

~~Honey~~The honey samples sent to Java were analyzed at BBIA, Bogor. ~~There were changes~~Changes in the composition of honey samples were observed, primarily in the level

of diastase ~~enzyme~~ activity and HMF levels. These two parameters are affected by the heating process and have a negative correlation. Diastase ~~enzyme~~ activity tends to decrease when the heating process ~~prolongs, while the~~ is prolonged, and HMF level ~~in~~ tends to increase with heating time (7). Table III provides the changes in the composition of Riau honey sent by land transportation to Java Island.

Table 3. Change In Honey Composition After Inter-Island Delivery.

~~Charasteristics~~Characteristics	Kuansing	Inhu	Bengkalis	Kampar	Sorek	Commercial
Diastase ~~Enzyme~~ Activity (Dn)	0	0	0	0	0	1.83
Hydroxymethylfurfural (Mg/Kg)	128	153	0	129	213	0
Moisture (% B/B)	24.0	23.6	19.1	33.9	23.3	17.5
Reducing Sugar (% B/B)	64.0	65.7	57.4	28.7	58.4	61.2
Sucrose (% B/B)	1.71	0	7.68	0	10.1	7.70
Acidity (1 N/Kg)	31.5	33.3	88.9	62.8	37.3	38.3
Total Insoluble Solid (% B/B)	0.04	0.23	0.76	0.65	0.39	0.16
Ash (% B/B)	0.08	0.09	0.40	0.09	0.11	0.42
Metal Contamination:						
Lead (Mg/Kg)	< 0.034	< 0.034	< 0.034	< 0.034	< 0.034	< 0.034
Cadmium (Mg/Kg)	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Copper (Mg/Kg)	0.09	0.02	0.04	0.34	0.09	0.15
Mercury (Mg/Kg)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Arsenic (Mg/Kg)	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013	< 0.013
Microbial Contamination:						
Total Plate Count (Kol/G)	10	25	< 10	< 10	50	5
Coliform (Apm/G)	< 3	< 3	< 3	< 3	< 3	< 3
Mold (Kol/G)	< 10	27	< 10	< 10	< 10	< 10
Yeast (Kol/G)	4.9 X 10^2	1.8 X 10^2	< 10	< 10	7.4 X 10^2	< 10
Calcium (Mg/100 G)	9.74	18.6	27.0	18.5	12.1	12.7

~~As shown in~~ Table 3~~, it could be observed that there is~~ shows a significant decrease in the quality of honey after inter-island delivery, especially in the ~~level of~~ diastase ~~enzyme~~ activity. Almost all honey samples ~~have~~had 0 (zero) activity of diastase ~~enzyme~~, except for the commercial honey from Pelalawan ~~which has~~ with a diastase ~~enzyme~~ level of 1.83 DN~~, but it~~. This value is ~~still under~~below the SNI ~~requirements, which~~requirement, that is, a minimum of 3 DN.

Commented [A7]: Remark: In scientific, technical, and medical fields, significant / significance / significantly should only be used when referring to a statistical threshold and with a p value. In the absence of a p value, use remarkably or substantially instead.

~~The enzyme~~ Diastase activity ~~of diastase~~ is a measurement of α-amylase and β-amylase ~~activity~~activities and is often used as a quality parameter of honey. Diastase ~~enzyme~~ activity decreases due to heating (9). ~~Decreased~~A decreased diastase ~~enzyme~~ activity can be ~~caused by the influence of~~due to transportation between the islands of Sumatra and Java~~, considering the condition of~~. The storage conditions of honey samples ~~causes~~ prior to transport might have caused heating in honey ~~on the way~~during transport for ~~four~~4 days.

HMF levels increased significantly (>50 mg/kg), except in Bengkalis honey samples and commercial honey samples ~~which had~~with HMF 0 levels. This ~~could occur~~phenomenon occurred because HMF ~~had undergone the breaking~~broke down into levulinic acid and formic acid ~~hence~~. Hence, HMF was not detected.

The determination of HMF in honey samples aims to find out the freshness of honey. Increased HMF is associated with prolonged storage at high temperatures or excessive heating of honey. The HMF level acceptance limit varies by country and is ~~higher~~high in the tropics at 80 mg/kg (4,18). ~~Based on~~According to SNI 3545: 2013, HMF levels in honey ~~are~~must not be more than 50 mg/kg.

Factors that can affect the formation of HMF include high temperature, low pH, prolonged storage, high water content, and the use of metal box (4). Honey samples sent by land transportation can increase HMF levels due to storage conditions that cause the heating of honey during a four4-day expedition. The high water content in 4four honey samples (Kuansing, Inhu, Kampar, and Sorek) can also affectinduce the increase in their HMF levels in the samples.

In many research, HMF has been reported to have negative effects on human health, such as sitotoxiccytotoxicity on mucous membranes, skin, upper respiratory tract, chromosomal aberrations, and carcinogenic effects on humans and animals. However, recent research has shownshowed that HMF has positive effects such as antioxidants, anti-allergies, anti-inflammatory, and anti-carcinogens. These studies are stillresults were obtained at the preclinical stage and therefore requiresrequire further research (4).

For other parameters, no significant changes were seenobserved in the honey which was sent to Java. Measurement of calciumCalcium levels was were only conducted at measured in BBIA Bogor, and it was concluded that the highest calcium levels were of 270 mg/kg was found in Bengkalis honey, 270 mg/kg. The calcium level in this study is was higher than that in honey from natural hives in Nigeria which rangedthat ranges between 37,76 and 40,90 mg/kg (35), and honey from Tunisia which ranged fromthat ranges between 221,07 toand 113,85 mg/kg honey (13).

The predominant minerals in honey such asare potassium, sodium, calcium, and magnesium (14). The color of honey determines the mineral content of honey is manifested in honey, whichits color, that is, dark honey has more minerals than light honey (35). Consumption of honey provides calcium that is easily absorbed and could strengthen bone mass. This mineral could reduce the risk of osteoporosis or low bone mass which is, a cause of fractures especially in the elderly (36).

4. Conclusions

None of the analyzed Riau's honey samples have fulfilled all SNI 3545:2013 requirements. Only 3three honey samples could fulfil 8 requirements from 13 SNI requirements, namely Kuansing, Inhu, and Sorek honey samples, while 3 othercould fulfill 8 out of 13 SNI requirements, and another three honey samples could only meet 7 out of 13 SNI 3545:2013 requirements. There was aA decrease in the level of diastase enzyme activity and an increase of in HMF were observed in the honey which was sent to Java. LandTherefore, distance and storage conditions must be considered in the land transportation of honey out of Riau Province needs to consider the distance and storage conditions in order to maintain honey quality.

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Author Contributions

Conceptualization, S.D., W.S., Y.Y., U.P.; methodology, S.D. and W.S.; formal analysis, W.S. and S.D.; investigation, S.D. and W.S.; data curation, W.S. and S.D.; writing—original draft preparation, S.D.; writing—review and editing, S.D., W.S., Y.Y., U.P., G.B.; project

administration, S.D.; funding acquisition, S.D., W.S., Y.Y., and U.P. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

~~The~~This study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of ~~The~~the Health Research Ethics Committee, Faculty of Public Health, Universitas Indonesia, Indonesia~~,~~ (protocol code 332/UN2.F10/PPM.00.02/2019, 16 May 2019~~.~~).

Conflicts of Interest

The authors declare no conflict of interest.

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