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ASSESSMENT OF PHYSICOCHEMICAL AND MINERAL CHARACTERS OF THE ORANGE (*CITRUS SINENSIS*) PEELS

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ABSTRACT

This study aimed to identify the physicochemical and mineral characters of the peels derived from the orange (Citrus sinensis) to propose ways of increasing their commercial value. The investigations concerned two types of peels: the greens, resulting from the unripe oranges and the yellows, concerning the ripe oranges. The samples were gathered from sedentary saleswomen of oranges. The results showed heterogeneous physicochemical data related to the different sources of the oranges. Thus, the green peels had a maximal fat content of 4.4% whereas that of the yellow ones was lower (2.41%). However the great mineral composition of the peels did not result from the oranges sources but was induced by maturation stages. Potassium and calcium were the major elements from this composition. Thus, the peels have full of nutritional and therapeutic values related to their mineral and physicochemical characters.

The results of our study contributed to lighten ways of valorization of the oranges peels especially in various additives. They will help to reduce the recurring food deficiencies within the rural populations from the developing countries.

Keywords: Orange (*Citrus Sinensis*)- Peels- Composition- Mineral- Valorization.

1. INTRODUCTION

The orange (Citrus sinensis) is a fruit-bearing plant originating from Asia. It provides edible fruits through the whole tropical and subtropical lands (Suryawanshi Jyotsna A. Saonere, 2011). Oranges are citrus fruits consisting in a pericarp or the peel, a thin white membrane and a pulp including some pits. The world production of oranges is stated 62 709 636 tons. In Côte d'Ivoire, 500 000 t of citrus fruits are produced each year (FAO, 2004).

The oranges are important livelihoods for the many countries. Indeed, their economic value is especially resulting from their pulps thanks to their sensorial and nutritional advantages. Thus, the works of Mbogo Gloria *et al.* (2010) revealed high contents of glucid (11% to 33%) and especially ascorbic acid (22.5 to 50.4%) into the orange pulp. From this, the pulps of oranges record great interests for many dietaries. Besides, they are important additives for food (Tobias *et al.*, 2011).

Concerning with the orange peels, they provide 16% to 19% of the fruit weight. Some investigations on the composition in macro and micronutrients allowed accounting of several therapeutic and nutritional virtues of the orange peels (Suryawanshi Jyotsna A. Saonere, 2011). These characters are involving from volatile aromatic components of the zest called essences (Phytomania, 2010). These oils are used in numerous fields. Thus, in food diet, they have taken as aromas, additives or ingredients (Chattopadhyay *et al.*, 2008). From the cosmetic, they are perfumes for the manufactured.

The peels essences have therapeutic, antiseptic, analgesic and anti-inflammation values (Muhammad *et al.*, 2008; Akin *et al.*, 2010). Besides, they are the ingredients and essential additives to many preparations like as juices, cocktails and cookings. However, in Côte d'Ivoire, the oranges are always consumed after the removal of their peels. They do not undergo anymore processes. Generally their main technology is limited to a small-scale extraction of the juice from the pulp. The peels and the membranes remains waste from the consumption and the technologies of oranges.

From this, scanty attempts are concerning with the characterization of the peels resulting from oranges produced in Côte d'Ivoire, in spite of their numerous authenticated advantages. Thus, this survey is achieved in order to valorize the orange peels through investigation of its physicochemical characters. The results will allow proposal of valorizations of the peels, which would increase the benefits derived from of the oranges.

2. MATERIAL AND METHODS

2.1. Plant Material

The plant material was consisting in peels (Citrus sinensis) from unripe and ripe orange which had respectively green and yellow colours. This material was supplied by sliced-oranges saleswomen from the municipality of Yopougon, Abidjan, Côte d'Ivoire.

2.2. Methods

2.2.1. Sampling

The peels were gathered with 3 sedentary saleswomen of sliced-oranges. The samples were selected on evening after the sale of the oranges. The peels collected from each saleswoman were divided up to 2 sets; one set for the green (unripe) peels and another set for the yellow (ripe) peels. Thus, the investigations were concerning 6 sets of peels. Each set led to three samples. The peels were recovered using proper baskets previously given to the saleswomen. Then, they were conditioned in small bags under sealing and labelling before sending them to laboratory. The study was conducted from March to April 2013. Finally, 12 sets of orange peels have undergone all analyses.

2.2.2.Physicochemical Assessment

The dry matter content of the orange peels was measuring in oven at 65 °C for 4 Hrs (BIPEA, 1976). The fat content was determined by the Soxhlet extraction method, from the dry matter, according to AFNOR (1973) standards.

The contents of total soluble and reducing sugars were evaluated respectively with the phenol-sulphuric method (Dubois *et al.*, 1965) and with the 3,5-dinitrosallicylic acid (DNS) methods (Bernfeld, 1955) by using a spectrophotometer. The proteins content was determinate by the method described by Lowry *et al.* (1951).

The amount of ash was obtained after total incineration in a muffle furnace at 550 °C (BIPEA, 1976). The qualitative and quantitative evaluations of the minerals were carried out by spectrometer using diffusion energy (DES, INCA of Oxford Instruments).

2.2.3 Statistical Analysis

The results were means of each character and expressed in relation to the fresh peels. The Data were subjected to an analysis of variance (ANOVA) using the software SPSS 16.0 for windows). Mean and standard deviation were calculated and, when F-values were significant at the $P \leq 0.05$ level. The mean difference was separated using the Newman keul's test. The analyses were carried out to compare peels colours and saleswomen.

3. RESULTS

3.1. Physicochemical Characters

The statistical analysis of the physicochemical characters of the oranges peels revealed similar means for some characters and different means with other ones according to the peels colours and the types of saleswomen (Table 1).

Table-1. Physicochemical characters of the oranges peels according to their colour and the types of saleswomen

Peels colour	Saleswomen	Means ± SD of physicochemical characters					
		DM (%)	FM (%)	TS(mg/100g)	RS(mg/100g)	Prot (g/100g)	Ash (%)
Green	1st	32.93±0.80[a]	4.22±0.09[ab]	82.81±1.67[a]	0.39±0.01[c]	1.04±0.01[c]	2.17±0.02[a]
	2nd	33.87±0.70[a]	4.40±0.15[a]	84.50±0.78[a]	0.80±0.39[b]	0.90±0.39[b]	2.19±0.03[a]
	3rd	34.20±0.36[a]	3.92±0.14[b]	83.72±2.53[a]	1.21±0.68[a]	1.50±0.69[a]	2.11±0.03[a]
Yellow	1st	34.20±0.65[a]	3.21±0.13[c]	73.57±5.58[b]	0.52±0.24[c]	0.50±0.22[c]	2.17±0.04[a]
	2nd	32.80±0.10[a]	3.34±0.29[c]	72.28±2.75[b]	0.39±0.01[c]	0.37±0.01[c]	2.03±0.03[b]
	3rd	32.80±0.79[a]	2.41±0.14[d]	71.69±3.14[b]	0.50±0.25[c]	0.48±0.22[c]	2.15±0.06[a]

DM, dry matter; FM, fat matter; TS, total soluble sugars; SR, reducing sugars; Prot, proteins.
Averages followed by the same tiny letter in the same column are not significantly different for each parameter.

The dry matter contents did not statistically difference between oranges peels from the whole saleswomen ($P \geq 0.05$). The means of dry matter contents of the orange peels fluctuated between 32.8% and 34.20%.

A highly significant difference resulted with the fat contents ($P \leq 0.01$) according to the colour of the peels and the saleswoman.

From the green peels, the fat contents varied between 3.92% and 4.22% with an intermediate amount with first saleswoman. On the other hand, the fat contents of the yellow peels dropped from 3.34% to 2.41% with the same means recorded from the 2nd and 3rd saleswomen. The total sugars contents differentiated statistically ($P \leq 0.01$) both of the peels colours (Table 1). Thus, the means were between 82.81 and 84.50 mg/100 g of green peels. They dropped until 71.69 mg/100 g for the yellow peels.

Concerning the contents of reducing sugars, the means provided by the peels were different incording the colours and saleswomen ($P \leq 0.05$). Thus, the reducing sugars contents of green peels were significantly different, with a maximum value of 1.21 mg/100g (Table 1).

But, they did not differ anymore from the yellow peels, with values of 0.39 to 0.52 mg/100g.

Our results showed diverse ash contents ($P \leq 0.05$) relieving to the colour of the peels and the saleswomen (Table 1). The green oranges peels recorded similar ash contents, stated between 2.11 % and 2.19 %; while the yellows provided statistically low ash contents whose minimal value was 2.03 % given by the 3rd saleswoman.

The proteins contents were also significantly different ($P \leq 0.05$) according to the colours and the saleswomen (Table 1). The green peels provided highest proteins contents, with a maximum value of 1.50 g/100g; even when they seemed identical from the yellow ones, between 0.39 g/100 g and 0.54 g/100g.

3.2. Minerals Characters

The mineral composition expressed by mg per 100 g of fresh peels, presented the same minerals whatever the type of orange and the saleswomen. Quantitatively, the results revealed significant divergence between the minerals proportions according to the type of peels. However, from each type of peels, the three saleswomen recorded statistically the same means (Table 2). In addition, the spectrometric analysis revealed the presence of major and minor minerals into the orange peels.

3.3. Major Minerals of the Orange Peels

The predominant minerals of the oranges peels are potassium (K) and calcium (Ca).
The statistical analysis indicated a significant difference between the potassium contents with account of the type of peels ($P \leq 0.01$). Indeed, the potassium was more abundant into the green peels, with a content of 1565 mg/100g fresh peels. The calcium contents were lower than those of potassium. They didn't differ through both of the peels types ($P \geq 0.01$). However, their means increased slightly respectively from 470.5 mg/100 g (green peels) to 490.5 mg/100 g (yellow peels).

Table-2. Mineral composition of the oranges peels according to their colors

Peels colours	Means ± SD (mg/100 g) of minerals elements						
	K	Ca	Mg	P	Cl	S	Si
Green	1565±30.4[a]	470.5±23.43[a]	62.98±3.49[a]	43.34±5.72[a]	21.70±3.17[b]	10.69±1.19[b]	10.31±4.38[a]
Yellow	1490±32.94[b]	490.5±26.24[a]	41.83±5.59[b]	36.33±2.52[b]	33.87±2.28[a]	19.435±1.58[a]	12.39±2.31[a]

Mg, magnesium; Si, silicon; P, phosphor; S, sulfur; Cl, chloride; K, potassium; Ca, calcium.
Averages followed by the same tiny letter in the same column are not significantly different for each parameter.

3.4. Minor Minerals of the Orange Peels

The minor minerals of the oranges peels were, ordered in decreasing proportions: magnesium (Mg), phosphor (P), chloride (Cl), sulfur (S), silicon (Si) (Table 2).

The results showed a significant difference ($P \leq 0.01$) of the contents of magnesium and phosphor involved by the colour of oranges peels. Indeed, the contents were higher into the green peels. Thereby, the magnesium and phosphor contents reached respectively 62.98 and 43.34 mg/100g.

The chloride and sulfur contents also differentiated statistically the green and yellow oranges peels ($P \leq 0.01$). The yellow peels contained most Cl and S contents with respective means of 33.87 and 19.435 mg/100g.

Any significant difference resulted from the silicon contents between the whole colours of orange peels.

4. DISCUSSION

4.1. Physicochemical Characters of the Orange Peels

The constant dry matter contents however the colour of the peels expresses the stability of this character during the ripening stages of the oranges. In fact, the green peels were provided by the ripe oranges in opposition to the yellow ones.

On the other hand, the fat contents of the peels differ according to their colour, and presented internal variations involved by the saleswomen. The decrease of the fat contents from the green to the yellow peels suggests a loss of fat matter during the ripening of the oranges. Indeed, according to oral statements, the peeling of the green oranges produces more volatile fragrance. However, the works of Suryawanshi Jyotsna A. Saonere (2011)showed that these aromas are resulting from the essences among the lipid fraction of the peels. Thus, the more abundant fat matter into the green peels would contain more volatile aromas. These compounds evaporate during the drying of the peels into the steam room, explaining the stability of their dry matter contents.

According to our results, the reducing sugars are a tiny proportion of the soluble sugars of the oranges peels. Globally these sugars are more abundant into the green peels.

The differences recorded with the majority of the characters studied may result from their changes according to the ripening stage of the oranges. Indeed, the epidermis of the oranges and most other fruits, turns out their colours from green to yellow, red or orange during the ripening. Then, the colours do not change as soon as the fruits reach their full ripe stage.

This change of coloration may relate to the presence of hormones synthesized during the development of the fruit, such as ethylene and the abscissic acid (Kwang *et al.*, 2006). These hormones result in the synthesis of colorful complexes, like the flavonoïds. These phytochemicals are antioxidants with several nutritional and medicinal properties (Ilja and Peter, 2005; Beking and Vieira, 2010). So, their presence would explain the therapeutic virtues stated by Kubo *et al.* (2005) and Leite *et al.* (2008) about of the peels.

The heterogeneous physicochemical characters according to the saleswomen could be related to the origins of the oranges. Indeed, the fruits marketed by the saleswomen would not always come from the same field or the same wholesaler.

Besides, a saleswoman could gather from several wholesalers her stock of oranges whose the precise maturity stage remain unknown.

4.2. Minerals of the Orange Peels

The unvarying contents of peels minerals from the saleswomen would show their stability wherever the origin of the oranges. They could be therefore parameters of gene origin.

However, the variation in the contents of some minerals like magnesium, phosphor, chlorides and sulfur would be involved with the oranges maturation stage. That would justify their variation related to the color of the peels.

On the other hand, the potassium and calcium have steady contents whatever the type of peels. Besides, the spectrometric analyses showed that the potassium and calcium are the most abundant minerals of the oranges peels.

Indeed, from many studies, a high proportion of the potassium content is related to its assimilation or absorption by tissues. Thus, the great content of potassium in the orange peels may have resulted from its abundance in the tissues of the orange (Wastowski *et al*., 2013).

Otherwise, several studies stated on the prevalence of potassium in the plant organs (Martinez *et al*., 2007).

Potassium records an important nutritious role in any organism. Intake of higher potassium content and sodium less could prevent the hypertension, source of the cerebral vascular damages and the heart diseases (Cook and Obarzanek, 2009). It's the main intracellular mineral. It takes part in the muscular activity and to the heart muscular. A dietary with high potassium content is favourable to the bone healthy thanks to its alkaline effect (ANONYME, 2010).

The calcium proportion is lower than that of the potassium. One of the main benefits from calcium is related to interactions between cells walls. Therefore, it ensures the cells structure by hard cementing them. Calcium is a cellular component and regulator of the nervous excitability (Marschner, 1986). It's also a factor of ethylene synthesis during the fruits ripening (Morard, 1996).

From the other minerals of the orange peels, magnesium has major nutritional and therapeutic actions. Indeed, magnesium is an essential mineral for the cells functions. A daily sufficient intake is necessary for the energy production of the organism, the keeping of good cardiac rate and the fight against stress.

Magnesium intervenes in several metabolic reactions like activator or enzymatic regulator. Thus, it improves the good functioning of the digestive tract, the maintenance of the structures of bones and teeth, and the proteins synthesis. It takes part in the regulation of some minerals, such as calcium, potassium, copper or zinc.

Although the silicon content seemed weak into the peels, this mineral still has a great importance. Indeed, the Si improves the body health. It is naturally present in the human body ITS content decreases with age (N'damitso *et al*., 2012).

Silicon is part of the collagen structure, which keeps up the elasticity and the youth of skin. It records important role for the fixing of the calcium; it's therefore useful in the treatment of bony affections, such as the osteoporosis (Suryawanshi Jyotsna A. Saonere, 2011). A silicon intake could correct many dysfunctions caused by the age; from which the interests for the orange peels promoting.

Generally, the silicon is highly found in the non refined foods and the plant tissues because it's activator of many biological systems leading to plant protection (Ebrahimian and Bybordi, 2012).

These works showed ways of valorization to the orange peels. So, thanks to its minerals contents, the peels could be valorized through various beverages or teas (Wastowski *et al*., 2013). It must be taken account of the preservation of the minerals and their effective migration in the infusions and the soakings during such preparations.

Numerous nutritional investigations revealed that the Mg intakes are generally below the securities. Thus, the European health authorities recommend daily contributions of 150 to 500 mg of magnesium for the adults (Ilja and Hollman, 2005).The peels could be consumed as food additives in order to fill in the Mg deficiencies from the children and old people in the rural zones of the developing countries.

The ripe oranges peels could be more advisable because they're richer in fat, and could contain a lot of secondary metabolites such as polyphenols (Ilja and Hollman, 2005). This type of peels contains also higher contents of minerals than the peels resulting from the unripe oranges.

5. CONCLUSION

The survey about the orange peels permitted knowledge of their physicochemical and mineral characters. The results reveal heterogeneous physicochemical data related to the different sources of the oranges. However the mineral composition of the peels doesn't derive on the sources of the oranges but are proceeding from their ripening or maturation stages.

These results permitted statements of valorization ways to the oranges peels in various additives. However, these results should be strengthened by a large investigation about a high number of saleswomen from several zones, the right sources of the oranges and their precise maturation stages. That would lead to strength data of technologies which could help efficient valorization of the peels derived from the oranges.

REFERENCES

AFNOR, 1973. Norme Française homologuée NF V03-905. Graines oléagineuses: Détermination de l'extrait à l'hexane. pp: 513.

Akin, M., A. Aktumsek and A. Nostro, 2010. Antibacterial activity and composition of the essential oils of eucalyptus camaldulensis dehn and myrtus communis L. growing in northern cyprus. African Journal of Biotechnology, 9(4): 531-535.

ANONYME, 2010. Food and drug administration. Center for food safety and applied nutrition. Office of nutritional products, labels claims. Health Claim Notification for Potassium Containing Foods, October 31, 2000. Available from www.fda.gov.

Beking, K. and A. Vieira, 2010. An assessment of dietary flavonoid intake in the UK and Ireland. International Journal of Food Sciences and Nutrition, 62(1): 17-19.

Bernfeld, P., 1955. Amylase α and β (Assay method) in methods in enzymology I, colowick and Kaplan, Ed., Academic press, New York, USA. pp: 149-154.

BIPEA, 1976. Bureau Interprofessionnel d'Etudes Analytiques: Recueil des méthodes d'analyses des communautés Européennes. pp: 160.

Chattopadhyay, P., C. Sandipan and K. Sukanta, 2008. Biotechnological potential of natural food grade biocolorants. African Journal of Biotechnology, 7(17): 2972-2985.

Cook, N. and E. Obarzanek, 2009. Trials of hypertension prevention collaborative research group. Arch Intern Med, 169(1): 32-40.

Dubois, M., K. Gilles, J. Hamilton, P. Rebers and F. Smith, 1965. Colorimetric methods for determination of sugars and related substances. Anal. Chem., 28(4): 350-356.

Ebrahimian, E. and A. Bybordi, 2012. Effect of salinity, salicylic acid, silicium and ascorbic acid on lipid peroxidation, antioxidant enzyme activity and fatty acid content of sunflower. African Journal of Agricultural Research, 7(25): 3685-3694.

FAO, 2004. Données de FAOSTAT.

Ilja, C. and P. Hollman, 2005. Polyphenols and disease risk in epidemiologic studies. The American Journal of Clinical Nutrition, 81(4): 24-30.

Ilja, C.W. and C.H. Peter, 2005. Polyphenols and disease risk in epidemiologic studies. The American Journal of Clinical Nutrition, 81: 24-30.

Kubo, K., C. Kiyose, S. Ogino and M. Saito, 2005. Suppressive effect of citrus aurantium against body fat accumulation and its safety. J. Clin. Biochem. Nutr., 36(2): 11-17.

Kwang, H.L., L.P. Hai, K. Ho-Youn, Sang Mi Choi, J. Fan, H. Wolfram, H. Ildoo, M.K. June, L. In-Jung and H. Inhwan, 2006. Activation of glucosidase via stress-induced polymerization rapidly increases active pools of abscisic Acid. Cell, 126(9): 1109–1120.

Leite, M., J. Fassin, E. Baziloni, R. Almeida, R. Mattei and J. Leite, 2008. Behavioral effects of essential oil of citrus aurantium L. inhalation in rats. Braz. J. Pharmacogn, 18(5): 661-666.

Lowry, O.H., N.J. Rosebrough, Farrad and R.J. Randall, 1951. Protein measurement with folin-phenol reagent. Journal of Biological Chemistry, 193(3): 265-275.

Marschner, H., 1986. Mineral nutrition of higherplants. Chapitre 8 : Functions of mineral nutrients: Macronutrients. Academic Press. pp: 195-267.

Martinez, S., A. Curros, J. Bermúdez, J. Caballo and I. Franco, 2007. The composition of Arnoia peppers (Capsicum annuum L.) at different stages of maturity. Int. J. Food Sci. Nutr., 58(2): 150-161.

Mbogo Gloria, P., B. Mubofu Egid and C. Othman Chande, 2010. Post harvest changes in physico-chemical properties and levels of some inorganic elements in off vine ripened orange (Citrus sinensis) fruits CV (Navel and Valencia) of Tanzania. African Journal of Biotechnology, 9(12): 1809-1815.

Morard, P., 1996. Le calcium et les végétaux cultivés. PHM revue horticole, 371(6): 10-13.

Muhammad, G., M. Sajid, M. Nasir, J. Nyla, K. Rehana, J. Kokab and A. Gulshan, 2008. Composition and antimicrobial properties of essential oil of foeniculum vulgare. African Journal of Biotechnology, 7(24): 4364–4368.

N'damitso, M., O. Jacob, S. Idris and T. Jimoh, 2012. Prospects in the use of ficus polita as a local ruminant feed.

Phytomania, 2010. Huiles essentielles. Aromatherapie. Consulté le 22 juillet 2013. Available from http ://www.phytomania.com/index.htlm.

Suryawanshi Jyotsna A. Saonere, 2011. An overview of citrus aurantium used in treatment of various diseases. African Journal of Plant Science, 5(7): 390-395.

Tobias, J.A., V. Gamarra-Toledo and D. Garcia-Olaechea, 2011. Year-round resource defence and the evolution of male and female song in suboscine birds: Social armaments are mutual ornaments. Journal of Evolutionary Biology, 24(4): 2118-2138.

Wastowski, A.D., R. João Paulo Gonsiorkiewicz, R.C. Maurício, M.d.R. Genesio, Paulo Roberto Bairros da Silva and C. Silvia, 2013. Determination of the inorganic constituents of commercial teas and their infusions by the technique of energy dispersive X-ray fluorescence spectrometry. Journal of Medicinal Plants Research, 7(5): 179-185.

BIBLIOGRAPHY

AOAC, 2000. Association of official analytical chemical; official methods of analysis. 14th Edn. Washington D.C USA.

Coxam, 2005. Inulin, oligofructose and bone health: State of the art and perspectives in the management of osteoporosis. Br J Nutr, 93(suppl 1): S111-112.