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ORIGINAL ARTICLE

Assessment of Good Hygiene and Manufacturing practices in red palm oil production process in Benin

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Abstract

Field Investigations were carried-out on the processing of palm fruit (*Elaeis guineensis*) into red palm oil. A total of 40 palm oil producers were interviewed and data on their sociocultural profiles, production environment, and respect of Good Hygiene Practices were appraised using Xlstat. The critical control point of red palm oil production was assessed. The microbial load (*Coliforms, staphylococcus aureus,* yeast and Mold), of the produced oil was evaluated using standard methods. About 60.71% of producers were men and they used the semi-mechanic system to produce oils. 95% of producers had no control of good hygienic and manufacturing practices. Five critical control points were identified: fruits quality (97.5%); cooking of the fruits (90%); dehydration of the crude oil (92.5%); quality of packaging material (95%) and quality of processing equipment (97.5%). The mean values of microbial loads of collected red palm oil samples ranged for coliform from 1 to 2.55 log CFU/g, S*taphylococcus aureus* 1 to 2.42 log CFU/g, yeast 1 to 3.77 log CFU/g, and molds 1 to 3.54 log CFU/g. The poor hygienic and manufacturing practices could be responsible of the contaminations recorded.

Key words: Palm oil, processing, microbial load, quality, critical point.

1. Introduction

Red palm oil is obtained from the mesocarp of *Elaeis guineensis* (palm) fruit through traditional or mechanical methods (Urugo, Teka, Teshome & Tringo, 2021). The process generally include: Harvesting of palm nuts, threshing and cooking (at about 70°C for 90 min) followed by mashing and pressing (50-60°C). After pressing, the obtained crude red palm oil is boiled and skimmed for purification and residual water removal. The further processes now depend on the desired type of oil. Two types of oils namely crude red palm oil (CPO), and/or refined, bleached and deodorized red palm oil (RBD) can be obtained from CPO. Palm oil has been used in Africa and Asia in its crude form and is reportedly associated with many nutritional and health-enhancing benefits due to the presence of; carotenoids, tocopherols, tocotrienols, other micronutrients, and fatty acids (Mancini et *al.*, 2015; Daud, Kaur, & Khosla, 2012). Further insights on the nutritional and health-promoting features of red palm oil have been reported (Sulaiman *et al.,* 2022; Zulkiply *et al.,* 2019; May *et al.,* 2014). Additionally, reports show that the quality of the final palm oil depends on the processing method used (Ayompe *et al.,* 2021; Foong *et al.,* 2018; Ordway *et al.,* 2017; Neszmelyi, 2014). This deterioration in quality can consist of lipid oxidation which is typically catalyzed either by light, heat, or metals (Kärt *et al.,* 2022). In West Africa, apart from being used as an ingredient for almost all meals preparation, palm oil production has mainly been practiced by people who are not aware of the best practices and technologies to be used to increase the extraction yield and the quality of the product (Houssou *et al.,* 2020; Gesteiro *et al.,* 2019; Dongho *et al.,* 2017). In Ghana, palm oil production and consumption is gradually becoming a matter of safety concerns due to the quality of the equipment used and the associated microbial contamination (MacArthur *et al.,* 2021b). According to Dongho *et al.* (2021), oils produced and exposed during bulk sales are likely to be contaminated by micro-organisms. Similar sanitary risks have been highlighted in Nigeria and Cameroon (Ayompe *et al.,* 2021) and were associated to the lack of knowledge on good hygienic and manufacturing practices by producers. Consequently, crude palm oil consumption can be risky for consumers, especially if it is not produced following the good hygiene rules. The production process at the local level therefore requires improvement.

The objective of this study was to evaluate the level of hygiene, the good practices and microbiological quality of crude palm oil samples produced in different localities of Benin.

2. Materials and Methods

2.1. Survey areas and sampling

A survey was carried out in 14 localities in southern Benin (Ikpinlè, Pobè, Sakété, Dangbo, Ouando, Avrankou, Dangbo, Come, Azovè, Zê, Calavi, Bohicon, Zogbodomey, and Cotonou). These localities were selected based on their high number of red palm oil producers (Dansou *et al.,* 2022). The number of red palm oil producers was determined as reported by Dagnelie (1998) and a total of 40 producers both males and females were randomly interviewed.

2.2. Data and samples collection

A questionnaire was used for data collection. The questionnaire was administered either in French and/or local languages (Fon, Goun and Mina). As for palm oil samples collection, the number of samples to be included in the study was evaluated following the method described by Ngando-Ebongue et *al.* (2013). Using this method, forty (40) palm oil samples were collected twice from producers and mixed to obtain one sample. For this purpose, 250 mL of sterile plastic bottles were used to collect the samples. After sampling, the bottles were tightly sealed and labeled before being transported to the laboratory of the National Institute of Agronomic Research of Benin for further analysis. The samples were stored at -10°C for further analysis.

2.3. Quantitative assessment of the microbiological quality of the palm oil

2.3.1. Microbial Parameters

The microorganisms monitored in the laboratory included *Staphylococcus aureus*, faecal Coliform, yeast and Mold. Standard methods ((NF V 08 – 060 (1996), ISO 6888-1-2 (1999), ISO 21527-2: (2008)) were used for the analysis. The spread plate method was used to enumerate the various microorganisms. The determinations were done in duplicate and the results were expressed as log cfu/g of oil. One milliliter aliquot from each of the dilutions was inoculated into already prepared petri dishes containing the culture medium and incubated for a specified period of time.

2.3.1.1. Samples preparation

About 10 ml of sample were taken and introduced into the stomacher bag. 90 ml of Tryptone Salt (TS BK014HA; Biokar Diagnostics, France) was added and homogenized with stomacher for 2 min. The obtained solution was left for 15 min to ensure the revivification of germs stressed by homogenization.

2.3.1.2. Determination of Faecal Coliforms

Faecal coliform count was conducted following the NF V 08 – 060 (1996) method. One (1) ml of each appropriate dilution was aseptically introduced into petri dishes followed by the addition of 15 to 20 ml of agar medium with crystal violet, neutral red, bile and lactose (VRBL, BK 152 HA, Biokar Diagnostics, Biokar Diagnostics F60000 Beauvais). After solidification, 5 ml of the same VRBL agar was added and the petri dishes were incubated at 44°C for 24 h.

2.3.1.3. Determination of Staphylococcus aureus

Staphylococcus count was assessed on Baird Parker (Baird Parker, OXOID, CM0509) incubated at 37°C for 24 h (ISO 6888-1-2 (1999). About 0.1 ml of each appropriate dilution was aseptically introduced into the petri dishes. The plates of the dried inoculum were inverted and incubated at 37°C for 24 hours. After incubation, yellow colonies formed on the plate were immediately counted and recorded.

2.3.1.4. Determination of Yeast and Mold

Yeast and mold count were enumerated on agar dichloran glycerol 18% (DG18) (BM10908 BK170HA) as reported by ISO 21527-2: 2008 (2008). 0.1 ml of each dilution was aseptically introduced into petri dishes. The plates of the dried inoculum were inverted and incubated at 25°C for 192 hours. After incubation the colonies formed on the plate were counted and recorded.

2.4. Data analysis

Statistical analysis was performed at 5% level of significance on the collected data using XlStat from Addinsoft, New York, USA; and SPSS 25.0 (SPSS Inc., Chicago, IL, USA) package for windows. Duncan multiple range test was used to determine the significance across regions ($p < 0.05$).

3. Results

3.1. Sociocultural profile of palm oil processors

The sociocultural features of the respondents are presented in Table 1. Palm oil producers were from both genders with men representing the highest rate (60.71%). 88.2% of the surveyed processors were aged between 30 and 60 years; and 11.8 % more than 60 years old. Most processors (66.67%) had no formal education (illiterate) while 20.51, 9.82, and 3% of them had respectively primary, secondary, and university levels of education (Table1).

82.7% of participants learned palm oil processing from their parents, 13.3% from professional training and 4% acquired knowledge by themselves. About 35% of the interviewed individuals had 5 to 10 years of experience followed by 21.43, 20, 13, and 10.57% accounted for producers with 10 to 20 years, 20 to 30 years, less than 5 years, and between 30 and 40 years of experience respectively.

Table 1: Sociocultural profiles of palm oil producers (%)

Features	Processors (n = 40)
Gender	
Male	60.71
Female	39.29
Age	
30 - 40	48
41 - 50	22.87
51 - 60	17.33
>60	11.8
Educational level	
uneducated	66.67
Primary school	20.51
Secondary school	9.82
University	3
Access mode to palm oil processing knowledge	
Inherited from parents	82.7
Professional training	13.3
Personal research/ Self-taught	4
Years of experience	
< 5	13
5 - 10	35
10 - 20	21.43
20 - 30	20
30 - 40	10.57

3.2. Practices associated with the processing of E. guineensis fruit into palm oil

Before being processed into palm oil, fresh *E. guineensis* fruit is harvested transported and stored (Figure 1) at home. Table 2 summarizes the various practices used by producers concerning fruit quality requirements, capacity building, storage before treatment, equipment maintenance, critical point knowledge, etc. It can be observed that, *E. guineensis* fruit can be stored for 3 to 18 days (100% of respondents) either on the ground under a shaded terrace (23%), on the ground in a shed (37%) or on the ground in a store room (40%) which is the practice adopted by most interviewed producers. As for store maintenance, sweeping followed by cleaning with water and soap (18%) or sweeping only (82%) were the two hygienic measures recorded. For equipment maintenance, 82% of respondents use only water to wash machine. On the order hand, 8% use solid waste from palm oil extraction. For the fruit quality exigencies, 25% of producers have no requirement. The study also showed that for the capacity building, 95% of producers surveyed were not trained on good hygienic and manufacturing practices. From the 40 producers interviewed, five critical points were identified: i-fruits quality (97.5%), ii-cooking of the fruits (90%), iii-dehydration of the crude oil (92.5%), iv-quality of oil packaging material (95%) and v-quality processing equipment (97.5%). About storage containers, recycled bottles (85%) and barrels (15%) were used.

Figure 1: Photo of palm fruit storage on the ground before processing (Source: Rapport d'activités PTAA, 2020)

3.3. Microbial features of the palm oil produced

Figure 2 portrays the results of the fecal coliform (a), *S. aureus* (b), yeast (c) and mold counts (d) of the sampled palm oils with insight into acceptable threshold limit. Coliform counts ranged from 1 to 2.55 log CFU/g, and the oil sampled from Bohicon was the most contaminated (2.55 log CFU/g).

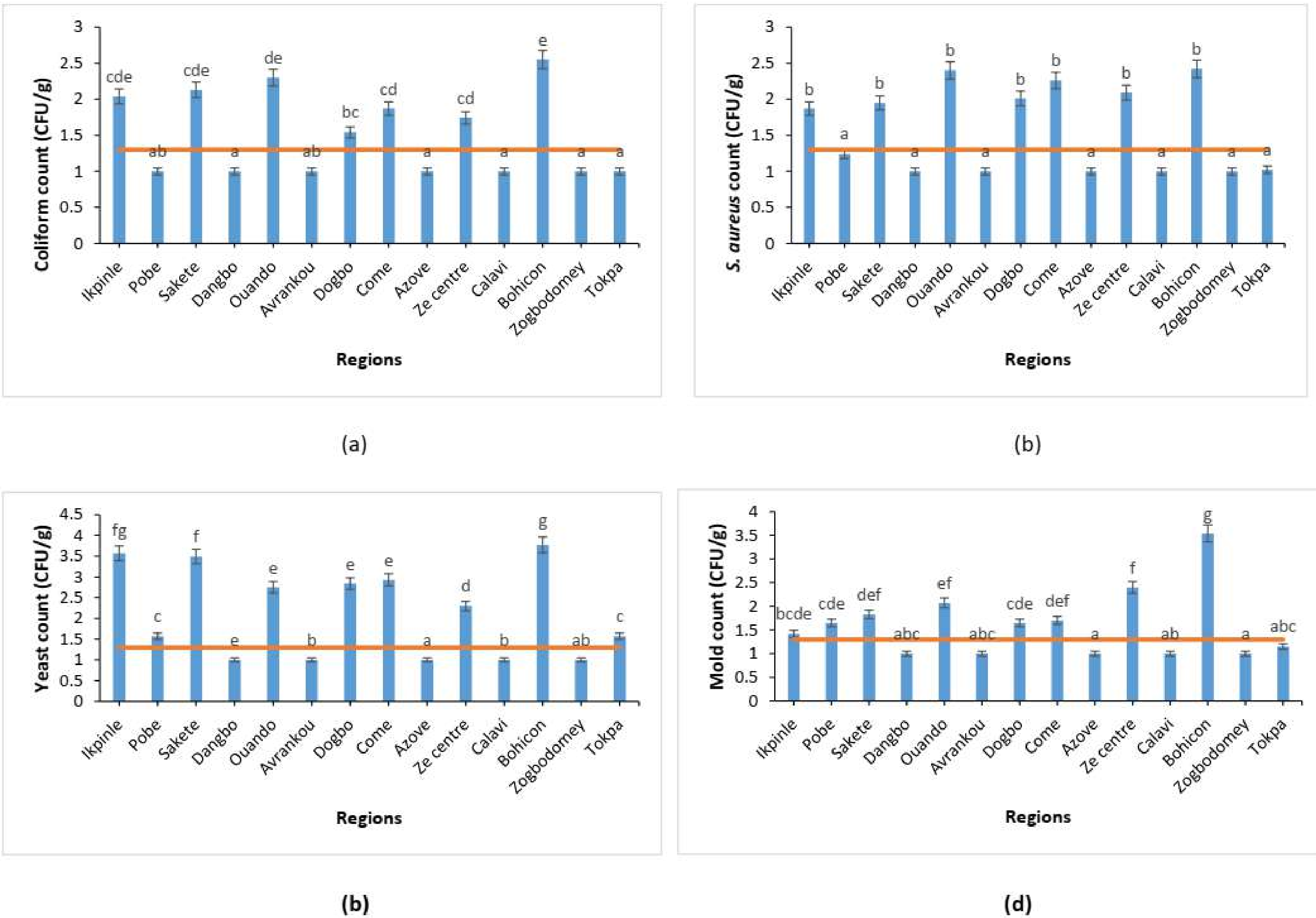

Figure 2: Coliform counts (a), *S. aureus* count (b), yeast (c), and mould count (d) of the sampled palm oils with insight into acceptable threshold limit.

They were followed by those from Ouando, Sakété, Ikpinlè, Comè, Zê Centre, and Dangbo. For the other regions the coliform counts were of 1 log CFU/g.

Microbial loads ranged from 1 to 2.42 log CFU/g; 1 to 3.77 log CFU/g and 1 to 3.54 log CFU/g for *Staphylococcus aureus*, yeast, and molds counts respectively.

Table 2: The producers practices

Practices	% of respondents (n = 40 processors)
Fruit quality exigencies	
Fruit fresh in good condition	5
No exigencies	25
Variety	25
Ripe fruit	45
Capacity building	
No capacity building	95
Good Hygiene Practices	0
Processing	5
Storage before treatment	
On the ground under a shaded terrace	23
On the ground in a shed	37
On the ground in a store	40
Equipment maintenance	
With soap and water	10
With water	82
With solid waste from palm oil	8
Critical point Knowledge	
Fruits quality,	87,5
Cooking of the fruits,	90
Dehydration of the crude oil,	92
Quality of oil packaging material	95
Quality processing equipment	97,5
Store maintenance	
Sweeping followed by cleaning with water and soap	18
Sweeping only	82
Containers for storage	
Recycled bottle 25 L	85
Recycled containers 200 L	15

4. Discussion

From the sociocultural profiles of palm oil producers, it can be assumed that as age goes by, producers involved in palm oil production reduce. Results showed that men were the most represented producers. This can be explained by the fact that physical strength is required during the extraction process. This clearly highlights one of the difficulties associated with palm oil production. These results are in line with those of Osei Amponsah *et al.* (2018) who reported that palm oil processing is mostly carried out by small-scale enterprises using traditional methods. Furthermore, the high rate of producers with no education level as well as the access to knowledge, raise concerns, from which we could link the poor quality of palm oil sold in Benin to the lack of good practices, lack of knowledge, poor use of equipment, poor sanitary and hygienic practices during production (figure 3). According to producers, everything is done on the basis of experience and empirical knowledge. Similar insights were reported by Tesfaye *et al.* (2015) in Ethiopia and MacArthur and Teye, Darkwa, (2021a & 2021b) in Ghana. According to a study by Dansou *et al.* (2022), traditional and semi-mechanical technologies are used in production areas in Benin.

Nanda et *al.* (2020) and Shamsudin et *al.* (2014) appraised the effect of storage conditions and time of palm fruits on the extraction yield and quality of CPO. They concluded on the positive relationships between storage practice, storage time, and obtained an oil of good quality. Similarly, an optimum of 3 days storage prior to artisanal extraction was found to be the best in extraction yield and oil quality.

Critical point in the oil processing chain may be the reason of poor oil quality. In the practice of traditional or artisanal processing, good harvesting of fruit, transport, conservation, storage and processing of palm fruits to obtain red oil are not known as there is no training for that as per the survey results. The learning process of palm oil extraction is from generation to generation. This study revealed five critical points: i-fruits quality, ii-cooking of the fruits, iii-dehydration of the crude oil, iv- quality of oil packaging material and v-quality processing equipment.

Figure 3: Photo showing unhygienic production conditions (Source: Rapport d'activités PTAA 2020)

The analysis of critical points on fruit quality showed that 100% of producers have no preliminary quality requirements for the fruits to be processed. Fruits are stored on the ground before processing, or they are fermented and stored in a net or loincloth on the ground, or they are dried under the sun with the development of mold and other microorganisms. Additionally, the fruits from different varieties are mixed together during processing. A long break time was observed between the de-steaming of grape bunches and the fruits processing, varying from three to eighteen days, according to the respondents. All this shows that fruits can be contaminated by microorganisms that can be pathogenic or not. These results are in line with those of Dansou et *al.* (2022), who reported that the palm fruits used for processing are not homogeneous in terms of quality. Also, the results of the microbiological analyses carried-out on oils collected from respondents showed microbial contamination in excess of permitted values.

The survey revealed that the majority of producers used a non-appropriate cooking vessel that cannot facilitate a homogeneous and rapid cooking of the palm fruits. After cooking, crude oil extraction is difficult and time-consuming, and the risk of microbial contamination is high. The quality of the water used can also be a source of contamination, as it is often not potable.

Dehydration involves reheating the oil obtained after clarification in a new barrel until most of the water evaporates. Although the survey revealed the use of this practice, very few producers use it because they don't want the oil to caramelize, which will not be appreciated by some buyers. Also, caramelization facilitates lipid oxidation reactions during storage. Only 5% of producers use this method (Dansou et *al.*, 2022). As for the quality of oil packaging material, the majority of producers use 25 liters yellow cans, metal and/or plastic drums. In practice, 95% of producers use 25 liters yellow drums for packaging. These containers have been used for the previous storage of red oil or other oils. The reused cans and drums are unwashed, uncovered and left in open air, containing reserves of old oil with rancid odors and dirty bottoms. Producers are not applying good hygiene practices, which require packaging in clean, unworn opaque material. These results are in line with those of Dansou *et al.* (2022); Shamsudin *et al.* (2014) and Okonkwo (2019).

Most farmers cook the oil in iron, aluminum or metal sheet containers (figure 4), which are not recommended for food processing. The exchange of materials between the cooking or mixing equipment and the product can lead to contamination by metal residues that can be harmful for the consumer.

Figure 4: Photo of a poorly maintained container of red palm oil (Source: Rapport d'activités PTAA 2020)

As it can be seen, no regulatory standards are used either for the fruit quality, their transportation, storage, maintenance, critical point, hygiene or for checking the oil during production. This confirms the lack of good practices knowledge as reported above. These five critical points figure among the twenty mentioned by Okonkwo (2019) in a similar work carried-out in Nigeria.

Results of the microbiological study showed that the production process was poor. These results are similar to those Okogbenin *et al.* (2014); Tagoe *et al.* (2012); Izah & Ohimain (2013); Enyoh *et al.* (2018) and Ngangjoh *et al.* (2020) who highlighted some public health concerns associated with the consumption of palm oil produced in neighboring countries.

Indeed, knowing that microorganisms can be found in various environments notwithstanding different conditions, it is worth mentioning that palm oil, due to its composition, provides a suitable medium for the growth of microorganisms. Coliforms have been associated with pathogenicity and toxicity, and thus their consumption and accumulation in the system could be harmful and may trigger some physiological responses (MacArthur *et al.,* 2021a; Odoh *et al.,* 2017). This makes it an important index to appraise food safety and quality. However, the quality of palm oil samples used in the present study could be considered as moderate (MacArthur et *al.*, 2021a & 2021b). Assuming that palm oil is used for cooking and frying, crude palm oil consumption as observed in some Beninese regions could lead to health issues.

The contamination by *staphylococcus aureus*, yeast and Mold confirm the poor production and handling practices in palm oil production. This is in line with the findings of Dongho *et al.* (2017) and Okogbenin *et al.* (2014). Detected *S. aureus* (found either in human skin, armpit and other areas) in food has been associated to a transfer from human to food (MacArthur *et al.,* 2021). In the present study, unhygienic practices might explain the observed results (Urugo *et al.,* 2021). The yeast and mold rate obtained was lower than that reported by MacArthur et *al.* (2021) in Ghana, who did not isolate yeast and mold in the oils collected in some regions, but similar to that of Okechalu et *al.* (2011) and Enemuor et *al.* (2012) in Nigeria, which did not exceed $1,10^4$ CFU/g. This difference in relation to MacArthur's results could be explained by the fact that, since the collections were made in commercial centers, the producers used good quality raw materials, the processing stages were well respected and the production conditions adequate, whereas in this study, collections were made from artisanal and semi-mechanical producers.

The contamination of samples with coliforms (hygiene indicator) and mold (storage condition indicator) are evidence of the non-application of the production standards of red oil production. More studies should be done in this context on palm oil production in Benin.

5. Conclusion

The study showed that red palm oil production practices in Benin are predominantly traditional or semi-mechanical using non-recommended equipments and materials. Most producers do not observe good hygiene practices and have not received any training. Five major critical points were identified along the red oil production chain, affecting the quality of the finished product. Microbiological analysis of the oils produced revealed the presence of pathogenic microorganisms and hygiene indicators. It is therefore essential to assess the quality of oils in terms of metal residues and mycotoxin contamination.

Conflict of interest

The authors declare that they have no competing interests.

Ethics

This Study does not involve Human or Animal Testing.

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