Enhanced Knowledge in Sciences and Technology Vol. 3 No. 2 (2023) 376-385

EKST

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/ekst
e-ISSN: 2773-6385

The Effect of Different Types of Oil On Non Dairy Frozen Dessert Quality

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DOI: https://doi.org/10.30880/ekst. 2023.03.02.043
Received 15 January 2023; Accepted 09 November 2023; Available online 30 November 2023

Abstract: Frozen dessert is a mixture of sugar, cream, milk and sometimes other ingredients, frozen in a soft, creamy treat using a manufacturing process. However, in this study, vegetable fat was substituted as an alternative for conventional milk from animal and the dessert was referred to as a non-dairy frozen dessert. Due to high concern of people with high lactose intolerant as well as the reduced amount of milk produced each year, this study intends to create a non-dairy frozen dessert derived from vegetable oil, virgin coconut oil, hazelnut oil, and olive oil as an alternative for conventional animal-based milk (unsaturated fat). The physicochemical properties such as pH, colour (L* a* b* values), moisture content, melting curve, total soluble solids (TSS) and overrun have been investigated while Fourier transform infrared spectroscopy (FTIR) was used for characterization of the significant compound and functional group in every oil. The non-dairy frozen dessert samples were fabricated in the form of chocolate chip by using an ice cream maker. All the physicochemical properties of the frozen dessert sample showed significant different values of $p<0.05$ for colour, pH, moisture content and TSS. Conclusively, the frozen dessert derived from virgin coconut oil showed the highest value in term of overrun, pH, TSS and melting curve while hazelnut oil showed the highest value in term of moisture content. Frozen dessert derived from virgin coconut oil recorded lighter colour compared to another sample since the colour of raw virgin coconut oil (VCO) is colourless.

Keywords: Frozen Dessert, Physicochemical Properties, Vegetable Oil, Virgin Coconut Oil, Milk

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1. Introduction

Ice creams, sherbets, sorbets, frozen yogurts, and non-dairy frozen desserts are included as the types of desserts that are intended to be consumed while they are still frozen and it is typically made with a combination of milk, sugars, emulsifiers, stabilizers, and flavouring ingredients [1]. Currently, all of aforementioned types of desserts are available in a variety of flavourings, colouring, vegan, and non-dairy. A growing number of people are interested in non-dairy substitutes due to the concern of health as well as the increased awareness of lactose intolerance in commercial dairy which originated from animal. In addition, due to reduced amount of milk production each year, lead to substitution of milk which normally derived from plant oil as an alternative source of milk in production of dessert. Interestingly, the sales for these non-dairy plant-based beverages such as vegetable oil or plant-based milk frozen desserts have surged due to high demand of this milk substitution, which lead to discovery of other sources to create the non-dairy frozen desserts.

Hence, the substitution of the milk fat from other alternative plant-based source such as vegetable oil was introduced in this study. It is called non-dairy frozen dessert instead of the ice cream since it contains zero milk fat [2]. It is well known that a lack of milk supply and the high cost of milk fat, particularly in industrialized nations, has become one of the most serious issues facing in the dairy industry [3]. This prompted researchers to explore acceptable vegetable oils to substitute milk fat in the production of frozen dessert. In addition, the use of milk fat in frozen dessert is not recommended due to it high in saturated fat. Saturated fats led to few drawbacks risk factors such as heart disease, and consumption in high amounts of this substances are not recommended by the health officials. Meanwhile, compared to vegetable oils, which are rich in unsaturated fat, has been proven to decrease the level of low-density lipoprotein (LDL) cholesterol and triglyceride and at the same time, has not influenced on high-density lipoprotein (HDL) cholesterol levels [3]. Fat is main element that needed in the production of the frozen dessert.

The physicochemical characteristics of the non-dairy frozen dessert have been studied in order to justify the quality is acceptable. The physicochemical characterization includes are overrun, melting curve, pH, colour, moisture content, total soluble solid (TSS) while Fourier transform infrared spectroscopy (FTIR) was used for characterization of the significant compound and functional group in every oil. Virgin coconut oil, olive oil, and hazelnut oil are the three types of oil that have been chosen as vegetable oil sources in this study. Aside from fat, stabilizer also was added to the frozen dessert to provide high-quality results in order to achieve a better texture. In addition, other than enhancing stability, stabilizer also leads to other advantageous effects on production, storage, and consumption. Then, the next aim for this study to produce non-dairy frozen dessert by using vegetable fat which is vegetable oil as an alternative. The physicochemical properties that have been examined in this study are also related to non-dairy frozen dessert quality. Food's physicochemical qualities are largely responsible for the end product's quality. Furthermore, the assessment of these qualities is critical for food processing design and quality control [4]. For example, pH is one of the physicochemical properties of frozen dessert. The normal pH values of frozen dessert ranges from 5.82 to 6.62 that is highly dependent on the flavor and other ingredients in the frozen dessert. Even though the pH is not too low, it's acid-forming, which can aggravate acid reflux and (Gastroesophageal reflux disease) GERD symptoms [3].

2. Materials and Methods

The vegetable oil samples used in this study were virgin coconut oil (Country Farm Organic brand), olive oil (Naturel brand) and hazelnut oil (IKO brand) that has been purchased from local market in Pagoh Jaya and Muar, Johor, Malaysia. The non-dairy frozen dessert was developed in *halal* certified laboratory at Universiti Tun Hussein Onn Malaysia (UTHM).

2.1 Production of non-dairy frozen dessert

12% of vegetable oil was mixed with other ingredients which were water (68%), corn syrup (8.3%), stabilizer (0.3%), emulsifier (0.2%), cocoa powder (4%), and salt in the ice cream maker (Staff Ice

Cream P600, Italy). The mixture was heated for 15 seconds until reached 80°C for pasteurization process in the same ice cream maker. After pasteurization, the mixtures were let to cool and left to be frozen until reached the temperature desire which is -4 ℃ in a freezer. The sample of frozen dessert was then stored in the freezer to keep it cold after it had been packed [5]. The formulation of the frozen dessert which included the ingredient and percentage for the formulation sample of frozen dessert is tabulated in Table 2.1.

Table 2.1: The formulation sample of frozen dessert

Ingredient	Percentage (%)
Water	63
Vegetable oil	12
Corn syrup	8.3
Chocolate chip	7
Cocoa powder	4
Stabilizer (guar gum)	0.3
Polysorbate-80	0.2
Salt	0.2

2.2 Physicochemical analysis

In order to investigate the quality of the fabricated frozen desserts, the samples were subjected to physicochemical analysis to investigate the effect of pH, colour, total soluble solid (TSS), overrun, melting time, and moisture content. Fourier Transform Infrared Spectroscopy (FTIR) was used to identify the corresponding functional groups in the samples and last but not least statistical analysis to justify the significant value (p<0.05) of the tabulated samples.

2.3.1 pH

The frozen dessert's pH levels were determined using a digital pH meter (Thermo Fisher Scientific, Ottawa, ON, Canada). It is important to calibrate the pH meter with pH buffer solutions before collecting measurements. The sample was dissolved in distilled water. The pH meter was calibrated before measuring and recording the pH value. The electrode was cleaned with distilled water before being submerged in the sample for three readings for each sample. [5]

2.3.2 Colour determination

A calorimeter (MiniScan EZ 4500) was used to ascertain the colour of frozen dessert. The sample was placed on the platform to measure colour in a tiny clear container. The glass light projection tube's screen will be put against the sample to test for light penetration. The calorimeter's screen has been display the results, and values for lightness (L*), greenness/redness (a*), and blueness or yellowness (b*) were recorded. Three readings were taken for each sample [5].

2.3.3 Total soluble solid

In accordance with [7] the total soluble solids (TSS) content of frozen dessert was determined using a digital refractometer (RX-5000a-Plus, Japan). Distilled water was used to calibrate the digital refractometer's lens first. After one drop of liquid of that sample was placed on the refractometer, the Brix value was recorded. Three readings were taken for each sample [5].

2.3.4 Overrun determination

In order to evaluate overrun, the sample was weighted before and after the frozen dessert mixture was frozen. The same amount of frozen dessert was added to the container once the frozen dessert mixture has frozen. The calculation is corresponded to Equation (1) as follow:

$$\text{Overrun} = \frac{M-1}{1} \quad (1)$$

M = Weight of mix

I =Weight of the frozen dessert

2.3.5 Melting time

Over a beaker, the mesh was suspended from a ring stand. The samples were placed on stainless steel wire mesh at 27℃. The test was kept going until all of the sample has been melting overall. The initial drop and total melting times was measured and record respectively. Sample was placed on the wire mesh to determine its melting time [5].

2.3.6 Moisture content determination

A sample of frozen dessert was put in the aluminium dish on the plate of the moisture analyzer (Thermo Scientific, EutechpH 700). Then, the button" on" will press, and the value on the screen was recorded. Three readings were taken for each sample [6].

2.3.7 Fourier Transform Infrared Spectroscopy (FTIR)

The FTIR spectrometer was used to examine the functional groups corresponding to the fabrication of the frozen desserts sample. The spectrometer directs infrared beams at the sample and measures the amount and frequencies at which the sample absorbs the IR light. Samples can be identified to the thousands of spectra in the reference database. This method allows for the identification of molecular identities. The outcome was recorded on CD for evaluation [6].

2.3.8 Statistical analysis

Result for the one-way ANOVA has been calculated by using Microsoft Excel, 2010 to identify the significant of data and significant of the different between data.

3. Results and Discussion

3.1 Colour measurement

Table 3.1 displays L*, a*, and b* values as influenced by several types of vegetable oil applied during frozen dessert production. For all samples, L* values ranged from 19.52 to 24.76, a* values from 10.88 to 9.00 and for b* values ranged from 12.87 to 9.28. The measurements of lightness or darkness were used to assess frozen dessert quality. The highest brightness among all the samples belong to sample virgin coconut oil. The highest redness and yellowness values were shown by sample hazelnut oil too. Regarding to the statistical analysis, it found that there were significantly different with all the formulations of frozen dessert, ($p < 0.05$). In contrast, the value of L* (lightness or darkness) increases due to decreasing value of b* (yellowness). Value b* (yellowness) for virgin coconut oil recorded the lowest values since it has a colourless colour compared to hazelnut oil which is yellow to yellow-brown and olive oil gives colour from golden yellow to even brown. L* is affected by the b* values [7]. Nevertheless, when heated, it transforms into a transparent liquid. The low value of b* for virgin coconut oil is due, in part, to this. Hazelnut oil, on the other hand, has the highest b* because it turns a more yellowish colour when heated during pasteurization [7].

Table 3.1: Colour measurement L* a* and b* values for each sample of frozen dessert

Formulation of the frozen dessert	Mean±SD (n=3)		
	L*	a*	b*
Hazelnut oil	19.52±0.21[a]	10.88±0.03[a]	12.87±0.19[a]
Olive oil	22.43±0.16[b]	8.28±0.04[c]	8.50-±0.08[c]
Virgin coconut oil	24.76±0.32[c]	9.00±0.03[b]	9.28±0.06[c]

3.2 Overrun

The percentage overrun for each frozen dessert made with a different type of vegetable oil is shown in table 3.2. Sample virgin coconut oil has been rated the highest overrun followed by hazelnut oil and olive oil. Frozen dessert that has lower overrun value will melt faster, while frozen dessert with a larger overrun value melts more slowly [7]. The presence of air in frozen dessert has a significant impact on its physical, sensory, and storage stability qualities. The resulting frozen dessert is dense, heavy, and more frigid to eat if less air is added. A greater quantity results in a lighter, creamier, and warmer-tasting texture [7]. Regarding to the result above, olive oil has the lowest overrun that make it to have dense and lighter compare with a formulation virgin coconut oil that have high overrun. Better frozen dessert is associated with higher overrun. Frozen dessert overrun was also affected by different fat sources as the fat content in vegetable oil is not same. Even though the time and speed of churning in the ice cream maker were the same, the volume of incorporated air was not the same for each sample. Virgin coconut oil has a higher overrun because it contains more saturated fat (87%), including lauric acid (47%), and less myristic and palmitic acids [8]. Saturated fats are much better at being aerated or to incorporated air during the overrun process [7].

Table 3.2: Overrun for each frozen dessert using a different type of vegetable oil

Formulation of frozen dessert	Overrun (%)
Hazelnut oil	66.66
Olive oil	53.26
Virgin coconut oil	68.07

3.3 Determination of pH

Table 3.3 shows that the pH value for each frozen dessert using different type of vegetable oil. Sample made with virgin coconut oil (VCO) had a highest pH value compared to other sample. Common pH value of frozen dessert is 6.3 [4]. Following to the all sample, pH values are not to slightly different. In fact, by comparing with statistically, it found that there were significant different with all the formulation of all sample, ($p < 0.05$). Low pH in frozen dessert results in an acidic state and is not good to be consumed since it can affect our stomach. Since different percentages or proportions of fat were present in each oil used in the manufacturing of the frozen dessert, there were noticeable differences. Virgin coconut oil (VCO) has a higher pH because it contains the most fat, specifically saturated fat [8].

Table 3.3 : pH value for each frozen dessert using a different type of vegetable oil

Mean±SD (n=3)	
Formulation of frozen dessert	pH
Hazelnut oil	6.17±0.15[b]
Olive oil	6.47±0.06[a]
Virgin coconut oil	6.67±0.12[a]

3.4 Determination of total soluble solid (TSS)

Table 3.4 present the total soluble solid (TSS) for each frozen dessert using different types of vegetable oil. The highest reading of TSS was (18.62°) belong to the formulation of virgin coconut oil, then followed by formulation hazelnut oil (18.42°) and olive oil (15.66°). There was a highly significant different ($p < 0.05$) between all those sample. The adequate amount of total soluble solids in frozen dessert helps to thicken the dough and keep the air bubbles stable [9]. The decreasing amount of water in the frozen dessert and decreased ice crystallization are both indicated by the rising amount of dissolved solids. Additionally, total soluble solids have an impact on the texture of frozen dessert. The texture of the frozen dessert will be limp if the total soluble solids content was high, while ice crystal formation and a gritty texture would result from a low total soluble solids level. According to the results, frozen dessert made with hazelnut oil has the lowest TTS, giving it a gritty and grainy texture [9].

Table 3.4: Total soluble solid (TSS) value for each frozen dessert using a different type of vegetable oil

Mean±SD (n=3)	
Formulation of frozen dessert	TSS (Brix°)
Hazelnut oil	18.42±0.07[a]
Olive oil	15.66±0.06[b]
Virgin coconut oil	18.62±0.11[a]

3.5 Melting curve

Vegetable oils slow the rate of heat transfer through the frozen dessert, and as the frozen dessert's fat content rises, the melting rate falls [10]. However, in this study, the amount of fat in each sample of frozen dessert was the same, and the kind of fat was looked for. It was done to assess the first drop time to manage frozen dessert stability. Figure 3.1 shows the melting curve for all sample by using a different type of vegetable oil.The sample of virgin coconut oil has the highest regarding the type of fat, olive oil and hazelnut oil made the melting of the frozen dessert worse. It has been demonstrated that frozen dessert samples made with hazelnut oil only last for 26 minutes and those made with olive oil only last for 12 minutes as contrasted with virgin coconut oil, which can last for at least 40 minutes. High-fat content frozen dessert typically melts more slowly. [10]. Ice cream or frozen dessert made with various fat contents demonstrated that the melting rate reduces with increasing fat levels. Frozen dessert with a higher fat content melts more slowly and is softer [10]. Similar findings were made, which also demonstrated that a slight delay in the frozen dessert melting in the mouth was caused by an increase in fat content [9]. Due to that, that is why virgin coconut oil has higher melting curve.

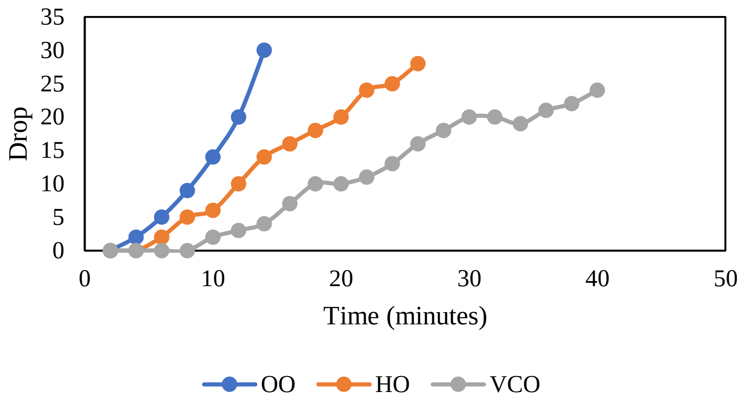

Figure 3.1: Graph of melting curve for 3 formulations of the frozen dessert (OO: Olive oil, HO:Hazelnut oil, VCO:Virgin coconut oil)

3.6 Moisture content

Table 3.5 shows the moisture content value for each sample using different type of vegetable oil. Sample made with hazelnut oil had a significant highest moisture content value followed by formulation olive oil (63.87%) and virgin coconut oil (57.13%). Normal frozen dessert) has a moisture content of 61.0% [11]**.** Frozen dessert that have high fat content estimated to have less moisture content. Then, by comparing with statistically, it found that there were significant different with all the formulation of frozen dessert, ($p < 0.05$). According to [11] when frozen dessert was hardened at the same storage temperature, frozen dessert that mix with a low total solids (high water content) generally has proportionally more water to freeze than mix with a higher total solids (low water content). Due of that, it will be form more ice crystal that will affect the moisture content of frozen dessert. Since oil is hygroscopic, it will directly absorb water from the humid air above. A hygroscopic oil, when in contact with the air, will absorb water from it until the air is likewise. Among of this three type of vegetable oil, moisture content of hazelnut oil was the highest compare with virgin coconut oil and olive oil [10]. Since of that, it will absorb more water.

Table 3.5:Moisture content value for each frozen dessert using a different type of vegetable oil

Mean±SD (n=3)	
Formulation of frozen dessert	Moisture content (%)
Hazelnut oil	72.43 ± 2.63^{a}
Olive oil	63.87 ± 1.46^{b}
Virgin coconut oil	57.13 ± 1.91^{c}

3.7 Fourier Transform Infrared Spectroscopy (FTIR)

Table 3.6 below show the absorption range and functional group name for virgin coconut oil (VCO). Virgin coconut oil has recently gained popularity as a healthy option because of high levels of medium-chain fatty acids (MCFAs) such as lauric acid. It is one of the functional group ester and carboxylic acid. Both functional group might be exist at absorption range 1109 cm^{-1} and 1150 cm^{-1} for ester and 2921 cm^{-1} for carboxylic acid. It also have an alkene bond that exists at wavelength 2852 cm^{-1}. Triacylglycerol linkage carbonyl absorption is visible at 1741cm^{-1}. Oleic acid and linoleic acid both have alkene in their chemical structure [9].

Table 3.6: Absorption range and functional group name of hazelnut oil and sample frozen dessert from virgin coconut oil

Virgin coconut oil (VCO)		Sample frozen dessert from virgin coconut oil (VCO)	
Absorption Range	Functional group name	Absorption Range	Functional group name
1109.52	Ester and ethers (C-O Stretch)	1059.35	Esters (C=O Stretch)
		1465.49	Nitro group (N=O Bend)
1150.47	Ester and ethers (C-O Stretch)		
1461.34	Aromatic ring (C-C=C Asymmetric stretch)	1636.89	Aldehydes (C=O)
1741.92	Carbonyl grouop (C=O Stretch)		
2852.86	Alkane C-H Asymmetric and symmetric stretch)		
2921.79	Carboxylic acid (Hydrogen bonded O-H stretch)		

The main composition of olive oil is linolenic acid, linoleic acid and oleic acid. Oleic acid is of the monounsaturated omega 9 that found in vegetable sources [9]. While, linolenic acid is a type of omega-3 fatty acid that exist in plant sources especially in olive. For linoleic acid contain polyunsaturated fatty acid. Absorption range at 1159.14 $cm^{-1}$and 1376.10 cm^{-1} which is contribute to the functional group esters and ether might exist in oleic acid, linoleic and linolenic acid. Aromatic ring which is phenolic compound expected are trans-2-hexanal and 3-methylbutan-1-ol. The sensory quality of olive oil is directly correlated with the molecules that give it taste [12]. Functional group alkene and carboxylic acid also exist in olive oil which is at wavelength 2852.68 cm^{-1} and 2921.78 cm^{-1} respectively.

Table 3.7: Absorption range and functional group name of hazelnut oil and sample frozen dessert from olive oil

Olive oil		Sample frozen dessert from olive oil	
Absorption Range	Functional group name	Absorption Range	Functional group name
1159.14	Ester and ethers (C-O Stretch)	1059.19	Esters (C-O Stretch)
1376.10	Ester and ethers (C-O Stretch)	1365.79	Nitro group (N=O Bend)
1460.47	Aromatic ring (C-C=C Asymmetric stretch)	1636.88	Aldehydes (C=O)
1743.47	Carbonyl group (C=O Stretch)	2188.58	Alkynes
2852.68	Alkane (H-C-H Asymmetric and symmetric stretch)	2926.30	Alkenes (H-C-H Asymmetric and symmetric stretch)
2921.78	Carboxylic acid (Hydrogen bonded O-H stretch	3292.13	Amides (N-H Stretch)

Meanwhile, for hazelnut oil, high levels of oleic and linoleic acids and low levels of palmitic acid can be found in hazelnut oil [13, 15]. The functional group of esters and ether can be found in wavelength 1159.71 cm^{-1} and 1376.36 cm^{-1} respectively. Fatty acids are the long hydrocarbon chained carboxylic acids found in fats and oils [9, 16]. Each of the three -OH groups join an ester to a fatty acid molecule. The composition of hazelnut oil like oleic acid, linoleic, and palmitic acid also contain functional group carboxylic acid at range 1742.97 cm^{-1}, 2853.04 cm^{-1} and 2922.26 cm^{-1}.

Table 3.8: Absorption range and functional group name of hazelnut oil and sample frozen dessert from hazelnut oil

Hazelnut oil		Sample frozen dessert from hazelnut oil	
Absorption Range	Functional group name	Absorption Range	Functional group name
1109.52	Ester and ethers (C-O Stretch)	1059.35	Esters (C=O Stretch)
1150.47	Ester and ethers (C-O Stretch)	1465.49	Nitro group (N=O Bend)
1461.34	Aromatic ring (C-C=C Asymmetric stretch)	1636.89	Aldehydes (C=O)
1741.92	Carbonyl grouop (C=O Stretch)		

Sample frozen dessert for virgin coconut oil, olive oil, and hazelnut oil, was examined using fourier transform infrared spectroscopy (FTIR) to determine which functionalities were present. Nearly all samples exhibit the same wavelength. It is because all oils contain essentially the same fat, but they vary in terms of their composition. Since, the same amount of the other ingredient in each sample were used, there do not be much variation in the FTIR results., all sample have the same wavelength at 3292 cm^{-1} belong to amides that contribute to (N-H Stretch). Moreover, functional group esters with C-O stretch were present at almost wavelength 1059 cm^{-1}. In addition, compound alkynes were existed for all sample frozen dessert at range wavelength 2118 cm^{-1} [14, 17].

4. Conclusion

In conclusion, rather than milk fat, vegetable oil such as olive oil, hazelnut oil and virgin coconut oil was effectively used to manufacture frozen dessert using an ice cream maker. The physicochemical properties of these frozen dessert have been investigated. Virgin coconut oil has the highest L* value for colour. The same is true for b* values that are more yellowish due to the colourless nature of virgin coconut oil. The b* values have an effect on the L* value. Due to the nature of its fat content, olive oil was found to have the lowest overrun. During the overrun process, unsaturated fat has little air incorporated. They have significance difference between pH and TSS ($p<0.05$), indicating that virgin coconut oil has the highest values for both properties. While, no significance difference ($p >0.05$) for properties overrun and moisture content Virgin coconut oil is a preferred vegetable oil to use in place of milk fat while preparing frozen dessert. It has the greatest melting time compare to other samples. Additionally, it has a wonderful scent and a sweet coconut flavour, unlike hazelnut and olive oils, which have a rancid odor. For further research of this study, there are a few recommendations that can be do which is to study the effect of the combination of different types of oil and milk fat in terms of its physicochemical properties. Lastly, further analysis that can be investigate in future is to study the nutritional composition of frozen dessert from vegetable oil such as fat, protein, carbohydrate, energy, and, sugar. Then, study the acceptance or preference of these frozen dessert by making the sensory evaluation for at least 50 panelists.

Acknowledgement

Greatest gratitude to the Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia for its support.

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