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A study of some physical and chemical properties of honey and the effect of local climatic changes on honey collected from some regions in Libya

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Abstract

Climate conditions and influences play a very important role in the productivity of honey bees and the resulting damages and losses. In the conditions of high temperatures that accompany the months of June/July/August during the year, and which may continue for several days, we notice that they exhaust the bees, which reduces their activity and thus reduces the collection of nectar. Heat also contributes to the fermentation of honey. High temperatures can negatively impact .honey's quality and nutritional value Severe cold conditions reduce the activity of bees, especially if the cold condition continues for a month, as a result of climate change. Heavy rains also cause nectar to drift from .flowers

Heavy rains also cause nectar to drift from flowers, and in the case of high humidity that continues for several days, it causes honey to ,ferment which leads to a decrease in productivity. High temperatures and high humidity also create a suitable environment for the spread of bee diseases and parasites.Wind is an important climatic factor as it makes it difficult for bees to fly, reducing their efficiency and time spent

searching for nectar. It also damages flowers and plants, stripping them of .their sources of nectar and pollen Sunlight is very beneficial for photosynthesis and the growth of nectar-producing plants. The more days of sunshine, the more flowers will be and consequently the more nectar the bees will collect. The ’amount of light also affects the bees biological clock, which in turn affects the times when they search for flowers. In laboratory tests conducted on selected samples, the results showed that some samples outperformed the others by small percentages, and these differences were close and in accordance with .local and international specifications

keywords: climate change, Physicochemical properties,beehives.

* Introduction

The honey bee (Apis mellifera), better known as the honey bee, is one of many magnificent insect species that pollinate nearly 75% of all major food crops across the world. Dating back over 33 million years old, with an estimated over 20,000 different species, bees of all varieties have helped hold our ecosystem together since the dawn of civilization. Honey is an important , medicinal and nutritional substance containing sugars, most of which are monosaccharides, enzymes, amino acids, rious tamins, and minerals (Al-Siddiq and Abdel Fattah; 2010).Over the past several decades, the world has begun observing increasingly unusual weather patterns due to climate change. Tropical storms, intense heat, flooding, drought, and forest fires have ravaged the globe, resulting in mass ecological devastation and displacement. Scientists from leading research organizations predict these weather extremes to become ever more common, leading us to wonder what other butterfly effects climate change has in store(Wunderground.com Editors.2021). Locally and in Libya, we wanted to shed light on some of the effects of climate fluctuations affecting the productivity of honey bees in terms of measuring the Physicochemical properties, which we consider a strong indicator of the adaptation or non-adaptation of honey bees to these environmental conditions, especially in terms of productivity and the extent to which the local market meets this product and what is reflected in its prices, whether they are high or low (Jamal A. Al-Ajili . March 2023).

Table (1.1) A comparative showing the most important climate fluctuations prevailing in Libya and their impact on bees and their productivity.

Extreme climate factor	Direct impact on bees	Impact on productivity (honey/wax/reproduction)
High temperature) ٤٠<(C Heat° stress.	increased ,water demand ,poor flight ,brood death decreased honey production.	wax melting, poor comb construction
,Drought .lack of rainfall	scarcity of nectar and pollen sources, a significant	decrease in honey production, and poor natural nutrition
Hot winds (Qabli/Shahili)	Hinder flight, dry up nectar, raise hive temperature	,Reduced nectar collection reduced field bee activity
Sudden temperature fluctuations (spring/fall)	Brood death or ,weakness disruption of the bee life cycle	Flower not synchronized with activity Reduced yield
Sand and dust storm	Clogged ,hive vents difficulty flying	,Flower contamination reduced nectar availability
Sudden extreme cold (winter)	Bees crowd into the hive, brood death	Rapid consumption of stored honey, poor colony survival

1- Honey Composition

Honey is primarily composed of carbon, hydrogen, and oxygen (the ,(basic components of organic matter in addition to other salts in varying proportions. The composition of honey varies depending on the variety of plants present in the pasture, as well as weather and soil conditions. The following table shows the average composition and components of honey.

Table (1.2): Explains the components of natural hone

Component	Percentage (%)
Water	17.7
Fructose (mono)	40.5
Glucose (mono)	34.02
Sucrose (disaccharide)	1.9
Minerals (Ash)	0.18
Acids	0.08
Unknown Substances	4.09

Source / study by - J.W. White, M.L. Riethof, M.H. Subers, and I. Kushnir,1975. titled "Composition of American Honeys. Published online :31Jul 2015.

* Objectives of the work

This research aims to collect a number of honey samples from the above-mentioned regions and conduct physicochemical tests on them, focusing on a set of climate changes and clarifying their environmental impact on honey production in the aforementioned areas. These tests include the following: -

1- Determine the moisture content of the honey samples (%).
2- Calculate the pH content of the honey sample solution(20 w/w%)
3- Measure the specific conductivity of the honey sample solution (20.(%w/w
4- Calculate the total dissolved solids (TDS) in the honey sample solution
5- Determine the percentage of elements (Ba, Na, Ca, K, and Li) in the honey samples
6- Measure the ash content
7- Compare the results obtained with the Codex Alimentarius Commission specifications and the Libyan honey specifications .

*** Materials and Methods**

*** Part one**

1- **Sampling**

Several honey samples were ,collected from the apiaries of Zliten Misrata, Souq Al Khamis, Al Khams, Mislata, Qasr Al Akhyar, Al Garbouli, and Tajoura, most of which are located along the coastal strip from Misrata to Tajoura in Libya, in March ٢٠٢١. They were ,classified into TiMR ,MS ,KT , KS,ZN ,ZZ,H S ,HR, GR, CN,Z N , SN, TSQR, Q ,S The samples were . stored in clean and dry glass bottles at room temperature until chemical .analysis

2 - **Sample Preparation**

Honey (Figure 1.1) was separated from the wax by manual squeezing, and impurities were then removed manually .

Figure (2.1): honey bee sample

Figure (2.2): illustrates the preparation of the samples under study.

*** Physicochemical properties**

1- Moisture Content %

The moisture content of the samples was calculated according to the standard method (FAO,1990) , ١g of the sample was weighed, then placed in a heat-resistant oven at ١٠٥ C for five hours. The dry sample° was then weighed and the water content was calculated using the following equation: -

Moisture content %= (W١- w١ / (W٢ Where: w1 represents the weight of the sample, w2 represents the weigh of the dry sample.

2- pH

A 20% w/w solution was prepared using distilled water, then stirred for half an hour using a magnetic stirrer. The pH values of all samples were then recorded (Pearson; 1976).

3- Specific Conductivity

A 20% w/w solution was prepared using distilled water. The solution was stirred for half an hour using a magnetic stirrer, and the specific conductivity values of all samples were recorded.

4- Total Dissolved Salts (TDS)

The total dissolved salts of the 20% w/w honey solution were calculated according to the method of White (Pearson; 1976).

5- Determining the Metal Composition

A sample of honey was taken in a crucible and placed in a dry oven at 105°C for 24 hours. The sample was then removed from the oven and placed in a desiccator to cool. After drying and cooling, one gram of the sample was taken using a sensitive analytical balance and placed in a special digestion flask. 20 ml of a 1:1 mixture of nitric acid (HNO_3) and perchloric acid ($HClO_4$) was added to the flask containing the sample. The flask containing the sample and the acid mixture was placed on a heater and the temperature was gradually increased for three hours until the mixture cleared and reached dryness. After the sample digestion, the mixture was cooled to room temperature, and 5 ml of 1N hydrochloric acid (HCl) was added to the flask. The beaker was then filled with deionized distilled water to the mark on the 50 ml beaker and a label was placed on the beaker indicating the sample number and location. The sample was then ready for measurement of the heavy elements to be measured by the graphite furnace atomic absorption spectrometer.(Reem Saadi Khalid et al.,2016)

*** Results and Discussion**

After collecting the samples, the physicochemical properties were studied to establish honey specifications for all the aforementioned regions in Libya. These specifications were compared with those of Libyan honey and international standards. These properties included moisture, specific gravity, pH, specific conductivity, and total dissolved salts (TDS). The percentage of metals and their composition were also determined, as shown in the following tables.

Table (1.3) -Physicochemical properties of honey from the collected area

Sample No.	Moisture%	pH	Specific conductivity µS /	T.D.S	Ash
ZZ	٤٤,١٨	٣,٣٠	٦١٦	٦١٦	-0.5
ZS	22.٥٣	2.81	4.06	406	0.6
KS	٤٥,٩٩	2.82	442	443	0.4
KR	٢٣,٨٠	2.58	142	142	0.5
MR	٤٤,٥٥	3.50	722	723	-0.0
TR	٢٩,٠٢	2.74	234	233	0.3
MR	٢٤,٧٤	3.08	299	299	0.1
TS	٩٧,٤٦	3.50	529	528	-0.5

(mean)

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

(Standard average deviation)

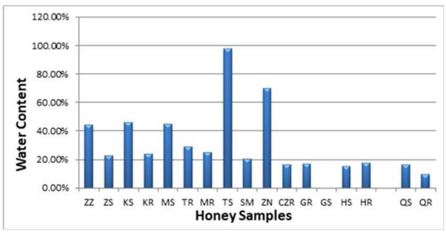
$$S = \sqrt{\frac{\sum_{i=1}^{n} \left(X_I - \overline{X}\right)^2}{n-1}}$$

(Relative standard deviatio)

$$S_r = \frac{S}{\overline{X}}$$

Moisture Content (%) - ٤.١,١

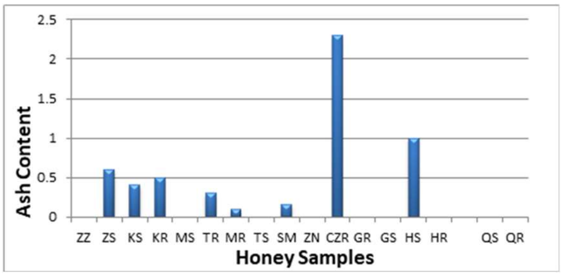
From Tables ١,٣, ٢,٣, and Figure ١,٣, it was found that the moisture content in the samples ranged between a minimum of ٩,٢٨٪ and a maximum of ٩٧,٤٦٪, with an average of ٢٧,٨٩٧٪ for honey from all regions. From these results of moisture, we note that the TS variety outperformed the rest of the samples by a percentage higher than the usual percentage according to international specifications, while the rest of the samples varied with significant differences between them, and these differences were close to .specifications international(Codex Alimentarius Commission (2001)).



Figure(.٣1): shows the Moisture Content (%)

2- Ash

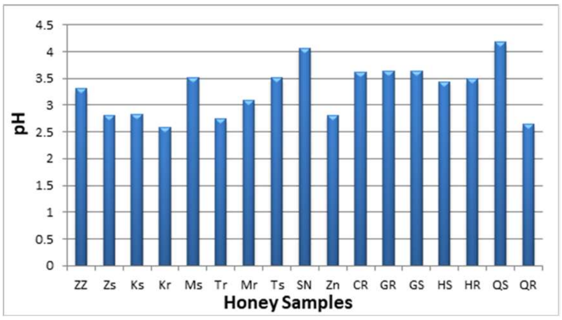
From the table(3. shown for (١ all the studied samples, it became clear that the ash percentage for each sample was between a maximum of and a minimum of ٠,٠, with the ٢,٣ arithmetic mean among all samples being ٠,٥٤. The CR variety outperformed the rest of the group in a large percentage of ash, as this number increased slightly from the international specifications, but in the overall samples, their arithmetic mean was close to the international specifications. As for the remaining samples, their percentages were consistent with the international specifications studied for honeybees .



Figure(.٣1):.shows the ash content

3- **pH**

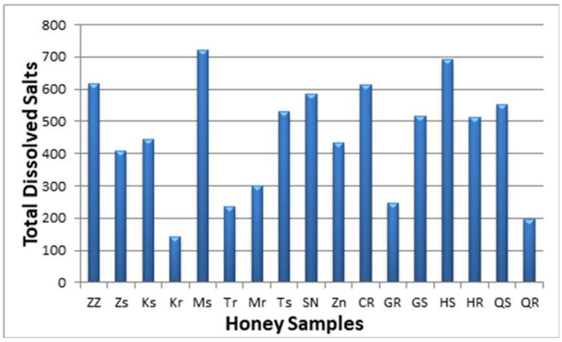
,From the results in Tables ١,٣ and Figure ٢,٣, we note that the ,٢,٣ pH of all studied samples ranged between a minimum of ٢,٥٨ and a maximum of ٤,٦٢, with the average for all samples being ٣,١. The SN variety outperformed all other varieties in pH, and it also slightly exceeded the local specification average. However, according to the results shown to us, all samples were close to and consistent with international honeybee .specifications These pH values indicate that all honey samples fall within the naturally acidic range typical of pure floral honey, which helps inhibit the growth of many microorganisms. The slight variation among samples reflects differences in botanical origin, soil conditions, and environmental factors affecting nectar composition. The relatively high pH recorded for the SN sample may suggest a nectar source with higher mineral or organic acid buffering capacity. Meanwhile, samples with lower pH values still remain safely within the acceptable international limits set for natural honey. This consistency across samples confirms the absence of adulteration or fermentation, both of which would have caused abnormal pH shifts.



Figure(3.3): Shows the pH content.

4- Dissolved salts (TDS)

From the results in Tables 1.3, 2.3, and Figure 3.3, we note that the dissolved salts for all samples ranged from a minimum of 142 ppm to a maximum of 723 ppm. The average for all samples was 456.2 ppm. All of these dissolved salts in these samples yielded results consistent with international specifications.



Figure(3.4): Shows the distribution of dissolved salts in honey samples from all regions

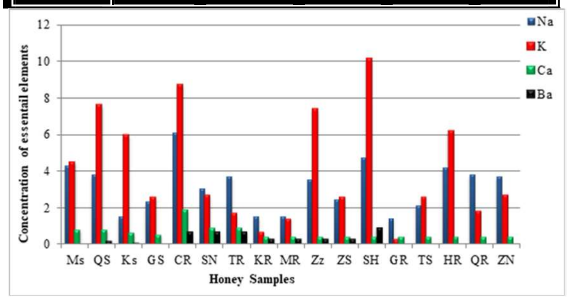
5- Mineral composition

From Tables 3.3, it was found that the percentage of sodium in mg/kg in the samples collected from all the mentioned areas ranged between a minimum of 1.5% and a maximum of 4.7%, with an average of 2.7058823529%. The percentage of potassium ranged between a minimum of 0.3% and a maximum of 10.1%, with an average of 4.0941176471%. The percentage of lithium ranged between a minimum of 0.6% and a maximum of 0.7%, with an average of 0.6411764706%. The percentage of calcium ranged between a minimum of 7.6% and a maximum of 9.1%, with an average of 7.8117647059%. The percentage of boron ranged between a minimum of 6.5% and a maximum of 7.4%, with an average of 0.6411764706%. %6.7058823529 .

Through this study, it was found that there are significant differences between these elements, and all of these differences that we obtained were consistent with local and international specifications.

Table (3.3): Shows the percentage of mineral elements measured for all the mentioned areas.

Code	0.6	0.0	0.6	7.2	6.5
	Na	K	Li	Ca	Ba
Ms	4.3	4.5	0.6	8	6
QS	3.8	7.6	0.6	8	6.7
Ks	1.5	6.0	0.6	7.8	6.6
GS	2.3	2.6	0.6	7.7	6.5
CR	6.1	8.7	0.6	9.1	7.2
SN	3.0	2.7	0.7	8.1	7.2
TR	3.7	1.7	0.6	8.1	7.2
KR	1.5	0.7	0.6	7.6	6.8
MR	1.5	1.4	0.6	7.6	6.8
Zz	3.5	7.4	0.6	7.6	6.8
ZS	2.4	2.6	0.6	7.6	6.8
SH	4.7	10.1	0.6	7.6	7.4
GR	1.4	0.3	0.6	7.6	6.5
TS	2.1	2.6	0.6	7.6	6.5
HR	4.2	6.2	0.6	7.6	6.5
QR	3.8	1.8	0.6	7.6	6.5
ZN	3.7	2.7	0.6	7.6	6.5



Figure(٣،٥): Percentage of mineral elements in honey samples collected from the mentioned areas.

*** Part Two**

*** The prevailing environmental conditions in the studied areas and their impact on the stages of honey production**

1- High temperatures

Negatively impact honey due to the presence of several environmental factors prevalent in the areas selected for this study, including the temperatures during the months of June, July, August, and September of 2021/2022. These effects include the loss of the nutritional properties of honey, as several nutrients are destroyed, including the diastase enzyme, vitamins, and antioxidants (COAG . (2022–2023)).High temperatures above (35-43°C), especially when the honeycomb cells are directly exposed to sunlight, cause the formation of harmful substances, including the formation of the compound (hydroxyl methyl furfural) (HME), which is a very harmful compound and the percentage of its harm increases the longer the period of exposure to high temperatures. High temperatures also cause a change in color, taste and smell, and thus affect the sensory properties of honey.The researcher (Shapla, U. M., et al (2018))) also confirms that these results are consistent with the effects of temperature on honey in his research—that 5-hydroxymethylfurfural is formed from reducing sugars in acidic environments during heating and storage. He describes the factors (temperature, time, acidity, and water activity) that increase 5-hydroxymethylfurfural and indicates that higher 5-hydroxymethylfurfural is associated with a darker color and altered flavor the same mechanism he described.If honey is exposed to high temperatures and contains a high percentage of moisture exceeding (60 C^0), it will speed up the fermentation process, which will lead to its spoilage. Many beekeepers and specialists in this field advise storing honey in suitable places where temperatures do not exceed (10 to 24 C^0). The effect of low temperatures (cold) causes physical changes, including crystallization (freezing), especially at temperatures of 14 C^0. In fact, it is a natural process, as it causes the glucose sugar in honey to change from a liquid state to a crystalline state, and thus to spoil the honey. Low temperatures also contribute to changing the consistency, which increases the viscosity of the honey and makes it harden.There is complete agreement in research(Diego Gómez-Díaz.,et al.(2007)) that agrees with and supports these results.

2- Drought and scarcity of rain

Drought and water scarcity affect honey in several aspects and forms, including changes in the composition of honey content, as its quality deteriorates and the percentage of moisture decreases, thereby reducing the concentration of sugars. This characteristic may increase the viscosity and density of honey. There is also a change in the composition of sugars, such as fructose and glucose. depending on the type of plant, whether thorny or mountainous. Additionally, environmental effects associated with honey production include a reduction in honey yield, as drought and water scarcity directly impact the amount of nectar produced by plants. Another effect is a deficiency in nutritional elements, such as the percentage of minerals, vitamins, proteins, and amino acids in honey. Among the scientific evidence that demonstrates the extent of the impact of climatic conditions such as drought and water scarcity on natural honey is what the researcher (Ankush S. Gadge ., et al.2023) wrote.Recent facts and studies indicate sharp declines in honey production due to drought, as occurred in Spain in 2022, where honey production fell by 40-50% due to the heat and subsequent dry season. Data also shows a clear decline in honey production in 2023, reaching up to 85% in some regions of Spain (COAG., 2022-2023).Other studies indicate that Italy experienced a difficult year in 2023 in terms of climate conditions, with honey production declining by approximately 80% compared to 2022. This is attributed to a cold wave followed by a drought and high service costs (European Parliament Report .,2023).In greece, in the summer of 2023/2024, due to the heat, drought, and multiple fires, the bee grazing season (vegetation cover) on which beehives depend was eliminated, making the flowering season shorter and providing less nectar for bees. This affected the productivity of the hives and caused huge losses for beekeepers. (European Commission Reports.,2023-2024).

3- Strong winds

Strong winds, with speeds exceeding 25 km/h, affect the flight of bees, as they hinder flight, preventing the foraging bees from returning to the hive and increasing their mortality. In the worst conditions, where wind speeds reach 40 km/h, the bees completely stop searching for food. Another effect of strong winds is increased energy consumption, meaning that the bees exert more effort, which leads to the consumption of more energy, and this translates into the consumption of honey reserves in the hive. These facts, mentioned by (Georgia Hennessy et al ., 2020), support the environmental influences, namely strong winds and their effect on the daily work of honeybees. Due to the strong, multi-directional winds, it becomes difficult to find food sources due to the severe damage to the flowers and their drying out, which reduces the available nectar and pollen.Strong winds have other harmful effects on beehives and honey production, such as loss of heat from the hive, especially when cold winds blow, which makes the bees exert extra effort to warm the hive, which increases the bees' consumption of honey to produce heat. Strong winds also lead to losses in production for reasons mentioned previously. Also, due to strong winds, there are material losses for the beekeeper, such as overturning the hives or damaging parts of them.Burnett and others show (Nicholas P Burnett et al.,2022). demonstrate the fact that strong winds have harmful environmental effects that impact bee performance and cause material losses and economic costs for beekeepers. These facts came as a result of an experiment that lasted for two years.

4- Diseases and humidity

Humidity and diseases are environmental influences that contribute to the weakness of bees and low productivity, which contributes primarily to the growth of fungi and bacteria and the spread of other diseases such as parasites and others. Also, the high humidity in beehives and their surroundings makes it very difficult to preserve honey, which leads to its fermentation or the growth of fungi on it. Humidity also plays a role called (interactional relationship), especially when humidity is high above 60%, as the severity of some diseases doubles and makes them more deadly. One of the manifestations of the environmental effects of high or very low humidity is the death of adult bees and brood, as eggs usually need a high humidity environment above 60% for healthy growth. On the other hand, the humidity factor inside the hive may reduce the concentration of nectar, because the bees evaporate water from the nectar to produce honey (Onur Tosu . Mustafa Yaman .,2016).The important environmental factor in the humidity ratio is the spread and occurrence of several diseases, including bacterial, fungal, viral and other diseases, which affect the activity and vitality of the bees and reduce their activity and sometimes their death. What is more dangerous than that is that diseases and the humidity factor share in weak productivity and low economic return(Annette B. Jensen et al.,2024). Among the most important diseases in our research, we will address a simple matter that is consistent with the study areas, each according to its location, as follows: -

1- Fungal diseases, which are widespread and severe, especially in the humid areas adjacent to the coastal strip (the Mediterranean Sea), including, for example, chalk brood, caused by the fungus (Ascosphaera apis), which is a common disease that affects honeybee larvae, as infected larvae freeze and turn into solid bodies resembling chalk. This disease is more prevalent in conditions of high humidity and poor ventilation within the hive.

2- Bacterial diseases, the most widespread of which in the honey bee environment in Libya, is American foulbrood (AFB), which is caused by Paenibacillus larvae. It is a highly contagious and destructive disease that affects honey bee larvae.

3- As for parasitic diseases, there are two common types Varroa destructor, which is one of the most dangerous pests of honeybees worldwide. It is an external parasite that feeds on adult bees and transmits a harmful group of viruses, such as wing virus. Low humidity is associated with its reproduction, while high humidity reduces the fertility of the parasite in some species(Clara Jabal-Uriel et al.,2022).The second parasite is called Nosema Ceranae, which infects the digestive system of bees, leading to a shortened lifespan and an inability to search for food. Its danger increases in high temperatures and high humidity (Clara Jabal-Uriel .Laura Barrios and Anne Dalmon. .,2022).

*** Recommendations**

1- Provide shading and cooling systems during hot weather, including shade nets, evaporative cooling, and painting hives white to reduce heat stress.

2- Insulate hives during cold periods using appropriate materials to minimize heat loss and maintain colony stability.

3- Ensure adequate hive ventilation to prevent overheating and moisture accumulation.

4- Supply accessible fresh water sources near apiaries, particularly during hot and dry conditions.

5- Provide supplemental feeding (sugar syrup and pollen substitutes) during periods of nectar and pollen scarcity.

6- Maintain sufficient honey reserves within hives and avoid excessive harvesting.

7- Conduct regular monitoring and early detection of key diseases and pests, including Varroa destructor, Nosema, and American foulbrood.

8- Apply integrated pest management (IPM) strategies emphasizing biological and mechanical controls over chemical treatments.

9- Maintain proper hive hygiene and replace old combs regularly to reduce disease risk.

10- Select apiary locations with natural shelter, diverse floral resources, and minimal exposure to pesticides and pollutants.

11- Utilize and selectively breed locally adapted bee strains with improved resilience to environmental stress and disease.

12- Regulate and reduce the use of harmful pesticides and promote pollinator-safe application practices.

13- Conserve and restore natural habitats through afforestation, reforestation, and biodiversity protection initiatives.

14- Support research, extension services, and early warning systems for climate extremes, pests, and diseases.

15- Promote education, training, and collaboration among beekeepers, farmers, and policymakers to enhance sustainable beekeeping practices.

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