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Contribution to the improvement of the sensory properties of a margarine made from cocoa oil and fish oil (*Chrysichthys nigrodigitatus*)

Contribution à l'amélioration des propriétés sensorielles d'une margarine à base d'huile de cacao et d'huile de poisson (Chrysichthys nigrodigitatus)

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ABSTRACT:

The study of valuation routes of co-products from fishing and their integration into other processing chains as added value is an interesting axis of the integral transformation of local fishery resources. The aim of this study is to propose a way of valuing the carcasses of *Chrysichthys nigrodigitatus* by integrating the oil extracted from it into the formulation of an enriched margarine with an appreciable sensory property. For this to be done, oils from the cocoa harvested in Yabassi and from *Chrysichthys nigrodigitatus* caught in the Nkam river in Yabassi in the Nkam department were extracted in May 2020. The oils were subject to a macroscopic characterization and served as raw materials in the formulation of four test margarines (A20, A30, A40, A50). These four formulations were later subjected to a descriptive sensory analysis and the general acceptability was assessed to determine the best combinations out of which a margarine with a texture appreciated by consumers could be obtained. The experimental device set up made it possible to retain in terms of the proportion of *Chrysichthys nigrodigitatus* and cocoa oil, 20, 30, 40, 50 % and 80, 70, 60, 50 % respectively. The results obtained show that the samples with a high acceptability level are A50 and A40.which have an acceptability score of 6.3 ± 0.2, A50 was made up of the two ingredients in equal proportions that is, 50 % cocoa oil and 50 % oil from *Chrysichthys nigrodigitatus*. unlike A40 which had in its formulation 40 % *Chrysichthys nigrodigitatus* oil and 60 % cocoa oil. The data obtained from the sensory analysis show that samples A50 and A40 exhibit a sensory profile similar to that of ordinary margarine.

Keywords: margarine, *Chrysichthys nigrodigitatus*, cocoa, sensory properties

RÉSUMÉ :

L'étude des voies de valorisation des co-produits issues de la pêche et leur intégration dans d'autres chaines de transformation comme valeur ajouté est un axe intéressant de la transformation intégrale des ressources halieutiques locales. Le but de cette étude est de proposer une voie de valorisation des carcasses de *Chrysichthys nigrodigitatus* par l'intégration de l'huile extraite dans la formulation d'une margarine enrichie de bonne caractéristiques sensorielles appréciable. Pour ce faire, les huiles de cacao récoltés à Yabassi et de *Chrysichthys nigrodigitatus* péchés dans le fleuve *Nkam* à Yabassi dans le département du Nkam ont été extraites en mai 2020. Celles-ci ont fait l'objet d'une caractérisation macroscopique et ont servi de matières premières à la formulation de quatre margarines essais (A20, A30, A40, A50). Ces quatre formulations ont fait l'objet d'une analyse sensorielle descriptive et l'acceptabilité générale a aussi été évaluée en vue de déterminer les meilleures combinaisons pouvant permettre d'obtenir une margarine de texture appréciée par les consommateurs. Le dispositif expérimental mis sur pieds a permis de retenir en termes de proportion d'huile de *Chrysichthys nigrodigitatus* et de cacao notamment 20, 30, 40, 50 % et 80, 70, 60, 50 % respectivement. Les résultats montrent que les échantillons ayant un niveau d'acceptabilité élevé sont A50 et A40. Avec une note d'acceptabilité de 6,3 ± 0,2, l'échantillon A50 était constitué des deux ingrédients à proportions égales à savoir, 50 % d'huile de cacao et 50 % d'huile de *Chrysichthys nigrodigitatus* contrairement à l'échantillon A40 ayant dans sa formulation 40 % d'huile de *Chrysichthys nigrodigitatus* pour 60 % d'huile de cacao. Les données obtenues de l'analyse sensorielle montrent que les échantillons A50 et A40 présentent un profil sensoriel similaire à celui de la margarine ordinaire.

Mots clés : Margarine, *Chrysichthys nigrodigitatus*, Cacao, Propriétés sensorielles.

1. INTRODUCTION

The fisheries resources in Cameroon remain underexploited by the populations because of technologies which have remained up to date artisanal and not standardized on an industrial scale. However, fish and seafood are foods of high nutritional value and play an important role in the diet of populations (FAO, 2016). The artisanal and rudimentary nature of the processing and conservation chain of these resources results in shortfall associated with post-catch losses which amount to more than 15 % of the national production which represents more than 289,764 tonnes of fish per year (FAO, 2011; FAO, 2014). A few processing units exist here and there and are mainly dominated by smoking and drying, which transform 75 to 80 % of landings and contribute up to 16.8 billion to the national economy (Ngok et al., 2005). Fish processing is a very extensive activity in the production sites of Douala and in several other localities drained by rivers. The field of delicatessen is booming with fish and fish sausages that have emerged on the Cameroonian market. The operation of these meat processing units generates a large mass of co-products which are still rich in nutrients and responsible for environmental pollution. The question of valuing co-products from the sea does not arise only in terms of increasing added value but also with a view of reducing polluting effects (Shahidul et al., 2004; Arvanitoyannis and Kassaveti, 2008). Reducing this pollution involves finding ways to enhance the value of these co-products by integrating them into other processing circuits as raw materials. Thus, fishmeal, fish oil and compost are the main by-products derived from fish found in sub-Saharan Africa (Barro, 2004). The axis of the recovery of fish carcasses after threading is very suitable with the field of edible oils and fats with regard to their high lipid content, in particular omega 3, vitamins A and D (Ifremer, 2005; Hallereau, 2003). We have therefore been interested in the production of margarine enriched with fish oil and the question of acceptability is urgently raised. What proportions of fish oil can be combined with cocoa oil to obtain a margarine with sensory properties similar to that of regular margarine? It is to answer this question that this study, which is part of the valorization of by-products from fish processing, has set as its main objective the formulation of a margarine enriched with fish oil and having sensory characteristics similar to those of ordinary margarine.

2. MATERIAL AND METHOD

2.1. Material

2.1.1. Oil source

The cocoa used for the extraction of cocoa oil was harvested in Yabassi in the Department of Nkam along with *Chrysichthys nigrodigitatus* (machoiron) which was caught in the Nkam river in May 2020.

2.1.2. Ingredients

The emulsifier used is soy lecithin.

2.2. Method

2.2.1. Preparation of samples

Extraction of cocoa oil

The cocoa beans were weighed before being dried in an oven at 45 °C for 48 hours, then roasted at 130 to 140 °C for 20 to 40 minutes and peeled. The seeds thus separated from their skin were ground into a fine paste (500 µm) which was then weighed. The paste obtained was subjected to a water extraction of lipids which were collected and packaged in an opaque glass bottle (Fewou et al., 2015).

Extraction of Chrysichthys nigrodigitatus fish oil

The extraction was made from the carcasses of fish from the manufacture of sausage. Thus, after recovery, these carcasses were washed with clean water and then brought to a boil in water at a ratio of 0.5 L per kg of carcass. They were then pressed and the juice obtained introduced into a separating funnel which was kept at rest for 24 hours to separate the fatty phase from the aqueous phase (Gbogouri, 2018). The lipids which float over the mixture was collected, dehydrated and then conditioned away from contact with air and protected from light.

Production of margarine enriched with fish oil Chrysichthys nigrodigitatus

The production of margarine consists of six (6) steps which are, the preparation of the fatty phase, the preparation of the aqueous phase, the preparation of the emulsion, cooling, mixing, packaging and storage (Figure 1).

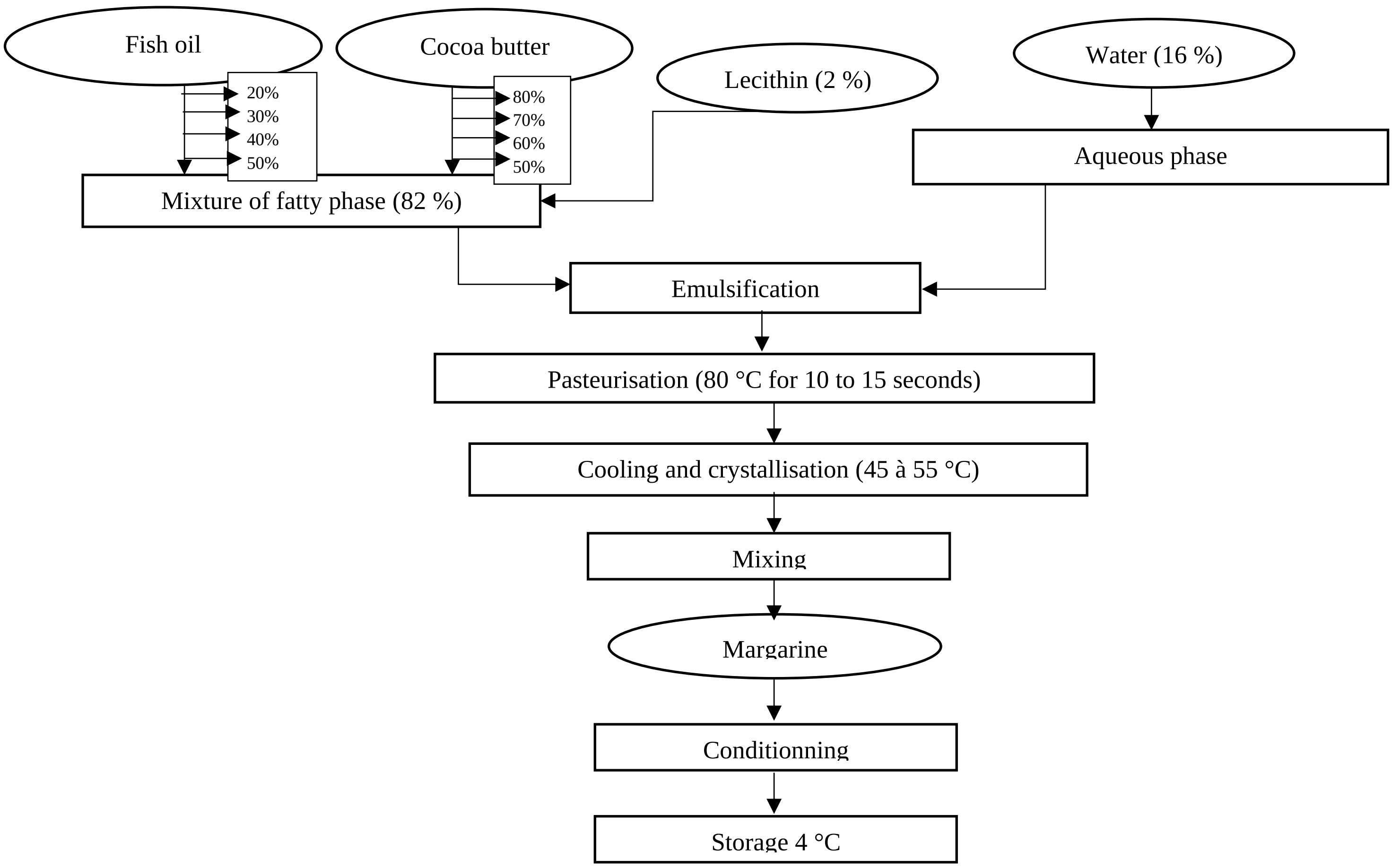

Figure 1: Production of margarine enriched with fish oil.

2.2.2. Aqueous phase

The aqueous phase consists of water previously pasteurized to destroy any germs it may contain. It accounts for 16 % of the emulsion (8 g).

2.2.3. Fatty phase

The fatty phase accounts for 82 % of the emulsion and in our case is of plant (cocoa) and fishery (*Chrysichthys nigrodigitatus*) origin depending on the desired performance of the product. This fatty phase was prepared from a mixture of cocoa oil and fish oil to which soy lecithin was added.

2.2.4. Emulsifier

Soy lecithin (L-α-Lecithin, Soybean - CAS 8002-43-5 – Calbiochem, Sigma-Aldrich) used as an emulsifying agent accounts for 2 % of the emulsion. Technologically, lecithin is a fat-soluble processing aid.

For the preparation of the emulsion, the aqueous phase was gradually incorporated into the fatty phase while stirring to allow the dispersion of the water droplets in the fatty phase until a sufficiently stable and homogeneous water / oil emulsion is obtained. Then the mixture was cooled in cold water with ice cubes and kneaded until a consistent, homogeneous and supple dough was obtained. This was then packaged in an opaque container (Norton and Fryer, 2012).

2.2.5. Sensory analysis

The samples obtained as such were subjected to a descriptive analysis. This method is based on the quantification of the appropriate descriptors (Larmond, 1977). It is carried out by a jury of 10 members (6 women and 4 men) aged 18 to 32 recruited according to the level of reproducibility of the results obtained by each member. Suitable candidates are trained on the basis of the 13 criteria selected during the panel training session and harmonization of the vocabulary of the analysis. Subsequently, the panelists evaluated the samples for 3 days with an interval of one day between each analysis. The samples previously stored at 4 ° C were presented to the jury. Following the instructions in the evaluation sheets, they examined the samples and rated the intensities of the various descriptors on a 9-point hedonic scale.

3. RESULTS AND DISCUSSION

3.1. Results

The methodology used led us to the results shown in Figure 2.

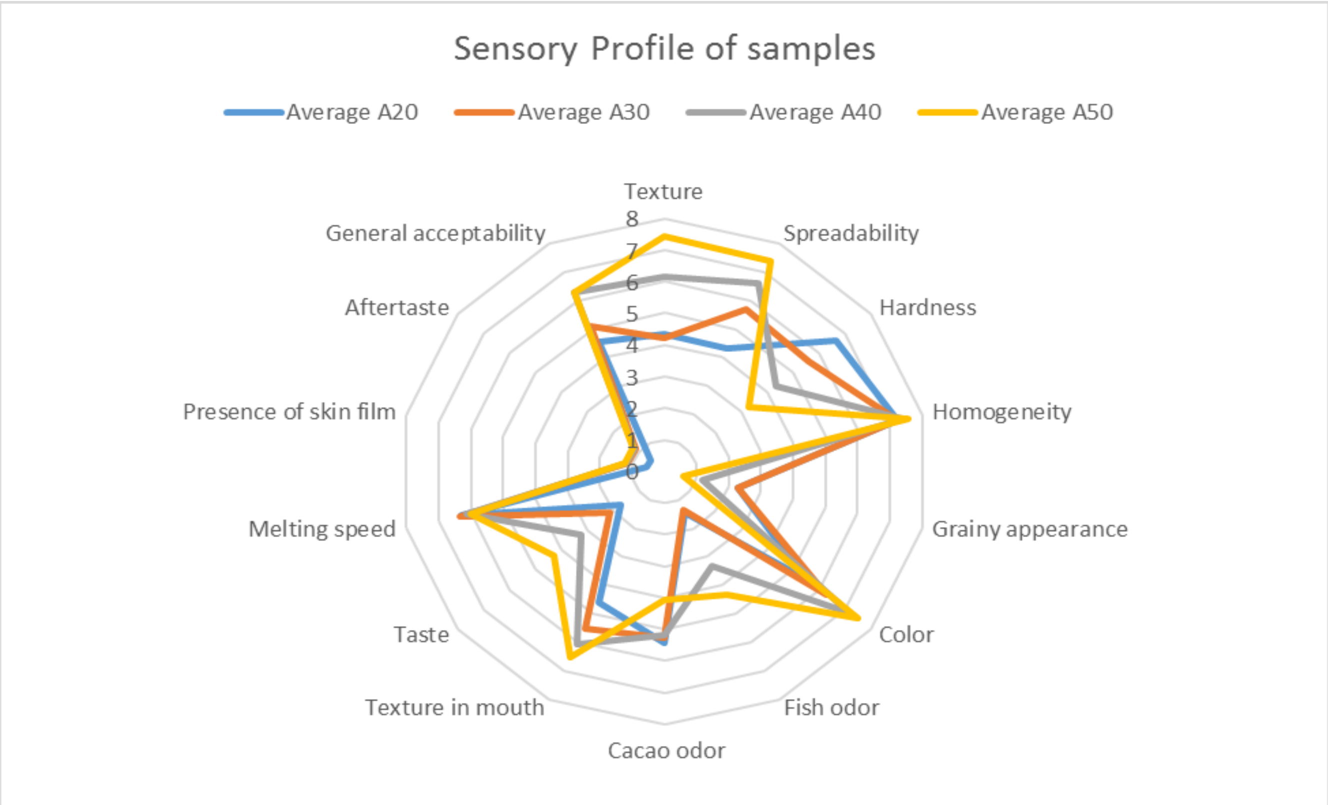

Figure 2: Sensory profile of margarines enriched with fish oil

3.1.1. Texture

For this descriptor, samples A20 and A30 have scores on a 9-point hedonic scale which range from 4.2 ± 0.3 to 4.3 ± 0.3 respectively compared to samples A40 and A50 which have higher averages ranging from 6.2 ± 0.3 to 7.4 ± 0.3. Beyond the measurement by wedging the product between the thumb and forefinger, the texture can be measured in the mouth by evaluating the force required for the tongue to flatten the product against the palate. Observation of our results shows that the texture in the mouth increases with increase in the rate of fats substitution with fish oil. Thus, samples A20 and A30 require more effort with averages of 4.6 ± 0.2 and 5.5 ± 0.3 respectively. As for A40 and A50, the necessary force is reduced having values between 6.1 ± 0.2 and 6.5 ± 0.2.

Analysis of these data shows that increasing the rate of substitution of vegetable fats by fish oil results in a product whose level of texture appreciation increases with the rate of substitution. The use of cocoa oil which has a stearic acid content of around 35 % gets its strength at room temperature from this fatty acid. This is equally true for fish oils, the composition of which indicates the presence of acids of this same nature. It is therefore the combined action of these different molecules that could justify the solid nature of the products manufactured and the increase in the level of appreciation with the increase in the substitution rate.

3.1.2. Spreadability

For samples A20 and A30, we recorded a rating out of 9 of the samples ranging from 4.3 ± 0.3 to 5.7 ± 0.2 respectively. For samples A40 and A50 we obtained values from 6.6 ± 0.2 to 7.4 ± 0.3 respectively. This can be explained by the fact that the closer the texture is to that of regular margarine as in samples A40 and A50 as shown above, the better the spreadability. However, samples with a high percentage of cocoa oil (A20 and 30) are more solid and therefore not easily spreadable.

3.1.3. Hardness

This parameter evolves in a decreasing way from sample A20 with an average of 6.6 ± 0.2, to A30 with 5.6 ± 0.3 which reflects a high hardness and therefore a high resistance unlike A40 and A50 which vary from 4.3 ± 0.3 to 3.3 ± 0.2 indicating less resistance to penetration. The intensity of the hardness here can be directly proportional to the amount of cocoa oil incorporated in the different margarines. The cocoa oil being solid at room temperature thus confers its hardness decreasingly from sample A20 (higher rate of incorporation) to A50 (lower rate of incorporation).

3.1.4. Grainy appearance (grain size)

The rates of perception of these sensations are low for all samples but are higher in A20 and A30 ranging between 2.3 ± 0.2 and 2.3 ± 0.3 compared to A40 and A50 which are at 1.2 ± 0.3, and 0.6 ± 0.1 respectively. This can be explained by the fact that cocoa butter exhibits a pronounced polymorphism that stabilizes in the β form thus generating crystals with a size of 100 μm and then become detectable. Unlike fish oil that does not exhibit a pronounced polymorphism and stabilizes in the β' form which is generally 5 μm in size (finer and less detectable).

3.1.5. Melting speed

The melting point of cocoa oil is higher than that of fish oil which gives samples A20 and A30 (80 and 70 % cocoa oil) the ability not to melt as fast as A40 and A50 (60 and 50% fish oil). This explains the decreasing evolution of the melting speed of A20, A30, A40, A50 with averages of 6.3 ± 0.2, 6.33, 6 ± 0.1 and 6.0.

3.1.6. Odors

Fishy odor predominates in samples A40 and A50 with intensities ranging from 3.3 ± 0.3 to 4.3 ± 0.3, but decreass in A20 and A30, both with a value of 1.4 ± 0.2. The fishy odor is caused by reactions of endogenous fish microorganisms and enzymes which release volatile molecules such as trimethylamine from the decomposition of fish flesh. However, the values remain low due to the relatively fresh state of the fish and the reduced time between capture and processing, thus reducing the duration of this degradation.

A reverse trend is observed for cocoa smell, the averages of which are 5.4 ± 0.3, 5.3 ± 0.3, 5.2 ± 0.3 and 4.1 ± 0.2 respectively. The heat treatment carried out on the cocoa beans by roasting generates many odorous compounds following the Maillard reaction also called non-enzymatic browning reaction. This chemical reaction is the origin of the formation of many molecules such as pyrazines and aldehydes responsible for the aromatic properties of the product.

3.1.7. Color

The averages 5.5 ± 0.3, 6.3 ± 0.2, 7.2 ± 0.2 and 7.4 ± 0.2 correspond respectively to samples A20, A30, A40, A50. There is an increasing change from yellowish to brownish which may be due to the yellowish coloration of cocoa oil and the brown coloration of fish oil. The different proportions give variations in the color of the finished product.

3.1.8. Taste

The values for taste are 1.7, 2.1 ± 0.2 3.2 ± 0.3 and 4.2 ± 0.3 from A20 to A50 respectively. This development can be explained by the increasing levels of fish oil which provides additional flavor. However, the values remain low because the formulation does not include a flavor enhancer and consists only of the mixture of oil and water.

3.1.9. Presence of a skin film and aftertaste

The intensity of perception of this criterion is very low (< 2) for all samples; this could indicate a good progress of the mixing and cooling steps. The values are between 0.5 ± 0.2, 1.1 ± 0.3, 1.2 ± 0.2, and 1.2 ± 0.3 for A20, A30, A40, A50 respectively.

3.1.10. General acceptability

General acceptability was assessed by the panel by rating on a 9-point hedonic scale. It appears that samples A50 and A40 have a higher general acceptability (6.3 ± 0.2) than the other two A30 and A20 which are less appreciated (5.1 ± 0.2 and 4.6 ± 0.3 respectively). This can be explained by the high fish oil substitution rate in these first two, which helped provide better properties especially in terms of texture and spreadability. It also made it possible to have reduced intensities on the unfavorable characteristics to the acceptability of the product such as hardness, grain size.

3.2. Discussion

The various descriptors have an increasing or decreasing evolution from sample A20 to sample A50 depending on the rate of incorporation of the various fatty substances which are involved in their composition.

3.2.1. Descriptors evaluated by touch

The texture increases from A20 to A50, thus approaching the texture of regular margarine. This may be due to the volume fractions of the fatty substances present, one of which (cocoa oil) has a high melting point. These results are similar to those obtained by Boutoumi (2013) where we note good, melting and light textures for samples with a melting point < 37 ° C and hard for those with melting points > 37 ° C. The spreadability follows the same evolution as the texture with the samples A40 and A50 having a greater ease of spreading than A20 and A30 thus approaching the results of Ollé, (2002), where the samples with levels of SFC (solid fat content / solid fat) showed better spreadability than those with a higher rate. The Hardness evolves in a decreasing way from A20 to A50. This can be explained by the presence of a higher level of cocoa oil which contains saturated fatty acids making it solid at room temperature. The same phenomenon is observed by Ollé, (2002) on two samples of margarines having quantities of interstified oil (softening effect) increasing from one sample to another. The grainy appearance changes in proportion to the level of fish oil present. According to Oumeddah (2016), previous studies show that products with extreme hardness accentuate the phenomenon of sandy texture. Thus, binary mixtures using two components: solid fat and liquid oil have become the object of common practices among formulators in order to overcome this problem. As a result, the margarine samples exhibited a smooth, non-sandy texture.

3.2.2. Descriptors evaluated by sight

The color varies in proportion to the incorporation rate of cocoa butter because it has a yellowish color. The more its quantity in the formulation decreases, the more the margarine tends towards a whitish color. This phenomenon is observed in the work of Achour et al. (2017) where the color of the margarine varies proportionally to the rate of incorporation of olive oil. This has a more intense yellowish orange color for an enrichment rate of 35 % olive oil.The homogeneity is similar for all samples with averages bet ween 7.2 and 7.6, describing an appreciable homogeneity. These results are comparable to those obtained by Oumeddah (2016) who notes a good homogeneity of a margarine which can be stored at room temperature, due to good agitation and good cooling during production.

3.2.3. Descriptors evaluated in the mouth

The taste varies in proportion to the percentages of fish oil incorporated. The taste remains bland however, due to the absence of flavor enhancers or additional auxiliaries. This result is different from that of margarine that can be stored at room temperature studied by Oumeddah (2016), which has a buttery taste due to the buttery aroma incorporated in the formulation. The melting speed of the four (04) samples is between 6 and 6.3 which reflects rapid melting in the mouth. This result is close to that obtained by Oumeddah (2016) who obtained a melting point of a margarine at 35.7 ° C because the melting point of the margarine must be set so that it melts completely at body temperature. However, below this temperature, a certain solid content is required in order to contribute to the structure and texture of the margarine (Ollé, 2002). The presence of a skin film is between 0.5 and 1.2 for the four (04) samples, which is negligible and in agreement with the facts given by Kok et al. (1999) stipulating that margarines should not show a sticky appearance (or wax appearance in Anglo-Saxon authors) on the tongue.

4. CONCLUSION

The descriptive analysis made it possible to draw up a sensory profile of the samples of margarine produced in various proportions of fish oil and cocoa butter that is 20, 30, 40, 50 % and 80, 70, 60 and 50 % respectively. From the results obtained, it appears that the samples with the highest percentages of fish oil (A50 and A40) have the highest general acceptability rate (6.3 ± 0.2) with more appreciable characteristics which are closer to regular margarine. Samples A30 and A20, on the other hand, having lower fish oil incorporation rates have less appreciable overall acceptability averages of 5.1 ± 0.2 and 4.6 ± 0.2 respectively.

5. CONFLICT OF INTEREST

The authors declare no conflict of interest.

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