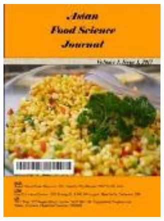

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Effect of Different Extraction Methods on the Quality and Stability of Coconut Oil

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Authors' contributions

This work was carried out in collaboration between all authors. Authors FTD, MCNM and GBT designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors FTD, MCNM, GBT and HMW managed the analyses of the study. Authors FTD and MCNM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study was conducted in order to assess the effect of different extraction methods on the physicochemical properties of coconut oil.
Study Design: Coconut harvesting, cleaning, oil extraction, quality analysis.
Place and Duration of Study: General Science Laboratory, School of Agriculture and Natural Resources, Catholic University Institute of Buea, South-West Region, Cameroon, from January 2018 to June 2018.
Methodology: Oil samples were extracted from coconuts through five different methods, the traditional method 1 (Boiling and grilling for 2 hours), the traditional method 2 (cooling and grilling for 18 min), the maceration method (Hexane extraction), oven drying + pressing (Pressing 1) and finally sun drying + Pressing (Pressing 2). The obtained oils were then characterised by

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determining their Peroxide, Thiobarbituric acid, Iodine, Acid values and oxidative stability (Rancimat method).

Results: Results showed that the traditional method 1 significantly ($p<0.05$) alter the quality of coconut oil. The best extraction methods were hexane extraction, pressing methods 1 and 2, as they preserve better the quality of coconut oil and have the highest induction and stability times. Among these, hexane extraction and pressing method 1 were the best.

Conclusion: The maceration and pressing methods are the best techniques for coconut oil extraction, as they preserve better its quality.

Keywords: Coconut oil; extraction methods; quality.

1. INTRODUCTION

Coconut oil is an edible vegetable oil processed from the coconut mature fruits. It's significantly growing in popularity for its nutraceutical benefits and functional properties [1]. Several extraction methods are accounted for coconut oil production, including pressing, heating, etc. The world demand of this oil is significantly increasing and nowadays most of it is being produced at household and micro-scale level. Coconut oil has many advantages which include the health benefit of its vitamins and anti-oxidants, from the retained vitamins and anti-oxidants, the anti-microbial and anti-viral activity from its lauric acid Mansor et al. [2]. Apart from these properties coconut oil is used to enhanced the beauty and promote growth of tresses, refine and moisturised the skin as well as to cure some minor illnesses such as diarrhoea and skin inflammation Mansor et al. [2]. One of the major challenges with this oil is that when it is not produced under hygienic and proper conditions its quality can be affected in such a way that, they do not meet the prescribed standard [3] and lost some of their beneficial effects. Such malpractices can lead in the oil to the decrease of their nutritional (reduction of the vitamin and essential fatty acids) and organoleptic properties (changes in taste, odour and flavour). They can also lead to the formation of toxic substances in oil such as free radicals and reactive oxygen species which have being proven to be implicated in many health risks such as cancer, cardiovascular diseases, Parkinson's diseases etc.

Rosenthal et al. [4] reported direct significant effect between the extraction process and the quality and quantity of the resulting oil. In various Cameroon regions, the coconut oil extraction using heat is the most widespread process applied. This method is supposed to result in higher extraction yield and therefore to be more profitable compared to the other methods. However, the use of heat is not really suitable for the extraction of good quality oil as they can easily turn rancid. Many reports have been published on the effect of different extraction methods on the quality of coconut oil but most of them where focused on induced fermentation, natural fermentation, enzymatic extraction, centrifugation, chilling and thawing [2,5]. However, relatively low reports are available on the effect of the traditional methods of extraction used in Cameroon on the physicochemical characteristic of coconut oil. The traditional method used for the local extraction of coconut oil in Cameroon might have a significant impact on its quality.

The current study investigates several methods, namely the pressing method, the dry method, the cold method, and the solvent extraction method. It assesses the effect of common method of coconut oil extraction used by local populations in Cameroon and the physicochemical properties of the products.

2. MATERIAL AND METHODS

2.1 Material

Fresh coconuts (*Cocos nucifera L.*) were purchased at Muea central market, Buea South-West Region, Cameroon, in May 2018. All the chemicals and reagents used were of analytical grade.

2.2 Methods

2.2.1 Oil extraction

2.2.1.1 Maceration method

This method was used for oil extraction from coconut as described by Womeni et al. [6]. Coconut was dried in an electric-air-dried oven at 45°C for 24 hours. 500 g of dried samples were then grounded and macerated in 750 ml of hexane at room temperature with constant shaking. After that, the mixture was filtered using the Whatman filter paper N°1, and the filtrate stored in the dark at room temperature for the removal of the solvent by evaporation. The extracted oils were stored in the freezer at -18°C for further analysis.

2.2.1.2 Traditional method 1

1000 g of fresh coconut was cut into small pieces and grounded using 3 L water. After that, the mixture was filtered and the filtrate boiled for 2 hours at 98°C until the complete evaporation of water. When the water was evaporated, the coconuts were grilled until the oil started being released. The oil was collected and cooled at room temperature. After that, it was kept in the freezer for further analysis.

2.2.1.3 Traditional method 2

1000 g of fresh coconut was cut into small pieces and grounded using 3 L water. After that, the mixture was filtered and kept in the refrigerator for overnight for the separation of phases. On the next day, the butter was collected and grilled for 18 min until the oil started being release. The oil was collected and cooled at room temperature. After that, it was kept in the freezer for further analysis.

2.2.1.4 Pressing

Coconut was cut into small pieces and dried in the oven at 45°C for 24 hours. Another set was dried under sunlight for 4 days. After that, the samples were grounded and pressed for the extraction of the oil. The extracted oils were then stored in the freezer for further analysis.

2.2.2 Chemical analysis of oil samples

Peroxide value was determined following the spectrophotometrical IDF standard method, 74A: 1991 [7]. Free fatty acids value assays were carried out according to the procedure of AOCS Official Method CD 1-25 [8]. Thiobarbituric acid value was evaluated as described by Draper and Hadley [9]. The iodine value was also evaluated by the AOCS official method, but the CD 1-25 [8].

2.2.3 Rancimat test

The Rancimat test was also performed to evaluate the stability of the oil. Each oil sample (≥ 5 g) was separately weighted in a Rancimat tests tube. The instrument (an automated Metrohm Rancimat, Model 892) was switch on and the heating block temperature set at 120°C. After reaching the 120°C, the measuring vessels filled with 60 mL deionised water were connected to the instrument via electrodes. The tubes containing the sample were sealed using the appropriate caps, and connected to both instrument and measuring vessels via the appropriate cables. After starting the gas flow (20 L/h), the reaction tubes were individually placed in their respective heating blocks, and the reaction started. Induction and stability times were automatically recorded by the instrument. The analyses were done in triplicate.

2.3 Statistical Analysis

Results obtained in the present study were subjected to one-way analysis of variance (ANOVA) with Student-Newman-Keuls tests using Graphpad-InStat version 3.05, to evaluate the statistical significance of the data. A probability value at $p < 0.05$ was considered statistically significant.

3. RESULTS AND DISCUSSION

3.1 Effect of Extraction Method on Coconut Oil

3.1.1 Peroxide value

The effect of the extraction methods on the peroxide values (PV) of coconut oil is presented in Fig. 1. The main PV ranged between 3-10 meq O^2/kg, varying statistically according to the treatments ($P<0.05$), apart from the oil extracted using both pressing 1 and hexane methods which display similar ($p>0.05$) values of 4.59 and 4.22 meq O_2/kg. The traditional method 2 has exhibited significantly higher ($p< 0.001$) peroxide value.

3.1.2 Thiobarbituric value

Fig. 2 presents the effect of the difference extraction methods on the thiobarbituric acid value of coconut oil. It is clearly observed that the traditional method 1 has presented a significantly higher ($p< 0.001$) TBA value compared to the other extraction techniques. It was followed by the traditional method 2. The lowest TBA values were recorded in oils extracted with hexane, pressing method 1 and pressing method 2. No significant difference ($p>0.05$) was observed between the TBA value of oil extracted with hexane pressing 1 and 2.

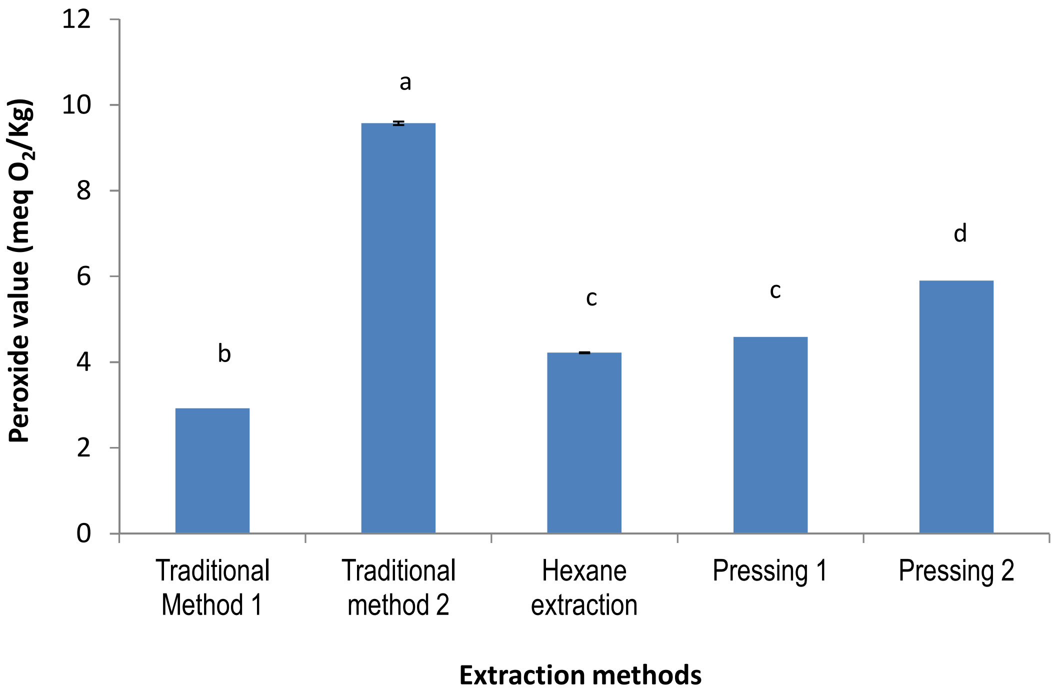

Fig. 1. Effect of the extraction method on the peroxide value of coconut oil

Data are presented as mean (±SD) (n=2) (a-c). Value with different superscripts are significantly differents ($p<0.05$)

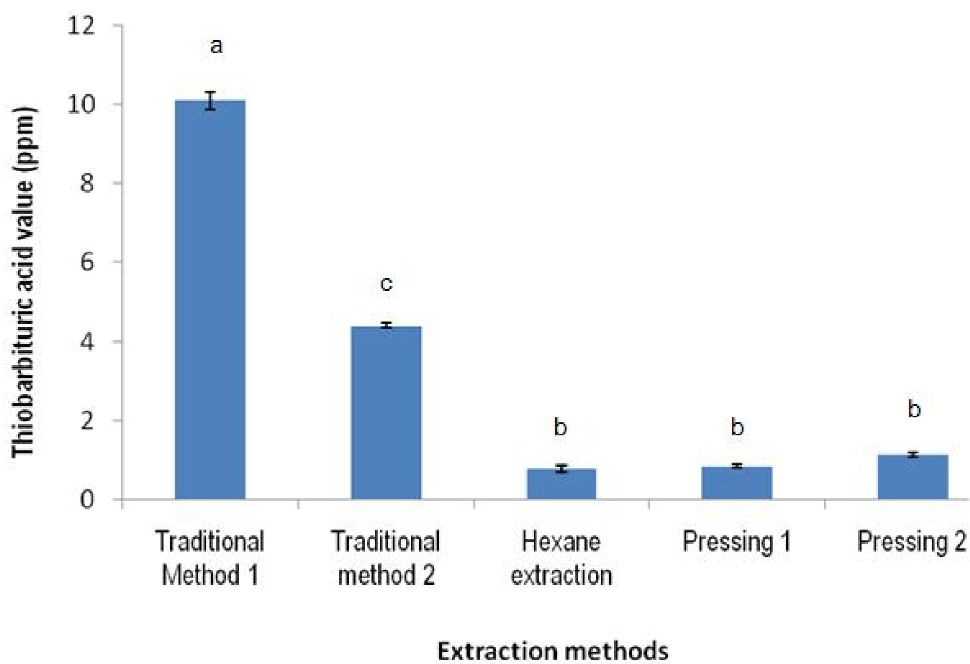

Fig. 2. Effect of the extraction method on the thiobarbituric acid value of coconut oil

Data are presented as mean (±SD) (n=2) (a-c). Value with different superscripts are significantly differents ($p<0.05$)

3.1.3 Iodine value

The variation of the iodine value of coconut oil extracted with different methods is presented in Fig. 3. The highest iodine value was registered with pressing method 2 (11.05 g I_2/100 g) followed by the pressing method 1 (8.27 g I_2/100 g). Their IV were significantly different ($p<0.05$) and higher than those of the other samples. No significant difference ($p>0.05$) was observed between the IV of the oil extracted by the traditional method 1 (5.64 g I_2/100 g) and hexane (6.72 g I_2/100 g). The lowest IV was obtained in the oil extracted by the traditional method 1. Generally, the iodine value of these coconut oil samples ranged between 5.5-11 g I_2/100 g.

3.1.4 Acid value

The effect of different extraction methods on the acidity of coconut oil is presented in Fig. 4. The highest acid value was obtained with the pressing method 2 followed by the pressing method 1 and the traditional method 2. The lowest acid value was recorded with the traditional method 1. The acidity of all the oil samples was significantly different ($p< 0.05$). However, its value ranged between 1-3% in oil extracted by the traditional method 1, 2, hexane and pressing 1 while that of pressing 2 was almost 7%.

3.1.5 Induction and stability time

The effect of different extraction techniques on the oxidative stability of coconut oil is presented in Table 1. It can be observed that, the oils extracted by the pressing method 1 has exhibited the highest ($p<0.05$) induction time, followed by that extracted by Pressing method 2 and Hexane. The lowest induction time were registered with oil samples extracted using the traditional method 1 and 2. Concerning the stability time, results showed that the oils extracted through pressing methods 1 and 2 have the best oxidative stability, as they have exhibited the highest stability time. They are followed by oils extracted using hexane and traditional method 1. The lowest stability time was recorded with Traditional method 2.

3.2 Discussion

Results of the investigated coconut oil samples revealed that the oil extracted with the traditional method 1 which has exhibited the lowest peroxide value had the highest thiobarbituric acid value. Its thiobarbituric acid value was significantly higher than its PV. This suggests that, the lowest peroxide value observed in that oil sample was not an indicator of its good quality. In fact, the hydroperoxides formed during this extraction were rapidly converted into secondary oxidation products such as

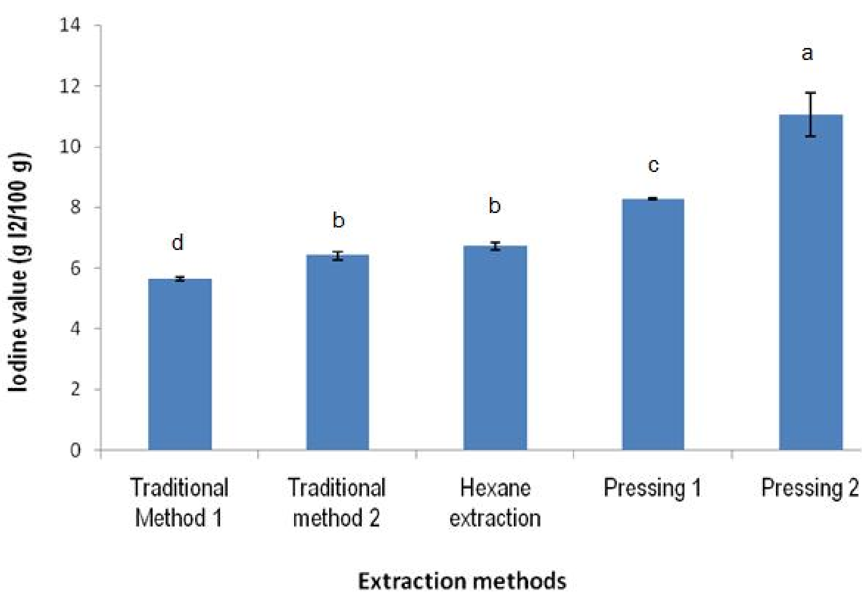

Fig. 3. Effect of the extraction methods on the iodine value of coconut oil
Data are presented as mean (±SD) (n=2) (a-c). Value with different superscripts are significantly differents ($p<0.05$)

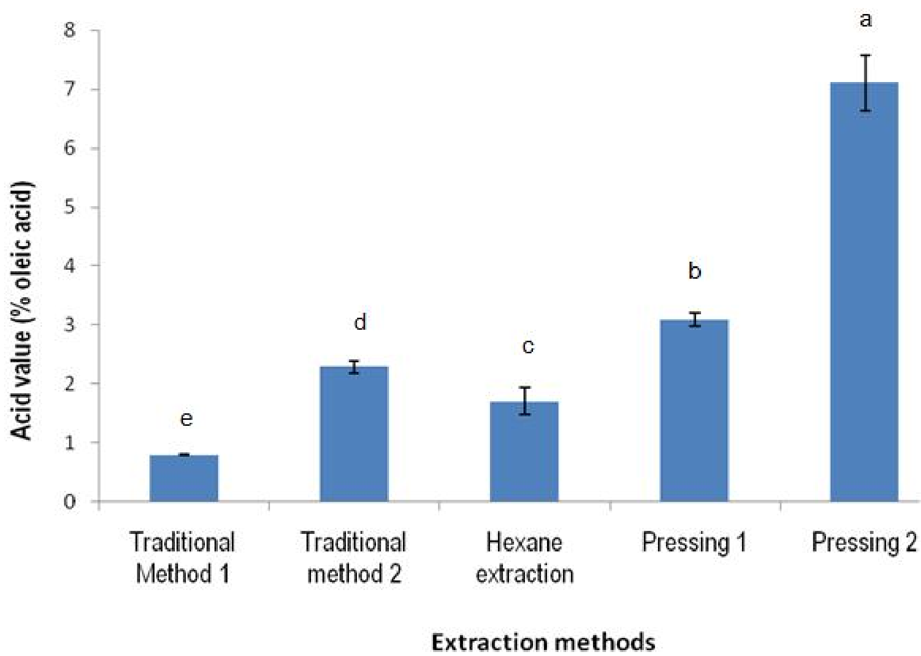

Fig. 4. Effect of the extraction method on the acidity of coconut oil

Data are presented as mean (±SD) (n=2) (a-c). Value with different superscripts are significantly differents ($p<0.05$)

malonaldehyde. This can be attributed to high temperature as it has been demonstrated that, it promotes the decomposition of primary oxidation products into secondary ones [6]. The secondary oxidation rate in this sample was higher than the primary. Apart of these samples, oils extracted with the other methods have presented significantly higher rate of primary oxidation than secondary one as the peroxide values were significantly higher than their thiobarbituric acid value. These suggest that, the formation of hydroperoxides in these samples was significantly higher than their decomposition. The highest peroxide and thiobarbituric acid value was obtained in the oil extracted by the traditional method 2 compared to those extracted with hexane, pressing method 1 and 2 can be explained by the fact that, these samples was processed at high temperature for 18 min while the other samples were extracted without heating. Heat generally promotes the initiation of lipid oxidation by abstracting a hydrogen atom from the aliphatic chain of unsaturated fatty acids leading to the formation of alkyl radicals. In the presence of oxygen these radicals are converted into peroxyl radicals which are very unstable and generally abstract another hydrogen atom from a neighboring fatty acid leading to the formation of hydroperoxides which are the main products of the primary oxidation of edible oils and which can easily decompose into secondary oxidation products by cleavage. Generally, the peroxide value of all these oil samples were ranged between 3-10 meq O_2/Kg which fall in the accepted range which is ≤ 10 meq O_2/Kg as reported by FAO/WHO [10]. These results are in accordance with those reported by Oseni et al. [5] who demonstrated that different extraction methods (enzymatic, chilling, centrifugation, natural fermentation, thawing and induced fermentation) were significantly affecting the peroxide value of coconut oil.

The effect of the extraction method on the iodine value of coconut oil showed that, oil extracted using heat for a long period (traditional method 1) has exhibited the lowest iodine value followed by the traditional method 2. This can be attributed to the destruction of the double bonds of their unsaturated fatty acids by free radicals as demonstrated by Tyneck et al. [11]. These results are in accordance with those previously obtained with the PV and TBA values as these samples were the most altered. The highest iodine values were registered in oil extracted without using heat. The fact that they were cold methods can justify their high iodine values. However, it is important to note that the best

Table 1. Induction and stability time of oil samples

Treatments	Induction time (h)	Stability time (h)
Traditional method 1	0.05 ± 0.00^{d}	18.20 ± 0.12^{d}
Traditional method 2	0.04 ± 0.00^{d}	16.81 ± 0.21^{c}
Hexane	12.44 ± 0.10^{c}	18.86 ± 0.08^{b}
Pressing 1	20.31 ± 0.31^{a}	20.25 ± 0.15^{a}
Pressing 2	18.92 ± 0.05^{b}	20.72 ± 0.11^{a}

Values are presented as Mean±Standard deviation. Values of the same column with different superscripts are significantly differents (p<0.05)

iodine value was obtained with the pressing method 2. This technique might be suitable to optimize the release of unsaturated fatty acid from the plant cell. The iodine value of all these samples was ranged between 6-10 g I_2/100 g which were significantly higher than those reported by Mansor et al. [2] who obtained iodine values varying between 4.13 - 4.30 g I_2/100 g in coconut oils extracted by chilling, fermentation, fresh-dry and enzyme. However, the iodine value of oil obtained in this study were in the accepted range which is 4.10 – 11 g I_2/100 g as reported by APCC standard [12]. The fact that the iodine value of coconut oil can vary with the extraction method has already been demonstrated Mansor et al. [2].

The variation in acidity of coconut oil samples extracted with different methods showed that the pressing method 2 significantly promote the increase in acid value of coconut oil. It was followed by the pressing method 1 and the traditional method 2. The high acidity registered in these samples can be attributed to the high rate of hydrolysis of their triglycerides [13]. Oil samples which have exhibited the highest acidity were previously observed to be of better quality. However, the acidity of the most oxidized oil (traditional method 1) was significantly lower. This can be explained by the fact that the free fatty acids released in this sample were rapidly transformed into hydroperoxides due to the temperature and heating. The high acidity observed in oil samples extracted using cold methods can be attributed to the poor transformation of free fatty acids into hydroperoxides due to very low temperature. The results obtained in this study showing that the acidity of coconut oil can vary with the extraction method have already been reported [2,5].

The evaluation of the effect of different extraction methods on the stability of coconut oil was evaluated by determining their induction and stability periods on Rancimat. The test is based on the conductometric determination of volatile degradation products of oils and fats during their oxidation. Long induction and stability times generally reflect good resistance toward oxidation [6]. The evaluation of the oxidative stability of coconut oil showed that hexane, pressing methods 1 and 2 have exhibited the longest induction and stability times. This is the proof of their good resistance toward oxidation reactions. These results are in accordance with those obtained with the chemical indexes, where these same oils have exhibited significantly lower primary and secondary oxidation state, which show that there are of good quality. Generally, the formation of these products in oils significantly reduces their induction and stability times. The lowest induction and stability times registered with the traditional methods 1 and 2 can be explained by a high rate of formation of primary and secondary oxidation products in the oils extracted using these techniques. These results are in accordance with those of Alicia et al. [14] who showed that the extraction methods significantly affect the oxidative stability of silkworm oil on Rancimat. Similar observations were made by Tasan et al. [15] who showed that the induction time of crude sunflower oil was varying with the extraction technique.

4. CONCLUSION

The objective of this study was to evaluate the effect of different extraction method on the physicochemical property of coconut oil. Results showed that the traditional method 1 and 2 significantly alter the quality and reduce the stability of coconut oil. The best extraction methods were the hexane extraction, pressing 1 and pressing 2. Among these, hexane extraction and pressing method 1 were the best extraction techniques.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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