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# Spoilage and microbial quality of crude palm oil from the North-west Region of Cameroon

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**In Cameroon, palm oil is extensively used in its crude form for food. The present study was carried out to access stakeholders' perception of spoilage and the microbial quality of crude palm oil in the North-west Region of Cameroon. A random survey was carried out on 148 stakeholders of the crude palm oil marketing channel about their perception of crude palm oil spoilage. 79 samples were collected from different market sites in the region. Handlings of crude palm oil by the stakeholders were unhygienic and they had poor knowledge of the causes and reasons associated with its spoilage. The microbial contaminants isolated were *Salmonella* sp., *Escherichia coli, Staphylococcus aureus,* yeast, and *Aspergillus niger, Aspergillus sulphureus* and *Aspergillus versicolor*. The estimated overall bacterial load ranged from 17.14 × $10^4$ to 36.41 ×$10^4$cfu/ml. The bacterial load of crude palm oil samples from each market was far above the minimum acceptable range stipulated by NAFDAC. There is need for these stakeholders to be educated on the health implications and risks associated with palm oil production and post-production handling.**

**Key words:** Crude palm oil, spoilage, microbiological quality, Northwest Region of Cameroon.

## INTRODUCTION

Palm oil (PO) has become the most important and most traded vegetable oil globally, with a global production of 76 million tons (Nesaretnam, 2017; USDA, 2019; Gesteiro et al., 2019). Worldwide, PO is extracted by industrial, semi-industrial, or traditional methods, with the non-industrial sector representing about 30% of the total production of crude palm oil (CPO) (Dongho et al., 2016). Seventy-seven percent of palm oil produced worldwide is consumed as food (Orinola, 2018; Nesaretnam, 2017).

In Africa, Cameroon is the fourth highest producer and is the world's 12th largest producer of PO (Palm oil production in 1000MT, 2019). In Cameroon, the production is done at individual and industrial levels (Nkeze, 2010). The major stakeholders involved in palm

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oil production, distribution and consumption include oil palm growers, palm oil processors wholesalers, retailers, investors, social or development Non-governmental organizations (NGOs) and environmental NGOs (Local and International Stakeholders, 2017) The major regions that produce palm oil in Cameroon are: Southwest, Littoral, Central and Part of Northwest Region ((Nkongho et al., 2014). In the Northwest region of Cameroon, palm oil is produced mostly in the Momo division (Nkongho et al*.,* 2014). Palm oil accounts for about 90% of the edible oil needs of Cameroonians (Ngando et al., 2013).

Cameroonians (80%) consume red palm oil, with an estimated 30% produced by artisanal mills (Nkongho et al., 2014). Palm oil is extensively used in its crude form (crude palm oil) for food purposes because it is cheaper and had been a long-term eating habit (Ngando et al., 2013). It is nutritionally beneficial to being a rich source of some essential fatty acids, vitamin E, and carotenoids. Vitamin E has been extensively known for its nutritional and health benefits, including cholesterol-lowering, anti-cancer effects, antioxidant activities, and protection against atherosclerosis (Mukherjee and Mitra, 2009; Imoisi et al., 2015; Dongho et al*.,* 2016). Moreover, because of its high provitamin A carotenoid content, Crude Palm oil (CPO) constitutes an important food that could be used to prevent Vitamin A deficiency (Dongho et al*.,* 2016).

Though CPO is quite beneficial for human consumption, studies show that there are still problems related to its safety and quality (Ngando et al., 2013). Firstly, traditional methods of production employed for the extraction of palm oil are done by individuals who have little or no knowledge neither of modern aseptic production techniques nor of the microbiological implication of poor sanitation and storage methods (Okechalu et al., 2011; Madhusudhan et al., 2015). Secondly, change in oil quality during inappropriate storage conditions is still a major concern to public health as different packaging containers used under different storage conditions enhance oil spoilage (Viana et al., 2019). Microbial contamination from the environment, raw materials, equipment used for the processing, storage, and distribution, can also contribute to or enhance deterioration of the oil (Madhusudhan et al., 2015; Okechalu et al., 2011). The microbial quality of CPO plays a critical role in food, animal feed, and traditional medicine, as CPO is frequently used as a major ingredient in their preparations (Dongho et al*.,* 2016). Frying and cooking of the oil can reduce the microbial load to the minimum level.

However, CPO is often consumed raw like in the yellow soup that is prepared cold and form one of the major meals consumed by the local people of the Northwest Region of Cameroon (Grimaldia et al., 2018). This calls for concern as this may cause health problems to consumers (Okechalu et al., 2011). This study was carried to access the stakeholders' perception of spoilage and the microbial quality of crude palm oil in the Northwest Region of Cameroon.

## MATERIALS AND METHODS

### Study area and design

In the Northwest region of Cameroon (Figure 1), four market sites that sell crude palm oil were chosen for the study, namely Bamenda food market, Bafut Market, Mbengwi Tad market, and Widikum Market. A cross-sectional and experimental based study design was used, and the study was conducted from December 2017 to June 2018.

### Data collection/survey

A survey on the stakeholder perceptions of crude palm oil spoilage was carried out where closed, and open-ended questionnaires were randomly administered to 148 stakeholders of the crude palm oil marketing channel from markets in Bamenda (52 consumers and 28 retailers), Widikum (23 producers), Mbengwi (16 retailers) and Bafut (29 retailers). Information on the respondents' awareness of crude palm oil spoilage, knowledge on the noticeable changes in organoleptic properties observed in spoiled palm oil, possible causes and reasons associated with CPO spoilage, appropriate methods of storage, signs of spoilage, appropriate mixing, knowledge on the microbiological quality of oil and effect of consumption of spoiled oil on human health were obtained.

### Sample collection

A total number of 79 crude palm oil samples were collected in containers as bottled by the wholesalers and retailers in Mbengwi (2 wholesalers, 8 retailers), Bamenda (7 wholesalers, 15 retailers), Bafut (9 wholesalers, 10 retailers), and Widikum (28 wholesalers), markets and taken to the laboratory at the Institute of Agricultural Research for Development (IRAD) Bambui for microbiological analysis.

### Laboratory analysis

#### *Aerobic plate count of the samples*

The aerobic plate count of the stock solution of each of the samples collected was made (Okechalu et al., 2011). This assay was done by dissolving 1 ml of each sample in 9 ml of sterile distilled water already emulsified with 10% v/v of Tween 80 solution, which acts as an emulsifying agent. Three more serial decimal dilutions were made from each stock solution. One milliliter of the last dilutions ($10^{-3}$) of each sample was inoculated into Plate count agar, EMB agar, Salmonella-Shigella agar, Mannitol Salt agar in duplicates by the pour plate method. All plates were incubated at 37°C for 18-36 h. After incubation, the growing colonies were promptly counted, and the results expressed as colony forming units (CFU/ml).

#### *Identification of bacterial isolates*

All bacterial isolates on plates were identified based on biochemical characteristics, as described by Berge (Snealth et al*.,* 1986).

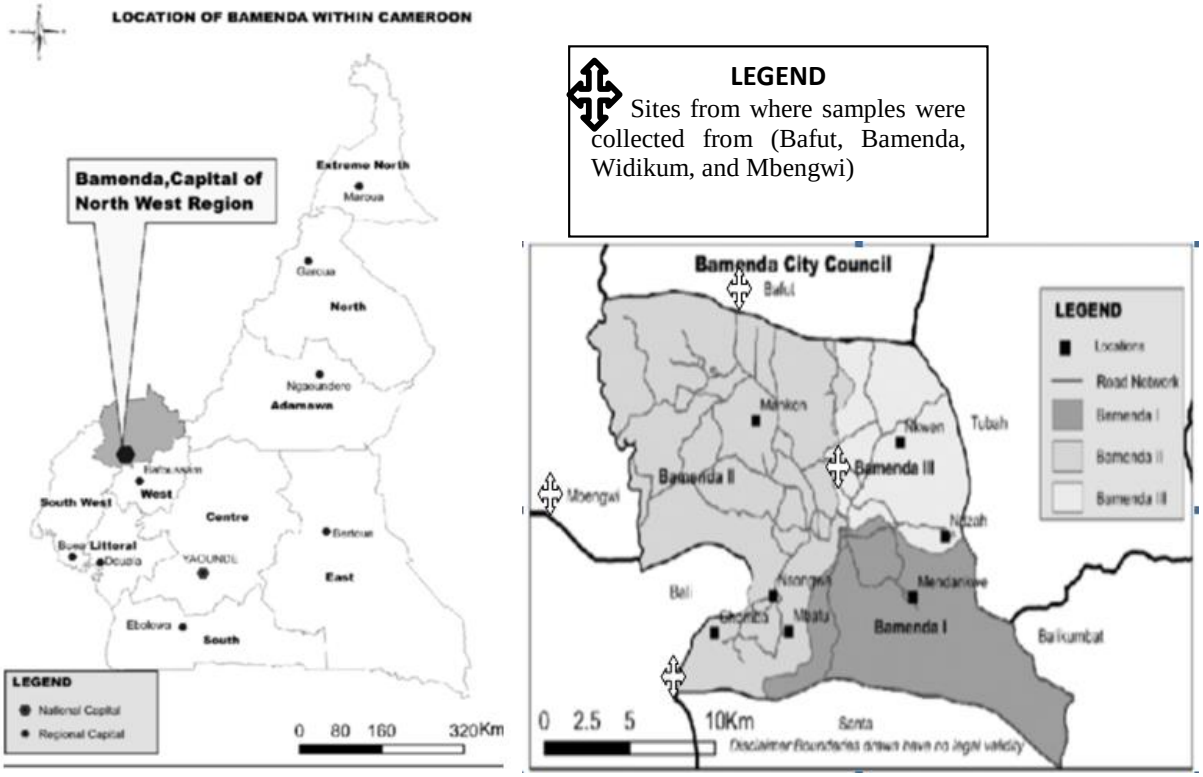


**Figure 1.** The map of North-West Region of Cameroon including the sites of sample collection.
Source: Kimengsi and Fogwe (2017).

***Isolation and identification of fungal Isolates***

One milliliter of $10^{-3}$ dilutions of each sample was inoculated into Potato Dextrose Agar in duplicates by the pour plate method and incubated at room temperature for 3-7days. All fungal isolates were identified based on their macroscopic appearance regarding mycology online of Ellis (2006).

**Data analysis**

The data were analyzed using ANOVA with the SPSS version 22, and total plate count was analyzed after angular transformation. Significant means were separated using the Tukey's test.

## RESULTS AND DISCUSSION

### From stakeholders

### *Characteristics of the study population*

The demographic characteristics of the 148 stakeholders investigated are shown in Table 1. Most (66.7%) of the respondents below 20 years were Bamenda consumers. The middle age group was mostly in Bamenda and Mbengwi. All of the respondents above 61 years of age were Bafut retailers. Majority of the Bamenda consumers interviewed were students (66.7%). Most of the Bamenda retailers were doing the palm oil business only as a source of income compared to other stakeholders in other places that were doing many other things as a source of income. A majority of the respondents were female for all the sites except for Widikum producers/wholesalers (Table 1).

### *Knowledge of oil stakeholders on crude palm oil spoilage in the North-west Region*

Out of all stakeholders surveyed, as shown in Table 2, 81% of them knew that palm oil gets bad. Majority (77%) of all the stakeholders knew that 'bad smell' is a sign of CPO spoilage, and meanwhile, just about 48.9, 33.8, and 37.2% in all sites knew the other three signs of CPO spoilage namely bad taste, soapiness, and bad colour respectively are signs of CPO spoilage. Out of the 4 major signs of CPO spoilage surveyed, more stakeholders knew about the bad smell, whereas many did not know about bad taste, soapiness, and bad colour hence a relatively poor knowledge and perception of stakeholders on CPO spoilage signs. Some authors attest

**Table 1.** Demographic characteristics of respondents for the five sites/stakeholders.

| Variable | Bamenda consumers (%) | Bafut retailers (%) | Bamenda retailers (%) | Mbengwi retailers (%) | Widikum producers/ wholesalers (%) | $X^2$ | *P* |
|---|---|---|---|---|---|---|---|
| **Gender** | | | | | | | |
| Male | 36.7 | 28.6 | 8.2 | 2.0 | 24.5 | 16.53 | 0.002 |
| Female | 34.3 | 15.2 | 24.2 | 15.2 | 15.4 | | |
| **Age** | | | | | | | |
| <20 | 66.7 | 0.0 | 8.3 | 8.3 | 16.7 | 37.62 | 0.000 |
| 21-30 | 46.7 | 15.0 | 8.3 | 5.0 | 25.0 | | |
| 31-40 | 28.6 | 18.4 | 28.6 | 16.3 | 8.2 | | |
| 41-50 | 11.8 | 29.4 | 29.4 | 23.5 | 5.9 | | |
| 51-60 | 0.0 | 51.1 | 42.9 | 0.0 | 0.0 | | |
| >61 | 0.0 | 0.0 | 100 | 0.0 | 0.0 | | |
| **Occupation** | | | | | | | |
| Civil servants | 44.2 | 1.8 | 22.2 | 0.0 | 0.0) | 67.92 | 0.000 |
| Farmer | 33.3 | 14.8 | 7.4 | 3.7 | 40.7 | | |
| Business | 18.5 | 16.7 | 38.9 | 22.2 | 3.7 | | |
| Student | 66.7 | 7.4 | 3.7 | 7.9 | 14.8 | | |
| House wife | 25.0 | 50.0 | 0.0 | 0.0 | 25.0 | | |
| Others | 37.0 | 33.3 | 7.4 | 3.7 | 18.5 | | |

Where: % = Percent.

to the fact that besides the rancidity of CPO, acidity, bitterness, soapiness and other off flavors may result from the lipolytic activity of microorganisms present in CPO that also leads to deterioration in their chemical quality (Ohimain and Izah, 2013; Okechalu et al., 2011).

Majority of the stakeholders in all the sites also knew the following related to the spoilage of CPO. 75.8% of the stakeholders in all the sites knew that bacteria cause CPO spoilage, 68.2% knew spoilt palm fruits cause CPO spoilage, 89.2% knew the quality of containers used and the activities involved in retailing (53.4%) are reasons associated with CPO spoilage respectively. However, just about 19.6 and 26.5% of all stakeholders in all sites knew that 'air and sunlight' and 'method of extraction' respectively are some reasons associated with CPO spoilage, respectively. In order words, most stakeholders did not know that 'air and sunlight' and 'method of extraction' are reasons associated with CPO spoilage. Furthermore, 56.1 and 66.5% for stakeholders in all sites recorded that 'mixing old oil and new oil' and 'readily eating oil at home' were measures they take to save and reuse bad CPO (Table 2). These results corroborate with the work done by Madhusudhan et al. (2015) in Gondar town Markets, North West Ethiopia, which showed that 36% expose oil to sunlight, 25% did oil measurement using clean jugs (retailing activities) and also as regarding responses to the knowledge of oil seller, 88% of them did not know the cause of oil spoilage.

### *Symptoms observed by stakeholders after palm oil consumption*

Mbengwi retailers (68.8%) were the most who felt nauseated after eating CPO (Table 2). Nevertheless, a small proportion of all stakeholders in all sites felt other symptoms like diarrhea, head-ache, rash, and cold after consuming CPO. Furthermore, from observation, over 90% of stakeholders, especially wholesalers, use storage containers for as long as they can store oil without proper routine cleaning. In Widikum, it was observed that over 90% of wholesalers put their oil in very big drums (100L and more), which have only a small hole or opening that can only take a funnel for oil transfer and so the inner part of these containers are seldom washed or cleaned. Also, 60% of the stakeholders (retailers and wholesalers) who buy CPO from producers/wholesalers in Widikum do not have one supplier, but they buy from different producers and then mix in their containers until it reaches the quantity of oil they desired to buy. They do this without any concern for microbiological implications. As a result of the above local activities or in case of a health problem after CPO consumption, traceability in the food supply chain for CPO may be difficult.

### *Microbial contamination of CPO samples*

The total plate count of the samples ranged from 17.14 ×

**Table 2.** Responses from stakeholders in percentages.

| Questions for respondents | Answer | Bamenda | Bafut | Bamenda retailers (n=28) | Mbengwi retailers | Widikum |
|---|---|---|---|---|---|---|
| | Options | Consumers (n=52) | Retailers (n=29) | | (n=16) | Wholesalers (n=23) |
| Awareness of crude palm oil spoilage | | 85 | 75 | 85.7 | 81.2 | 65 |
| Knowledge on the noticeable changes in organoleptic properties observed in palm oil | Bad smell | 75 | 65.5 | 92,9 | 81.2 | 73.9 |
| | Bad taste | 61.5 | 65.5 | 50 | 7.5 | 26.1 |
| | Bad color soapiness | 46.2 | 24.1 | 42.9 | 7.5 | 26.1 |
| | | 40.4 | 6.9 | 25 | 6.2 | 21.7 |
| Causes and reasons associated to CPO spoilage | Air/sunlight | 21.2 | 17.2 | 25 | 18.8 | 13 |
| | Bacteria | 65.4 | 86.2 | 75 | 93.8 | 75 |
| | Fungi | 46.2 | 34.5 | 82.1 | 81.2 | 56.5 |
| | Spoilt fruits | 69.2 | 62.1 | 78.6 | 81.2 | 52.2 |
| | Water | 55.8 | 41.4 | 82.1 | 81.2 | 52.2 |
| | Method extraction | 6.2 | 37.9 | 50 | 43.8 | 17.4 |
| | Storage conditions | 73.1 | 100 | 100 | 100 | 91.3 |
| | Retailing | 46.2 | 69 | 17.9 | 6.2 | 87 |
| How they store oil, | Closed containers | 92.3 | 55.2 | 89.3 | 87.5 | 91.3 |
| | Open containers | 1.9 | 0 | 0 | 0 | 0 |
| | New containers | 38..5 | 3.4 | 36 | 0 | 8.7 |
| | Old containers | 40.4 | 65.5 | 64.3 | 43.8 | 34.8 |
| Length of Time before spoilage, | 1-3months | 25.5 | 24.1 | 28.6 | 31.2 | 78.3 |
| | 4-12 months | 55.8 | 17.2 | 46.4 | 18.8 | 52.2 |
| | 2-5 years | 11.5 | 13.8 | 39.4 | 12.5 | 21.7 |
| Measures taken to safe palm oil showing signs of spoilage | Re-cook it | 61.5 | 65.5 | 50 | 62.5 | 34.8 |
| | Mix old and new oil Readily eat at home | 17.3 | 86.2 | 64.3 | 68.8 | 87 |
| | Feed animals | 28.8 | 82.2 | 89.3 | 93.8 | 91.3 |
| | Throw it | 21.2 | 13.8 | 50 | 0 | 78.3 |
| | | 46.1 | 10 | 28.6 | 43.8 | 21.7 |

n = number of stakeholders.

$10^4$ cfu/ml to 36.41 × $10^4$ cfu/ml (Table 4), with samples from Widikum market having the highest estimated overall bacterial load (36.41 × $10^4$ cfu/ml); while samples from Bafut market had the least estimated overall bacterial load (17.14 × $10^4$ cfu/ml). There is, however, a significant difference in the estimated bacterial load of samples from four markets at a 95% confidence level ($P<0.05$). This bacterial load of samples obtained from four markets were above the minimum acceptable range for oils as stipulated by Nigerian Agency of Food and Drug Administration and Control (NAFDAC) which states that, the maximum allowable number of organisms in a sample unit of oil should not be more than 2 with acceptable microbiological of $10^4$ as reported by Okechalu et al. (2011). This result is similar to the finding of Okogbenin et al. (2014) in Edo State, Nigeria who isolated food pathogens from palm oil and investigated the effect of sterilization on the oil quality. These microbial loads could be due to the habit of mixing old or bad oil with new oil, storage of oil in open and old containers, which are seldom washed and poor knowledge of causes and reason associated with palm oil spoilage (Table 2).

The wholesaler samples had a higher microbial load than retailer samples (Figure 2 and Table 5). The microbial isolates from the palm oil samples from four markets include *Staphylococcus aureus*, *Escherichia coli, Samonella species,* for bacteria, and *Aspergillus niger,*

*Aspergillus flavus, Aspergillus candidus, yeast, Aspergillus sulphureus, Aspergillus versicolor* and *Penicillium species* for fungi (Table 6). The presence of *E. coli, Salmonella* sp, *S. aureus*, *A. niger*, *A. flavus*, *A. candidus*, *A. versicolor* and *Penicillium sp* in samples is in concurrence with the findings of Okechalu et al. (2011) for palm oil obtained from Jos Metropolis, Plateau State, Nigeria. Yeast had the highest frequency of occurrence, while *A. niger, A. versicolor, and Penicillium* sp had the lowest frequency of occurrence.

The presence of *Aspergillus* sp was also similar to the findings of Odoh et al*.* (2016). The presence of *E. coli* could be indicative of fecal contamination or due to contamination from the environment or water (Okogbenin et al*.,* 2014). The presence of *S. aureus* corroborates with the work of Madhusudhan et al*.* (2015) and Okechalu et al. (2011). Other studies and scientific review have identified other microbes like *Enterobacter, Bacillus, Proteus, Micrococcus, Trichphyton scohoenleinii, Microsporum canis, Candida,* and *Mucor* as microbes found in palm oil (Enyoh et al., 2018; Izah et al., 2018, Okogbenin et al., 2014). The presence of these microbes could be an indication of unhygienic handling of the oil by the stakeholders since most of them do expose oil to air and sunlight for long periods at their market sales point. Hence, contamination could be from the environment or water in containers used for retailing or cleaning (Table 2). In addition, when the wind blows, dust containing microorganisms can settle on CPO during the operations of packaging, storage, transport, or distribution; hence the direct increase of microbial load of CPO contaminated by dust is evident (Ngono et al., 2016). This presence of *S. aureus* bacteria in the oil samples is a major health concern indicating unhygienic conditions of the oil (Gobena et al., 2018) and this bacterium is known to survive for extended periods in hostile environments and is capable of producing an enterotoxin; which can cause food poisoning (Madhusudhan et al., 2015).

It could also cause gastroenteritis in individuals if they consume the oil raw. It may cause common natural infections like arthritis (Madhusudhan et al., 2015). The presence of multiple microorganisms in CPO and their high loads are of great concern for the health of consumers. Although most Cameroonian CPO-based dishes are prepared hot, some like yellow soup/taro (which is one of the usual meals consumed by the local people of the North west Region of Cameroon) is prepared cold (Grimaldia et al., 2018). Likewise, CPO is sometimes used as an ingredient for traditional medicine. The nature of the microorganisms and microbial load is an essential marker of food quality. A food can have a low microbial load but contain a particular microorganism whose presence could be harmful to the consumer (Table 3) or that could contribute to the deterioration of that food (Ngono et al., 2016). Moreover, some of the isolates are tolerant of high temperatures (thermo-tolerant); hence these pathogens can spoil oil easily. Some of these microorganisms could have a lipase activity, and so increasing level of microbial load of a sample may lead to high free fatty acid content which in turn leads to a further deterioration of the oil (Frank et al., 2011).

Samples obtained from the Widikum market had the highest microbial load, while samples from the Mbengwi market had the least microbial load (Table 4), and this could be attributed to the fact most of them mixed both ‘old or bad oil’ with newly made oil before selling (Table 2). The Partial Eta squared value for site 0.071 is slightly lower than that of the stakeholders 0.093, which implies that the relative impact of stakeholders on microbial load is relatively stronger than the impact of the site on microbial load. The R-squared value 0.294 or 29.4% of variance microbial load attributed to site and stakeholders. Besides, the significant difference in the microbial load of samples from the four sites from the different stakeholders could be because, at marketing stage, the condition that oils are subjected to is quite different, as most oil marketers display their merchandise outside, under the sun daily (Kolapo and Oladimeji, 2011).

## Conclusion

The palm oil microbial quality of samples from wholesalers and retailers at the four marketing sites in the North West Region of Cameroon was poor due to poor post handling practices and limited knowledge on microbial contamination and spoilage. The microbial loads were above the NAFDAC acceptable limit hence the overall poor quality of crude palm oil samples collected from different sites in this region. This could be suggestive of the quality of CPO sold in the markets in this region of the country. The inappropriate handling of CPO by stakeholders is still a call for concern in these sites as this could be a probable route for cross-contamination, presence of microorganisms, and hence poor-quality oil.

## Recommendations

Since, all over worldwide, majority of palm oil produced is eaten as food, and in Cameroon it accounts for 90% of edible oil needs, it has become imperative that the highest food safety and quality standards be adopted in this regard. Based on the findings in this work, it is recommended that;

(i) There should be a strong partnership between the government regulators and the stakeholders (producers/ wholesalers, retailers) of the palm oil value chain.
(ii) Further research could be done to provide urgent

**Table 3.** Symptoms observed after palm oil consumption.

| | Stakeholders with positive response | | | | |
|---|---|---|---|---|---|
| | **Bamenda consumers (%)** | **Bafut retailers (%)** | **Bamenda retailers (%)** | **Mbengwi retailers (%)** | **Widikum producers (%)** |
| Nausea | 23.1 | 10.3 | 50.0 | 68.8 | 8.7 |
| Diarrhea/abdominal pain | 11.5 | 0.0 | 21.4 | 25.0 | 4.3 |
| Head ache | 0.0 | 6.9 | 3.6 | 31.2 | 8.7 |
| Rash | 9.6 | 6.9 | 3.6 | 12.5 | 13.0 |
| Cold | 15.4 | 3.4 | 42.9 | 50.0 | 21.7 |
| Total | 100 | 100 | 100 | 100 | 100 |

Key: % = percent.

**Table 4.** Microbial population of palm oil sold in the different sites of the North West Region.

| Sites | Total plate count × $10^4$ cfu/ml |
|---|---|
| Bamenda (n=22) | 17.91±3.86 |
| Bafut (n=19) | 17.14±4.53 |
| Widikum (n=28) | 36.41±10.19 |
| Mbengwi (n=10) | 24.20±1.09 |
| NAFDAC Limit | 1.00 |

Key: n=number of samples collected from different sites.

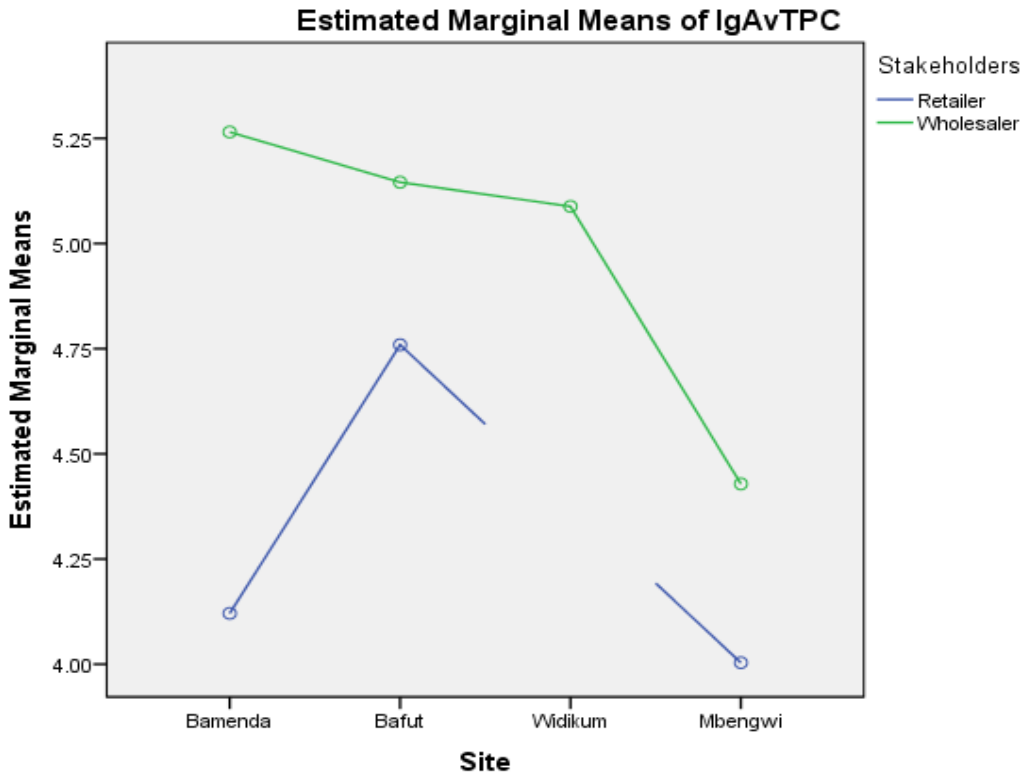


**Figure 2.** Shows a plot of log10 (total plate count values), site and stakeholders.

**Table 5.** Microbial population of palm oil for the different stakeholders of the North West Region, expressed as mean ± standard error.

| Stakeholders | Total plate count ×$10^4$cfu/ml |
|---|---|
| Retailers | 8.791±2.19 |
| Wholesalers | 34.50±7.17 |
| *NAFDAC Limit* | *1.00* |

**Table 6.** Tentative microbial isolates with frequencies of occurrence of oil samples from different sites in the North west Region.

| Microbial isolates present | Sites | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Bafut n=19 | | Bamenda n=22 | | Widikum n=28 | | Mbengwi n=10 | |
| | WH n=10 | RT n=9 | WH n=7 | RT n=15 | WH n=28 | RT n=0 | WH n=2 | RT n=8 |
| *E. coli* | 9 | 3 | 5 | 4 | 12 | / | 0 | 3 |
| Overall | + | | + | | + | | + | |
| *Staphilococcusaureus* | 0 | 5 | 1 | 3 | 8 | / | 0 | 3 |
| Overall | + | | + | | + | | + | |
| *Salmonella sp* | 7 | 2 | 0 | 0 | 13 | / | 0 | 0 |
| | + | | - | | + | | - | |
| *Yeast* | 10 | 7 | 7 | 15 | 28 | / | 2 | 8 |
| | + | | + | | + | | + | |
| *A. flavus* | 0 | 2 | 2 | 8 | 6 | / | 0 | 4 |
| | + | | + | | + | | + | |
| *A. candidus* | 3 | 5 | 2 | 8 | 16 | / | 1 | 3 |
| | + | | + | | + | | + | |
| *Peniciliumsp* | 1 | 0 | 0 | 2 | 2 | / | 0 | 2 |
| | + | | + | | + | | + | |
| *A. sulpureus* | 6 | 1 | 2 | 2 | 8 | / | 1 | 2 |
| | + | | + | | + | | + | |
| *A. versicolor* | 0 | 0 | 0 | 0 | 0 | / | 1 | 2 |
| | - | | - | | - | | + | |
| *A. niger* | 0 | 0 | 0 | 0 | 1 | / | 0 | 0 |
| | - | | - | | + | | - | |

Presence; - = absence; n=number of samples collected from different sites; WH=wholesalers, RT=retailers; /=no data: n=number of samples collected from different sites

alternatives to avoid the consumption of contaminated crude palm oil.

(ii) Further research could be done to urgently provide processing alternatives that include sanitation methods, in order to achieve minimum quality in palm oil for human consumption.

Frequently, there should be a public enlightenment in the form of workshops and seminars through which palm oil stakeholders should be educated on hygienic post handling methods and new methods of improving the quality of palm oil.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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## ABBREVIATIONS

**CPO,** Crude Palm oil; **NAFDAC,** Nigerian Agency for Food and Drug Administration and Control; **EMB Agar,** Eosin Methylene blue Agar; **NGO,** Non-governmental organizations; ***E. coli,*** *Escherichia coli;* ***S. aureus,*** *Staphilococcus aureus;* ***A. niger,*** *Aspergillus niger;* ***A. sulphureus,*** *Aspergillus sulphureus;* ***A. versicolor,*** *Aspergillus versicolor.*

### REFERENCES


Dongho DFF, Gouado I, Sameza LM, Mouokeu RS, Demasse SR, Schweigert JF, Ngane NAR (2016). Some factors affecting quality of crude palm oil sold in Douala, Cameroon. Journal of Food Research 6(1): 50-58.

Enyoh CE, Verla AW, Enyoh EC, Verla EN (2018). A review on the quality of palm oil (Elaeis guineensis) produced locally in Imo State, Nigeria. Sustainable Food Production 4:40-50.

Ellis D (2006). Mycology Online. Available at: http://members.iinet.net.au/~sambrod/Mycology_Online_Candida.html

Frank NEG, Albert MME, Laverdure DEE, Paul K (2011). Assessment of the quality of the crude palm oil from smallholders in Cameroon. Journal of Stored Products and Post Harvest Research 2:52-58.

Gesteiro E, Guijarro L, Francisco JS, Vidal-Carou C, Troncoso ALV, Vicente J, Quilez J, Anadón A, González-Gross M (2019). Palm Oil on Edge, Nutrients. Available at: http://www.mdpi.com/journal/nutrients

Gobena W, Girma S, Legesse T (2018). Microbial safety and quality of edible oil examined at Ethiopian public health institute, Addis Ababa, Ethiopia: a restrospetive study. Journal of Microbiology and Experimentation 6(3):136-139.

Grimaldia MI, Lekeb NW, Leke Nkeabeng MI, Tinde VA (2018). Traditional preparation of Achu, a cultural keystone dish in western Cameroon. International Journal of Gastronomy and Food Science. Available at: https://doi.org/10.1016/j.ijgfs.2018.05.001

Imoisi OB, Ilori GE, Agho I, Ekhator JO (2015). Palm oil, its nutritional and health Implications. Journal of Applied Science and Environmental Management 19(1):127-133.

Izah SC, Alagoa CT, Kigigha LT, Seiyaboh, EI (2018). Microbial quality of palm oil sold in Amassoma, Bayelsa State, Nigeria. International Journal of Public Health and Safety 3(153):2.

Kimengsi NJ, Fogwe NZ (2017). Urban green development planning opportunities and challenges in sub-saharan Africa: Lessons from Bamenda city, Cameroon. International Journal of Global Sustainability 1(1): 1-7.

Kolapo AL, Oladimeji GR (2011). Microbiology of Some Selected Nigerian Oils Stored Under Different Conditions, International Journal of Food Science and Nutrition Engineering 1(1):5-7.

Local and international stakeholders' collaboration drives improvement in Malaysia's palm oil sector (2017). Available at: http://sustainablesquare.com/local-international-stakeholders-collaboration-drives-improvement-malaysia-palm-oil-sector/

Madhusudhan A, Tesfaye L, Sahile S (2015). Microbial quality and chemical characteristics evaluation of edible oils sold at Gondar town markets, North West Ethiopia. International Journal of Modern Chemistry and Applied Science 2(4):238-247.

Mukherjee S, Mitra A (2009).Health Effects of Palm Oil. Journal Human Ecology 26(3):197-203.

Nesaretnam K (2017). Palm oil and its importance from food safety and nutrition perspective. Journal of Food Microbiology Safety and hygiene 2(2).

Ngando G, Mpondo-Mpondo AE, Ewane MA (2013). Alguns parâmetros de qualidade de óleo de palma bruto nos principais mercados de Douala, Camarões. Jornal Africano de Ciência Alimentar 7(2):473-478.

Ngono ARN, Florian JS, Adelaide MD, Raymond SM, Lambert MS, Innoocent G, Fabrice FDD (2016). Some factors affecting quality of Crude Palm oil sold in Douala, Cameroon. Journal of Food Research 6(1):114-116.

Nkongho RN, Feintrenie L, Levang P (2014). The non-industrial palm oil sector in Cameroon. CIFOR P 139.

Nkeze M (2010). Cameroon: South West – Hub of Palm oil production, Alla Africa. Available at: https:allaAfrica.com/stories/201004150571.html

Odoh KC, Amapu YT, Orjiakor PI, Martin EP, Seibai TB, Akpi KU, Ugwu SC, Lerum IN, Nwankwegu SA (2016). Assessment of mold contamination and physicochemical properties of crude palm oil sold in Jos, Nigeria. Food Science and Nutrition 5(2):310-316.

Okechalu JN, Dashen MM, Lar MP, Gushop T, Okechalu B (2011). Microbial quality and chemical characteristics of palm oil sold within Jos Metropolis, Plateau State, Nigeria. Journal of Microbiology and Biotechnology Research 1(2):107-112.

Okogbenin OB, Okogbenin EA, Okunwaye T, Odigie EE, Ojieabu A (2014). Isolation of Food Pathogens From Freshly Milled Palm Oil and the Effect of Sterilization on Oil Quality Parameters. Journal of Food Security 2(2):65-71.

Ohimain IE, Izah CS (2013). Microbiological quality of crude palm oil produced by smallholder processors in the Niger Delta, Nigeria. Journal of Microbiology and Biotechnology Research 3(2):30-36.

Orinola GS (2018). An investors's guide to Palm oil. Finance. Available at: http://www.toptal.com/finance/market-research-analyst/palm-oil-investing.

Palm oil the World's Most Important Vegetable Oil (2018). Available at: https/www.forumpalmoel.org>

Palm oil Production in 1000MT (2019). Available at: https:www.indexmundi.com/agriculture/?commodity=palm-oil

Snealth PHA, Mair SN, Holt GJ, Sharpe ME (1986). Bergey's Manual of Systemic Bacteriology P 2.

United States Department of Agriculture (USDA) (2019). Oilseeds: World markets and trade. Available at: http://apps.fas.usda.gov>oil.

Viana VT, Almeida DT, Costa MM, Silva C, Feitosa S (2019). Effects of different storage conditions on the oxidative stability of crude and refined palm oil, oleina and steastore (Elaeis guineensis). Food science and technology 39(1):211-217.