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RESEARCH ARTICLE

EFFECT OF TEMPERATURE ON THE DEGRADATION OF ASCORBIC ACID (VITAMIN C) CONTAINED IN INFANT SUPPLEMENT FLOURS DURING THE PREPARATION OF PORRIDGES

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Abstract

This work concerns the incorporation of *Parkia biglobosa* pulp and *Adansonia digitata* pulp (baobab) into infant flours produced by the Togolese Institute for Agricultural Research (ITRA) in order to increase their micronutrient and especially vitamin C content. The 2,6-dichlorophenol-indophenol (DIP) method is then used to determine vitamin C in the prepared porridges of these enriched flours to study the effect of heat or temperature on the degradation of this vitamin C. The results show that the highest destruction of ascorbic acid or vitamin C occurs at temperatures between 85 and 95°C, especially after 10 minutes of cooking time. The initial value of 66.67 mg for 10Nx10 enriched flour decreases to 2.64 mg after 2 minutes cooking time and becomes practically zero after 20 minutes (0.50 mg). As for the enriched 10Ne10 flour, its initial vitamin C value decreases from 67.74 mg to 3.04 mg after 2 minutes of cooking time and then to 0.40 mg after 20 minutes. The study of the degradation of vitamin C through a gradual decrease of temperature by cooling the porridges, shows a slightly degradation after 10 minutes cooling at the temperatures between 60 and 80°C. The initial values of 10Nx10 and 10Ne10 flours decrease from 66.67 mg to 52.20 mg and from 67.74 mg to 60.30 mg respectively. From these results, we can conclude that heat destroys almost all the vitamin C contained in the flours during the preparation of the porridges at the temperatures between 80 and 95°C. It becomes necessary to incorporate the baobab pulp rich in vitamin C after the cooking and cooling of the porridges between 60 and 80°C to avoid a total destruction of the vitamin C.

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Introduction:-

Since 2012, the prevalence of stunting has not been significantly reduced in Africa. In 2018, 90 per cent of the world's stunted children lived in Africa and Asia, where respectively 39.5 per cent and 54.9 per cent of the total number of children in the world were affected (FAO, 2019). Only 40 per cent of infants under six months are exclusively breastfed, far from the target of 70 per cent in 2030. In 2018, 7.3 per cent of children were emaciated, and this proportion must be reduced by more than half to reach the target of less than 3 per cent by 2030. Anemia currently affects 33 per cent of women of childbearing age, more than double of the 15 per cent target set in 2030 (FAO, 2019).

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The prevalence of anemia including hemoglobin, Hb < 11 g/L of children from 6 months to 59 months old in 11 French-speaking countries in Africa was 72.4 percent (Diouf et al., 2015).

In Togo, between 2016 and 2018, the prevalence of undernourishment was 16.1 percent or 1.3 million of the population and the prevalence of stunting among children under 5 years was 27.6 percent or 0.3 million. The prevalence of anemia among women of childbearing (15-49 years) is 48.9 percent or 0.9 million of the population and the prevalence of low birth weight or underweight is 16.1 per cent or less than 0.1 million in 2018 (FAO, 2019; SUN, 2017). One in six children under five years (16.6%) are underweight and this number is two times higher in rural (19.6%) than urban areas (10.4%). These under nutrition problems are partly due to poor infant and young child feeding practices. While the exclusive breastfeeding rate is 62.5 per cent in 2012 and declines to 57.2 per cent in 2018 (FAO, 2019), only 42.3 per cent of children from 6 to 9 months receive complementary feeding while breastfeeding continues and 18.5 per cent of children from 6 to 23 months receive the minimum acceptable food intake (MS, 2012). The prevalence of anemia remains high and is estimated at over 76 to 91 per cent among children from 6 to 36 months (MS, 2012). After 6 months, the energy and nutrient intakes of breast milk become insufficient to supply the nutritional needs of growing children and complementary foods must be introduced. In developing countries, complementary feeding often starts too early or too late. It is also after 6 months that the growth of most infants in these countries no longer follows the satisfactory growth model due to repeated infections and inadequate complementary foods (Nutrition, 1998).

In response to this situation, since 2010, UNICEF, the Togolese Institute for Agricultural Research (ITRA) laboratory and the National Nutrition Service have been committed to implementing a strategy to fight malnutrition by improving complementary foods through the fortification of Nutrimix flour with local foodstuffs rich in vitamins and minerals (Bouka Goto et al., 2015). The flours obtained provide 6-14 mg of iron (Bouka Goto et al., 2015). The foodstuffs of plant origin as flours contain "non-hemic" iron (little available to the human body) compared to meat that is food rich in "hemic" iron (the best form of iron assimilated by the body). Although the flours contain non-hemic iron, the simultaneous presence of vitamin C from fresh vegetables or fruit ingested during the same meal, significantly increases the absorption of the non-hemic iron in the intestine. It is therefore more appropriate to incorporate directly into the flours, an accessible local foodstuff rich in vitamin C. The presence of vitamin C will facilitate a high absorption of the "non-hemic" iron contained in large quantities in soya or *Parkia biglobosa* seeds used to prepare infant flours. Our work on the fortification of the flours with vitamin C has revealed the value of incorporating baobab (*Adansonia digitata*) pulp into the flours.

Nutritional analysis of baobab fruit pulp has shown that it is an excellent source of pectin, calcium, vitamin C and iron. Its vitamin C content is about three times higher than oranges vitamin C. It's reported that *Adansonia* pulp can also be used as a calcium supplement because of its high calcium content, in addition, leaves and seeds are identified as good sources of vitamins and minerals (Smith et al., 1996).

Ascorbic acid is an important component of our diet and is used as an additive in many foods because of its antioxidant capacity. It increases the quality and technological properties of foods and their nutritional value (Solomon et al., 1995). However, ascorbic acid is known to be a vitamin is sensitive to factors as pH, moisture content, oxygen, temperature and light (Lee and Coates, 1999). The degradation of ascorbic acid occurs through aerobic and anaerobic factors (Huelin, 1953; Johnson et al., 1995) and depends that on many other factors such as oxygen, heat, light (Robertson and Samaniego, 1986), storage temperature and storage time (Fellers, 1988; Gordon and Samaniego-Esquerre, 1990). Oxidation of ascorbic acid occurs during juice manufacturing processing, but an aerobic degradation of ascorbic acid occurs mainly during storage in thermally preserved juices (Lee and Nagy, 1988). For these reasons ascorbic acid is generally considered as nutritional index quality during food processing and storage (Nicoletti et al., 2007), (Fennema, 1977).

The aim of this work is to study the effect of temperature on the degradation of vitamin C contained in baobab pulp-enriched infant supplement flours during the preparation of porridges.

Materials and Methods:-

The studies were carried out in the Togolese Institute for Agricultural Research (ITRA) laboratories located in Cacao, Lomé-Togo. The production of fortified complementary infant flours was carried out in the ITRA Nutrimix workshop and the physico-chemical analyses at the ITRA physico-chemical laboratory. The determination of vitamin

C was carried out at the laboratory of the High School of Biological and Food Technology (ESTBA) of the University of Lomé.

Production equipment

The equipment used consists of a roaster, a mill, a balance, a sorting table, a gas dryer, a welding machine, drying tables and small kitchen equipment.

Vegetable material

The vegetable material used is corn (*Zea mays*), rice (*Oriza sativa*), soya (*Glycine max (L.) Merr.*), parkia pulp (*Parkia biglobosa*), baobab pulp (*Adansonia digitata*).

Preparation of baobab and parkia pulp

Baobab pulp is purchased directly from women in the villages. We have sieved it to obtain a finer grain size and got rid of impurities. The treated baobab pulp was packed in a non-transparent container that protected it against light. Parkia fruits were pulped. The pulp was dried until it became very crispy. It was then ground, sieved and packaged.

Production of experimental flours

ITRA produces Nutrimix 2 and Nutrine flours. Nutrimix 2 is made with corn, rice, and soya. Nutrine is made with corn, rice, soya and the seeds of Parkia (*Parkia biglobosa*) (Bouka & al., 2015). Nutimix 2 and Nutrine have been enriched with baobab pulp and parkia pulp in the following proportions: baobab pulp 10%, parkia pulp 10%. The Nutrimix 2 and Nutrine enriched flours are respectively called 10Nx10 and 10Ne10 flours and have been used to prepare porridge.

Preparation of the porridges

Two techniques have been developed in the porridge preparation:

First, the enriched flour porridges with parkia and baobab pulp (10Nx10 and 10Nx10) were prepared at different cooking time intervals (2 min, 3 min, 5 min, 7 min, 10 min, 12 min, 15 min and 20 min) at the temperature ranging from 85°C to 95°C and then cooled quickly by putting the cup containing the porridge into fresh water. In a second step, only the parkia pulp is incorporated into the flour for cooking and the baobab pulp is introduced after cooking at different cooling time intervals (0 min, 2 min, 3 min, 5 min, 7 min and 10 min).

Determination of vitamin C by the 2,6-dichlorophenol-indophenol (DIP) method

The determination of vitamin C was done by the Harris and Ray titrimetric method. 1g of flour was dissolved in 100 mL of distilled water, well mixed and filtered. We took 50 mL of the resulting juice from a 100 mL vial, filled the volume to 100 mL with 1% oxalic acid (w/v) and well mixed the contents. Then 10 ml of this diluted flour juice was pipetted from the above into a 50 mL bottle of erlenmeyer and 2.5 mL of pure acetone was added. The whole solution prepared was placed in a dark place for 10 minutes and titrated with 0.05% sodium 2,6-dichlorophenol-indophenol (DIP) (w/v) until the solution turned red (pink tending towards red). The title of the DIP solution was determined by titrating 10 mL of standard vitamin C solution in the same way.

The vitamin C content of the flour solution was determined by the relationship:

$$\text{VitC} = 40(V - V') / VA \text{ mg/100g MS}$$

V = initial volume in the burette V' = volume remaining in the burette

Every sample has been repeated three times and the results were expressed in mg/100 g MS

The result is the average of three tests.

Statistical Analysis

Microsoft Excel 2013 has been used to treat the data collected and to calculate the standard deviation and draw the graphs.

Results:-

Heat degradation of vitamin C in porridges containing baobab and parkia pulp

Table 1 shows the effect of heat treatments at different cooking times 2, 3, 5, 7, 10, 12, 15 and 20 minutes and at a temperature between 85 and 95°C of the porridges prepared with the flours enriched with baobab and parkia pulp (10Nx10 and 10Ne10). The ascorbic acid (vitamin C) content in flours was 66.67 mg/100g for (10Nx10) and 67.74 mg/100g for (10Ne10). After 2 minutes of cooking the rate of degradation of vitamin C was 96.4% for 10Nx10 and

95.51 for 10Ne10 compared to the rate of vitamin C in the flour. This degradation have reached 99% after 20 minutes of cooking. The ascorbic acid or vitamin C in the porridge decreased when the cooking time increased.

Table 1:- Heat degradation of vitamin C in porridges.

Cooking time (min)	Vit C (10Nx10) _i = 66.67 ± 2.01 mg		Vit C (10Ne10) _i = 67.74 ± 1.00 mg	
	Vit C in porridges 10Nx10 (mg)	Deterioration rate (%)	Vit C in porridges 10Ne10 (mg)	Deterioration rate (%)
2min	2.64 ± 0.63	96.04	3.04 ± 0.59	95.51
3min	2.64 ± 0.45	96.04	2.84 ± 0.36	95.81
5min	1.75 ± 0.21	97.37	1.80 ± 0.30	97.34
7min	1.75 ± 0.10	97.37	1.75 ± 0.16	97.42
10min	1.31 ± 0.31	98.03	1.40 ± 0.22	97.93
12min	1.20 ± 0.27	98.20	1.31 ± 0.32	98.07
15min	0.88 ± 0.61	98.68	0.95 ± 0.51	98.60
20min	0.50 ± 0.52	99.25	0.40 ± 0.26	99.41

Effect of cooling on vitamin C degradation

Table 2 shows the effect of cooling on the degradation of vitamin C in baobab pulp introduced after cooking the porridges enriched with parkia pulp 10 %. The cooking temperature varies between 85 and 95°C. For the cooking temperature (94-95°C), the degradation of vitamin C was 96%. After 10 minutes of cooling the degradation dropped from 96.04 % to 21.70 % for 10Nx10 and from 96.38 % to 10.98 % for 10Ne10 flour. Figure 2 shows that the rate of vitamin C in the porridge increases when the temperature decreases. At 60-80°C the porridge contained 52.20 ± 0.37 mg of vitamin C for 10Nx10 and 60.30 ± 0.67 mg for 10Ne10 when the baobab pulp was added after 10 minutes of cooling.

Table 2:- Effect of cooling before the introduction of baobab pulp on vitamin C degradation.

Cooking time (min)	Vit C (10Nx10) _i = 66.67 ± 2.01 mg		Vit C (10Ne10) _i = 67.74 ± 1.00 mg	
	Vit C in porridges 10Nx10 (mg)	Deterioration rate (%)	Vit C in porridges 10Ne10 (mg)	Deterioration rate (%)
0min (94-95°C)	2.44 ± 0.33	96.34	2.45 ± 0.62	96.38
3min (91-93°C)	5.84 ± 0.41	92.24	7.50 ± 0.43	88.93
5min (90-92°C)	20.50 ± 0.27	69.25	30.25 ± 0.20	55.34
7min (80-90°C)	35.7 ± 0.19	46.45	47.50 ± 0.26	29.88
10min (60-80°C)	52.20 ± 0.37	21.70	60.30 ± 0.67	10.98

Discussion:-

The results show the degradation of vitamin C by heat. The ascorbic acid (vitamin C) content in flours ranged from 66.67 mg/100g (10Nx10) to 67.74 mg/100g (10Ne10). The initial level of vitamin C in baobab pulp before it was incorporated into the flours at 10% was 265.88 mg/100g. This rate of the ascorbic acid of baobab fruit pulp is close to 300 mg/100 g found by Nour in 1980 (Nour, 1980). This slight decrease is due to the progressive degradation of vitamin C during storage and preservation either by light or heat (temperature) (Abioye et al., 2013).

Vitamin C is also known as the vitamin of fresh fruits and vegetables highly soluble in water and more easily destroyed than any other vitamin. It is easily oxidized and destroyed by heat and the presence of alkali. It is lost when food is dehydrated (Sunetra, 2018). The human body cannot synthesize vitamin C. Its presence in the body depend more on the diet and it is important for many metabolisms in the body. This study focuses on the production of hemoglobin by helping the body to absorb iron from food (non-heminic iron) (Sunetra, 2018).

This work has allowed us to increase the vitamin C content in flours to improve the assimilation of the non-heminic iron in flours Nutrimix 2 and Nutrine in order to fight anemia in children, pregnant or lactating women. The flours produced by ITRA had no vitamin C. In this study, the vitamin C content is 66.67 mg for Nutrimix flour (10Nx10) and 67.74 mg for Nutrine flour (10Ne10). These have been enriched with baobab pulp (10%) and parkia pulp (10%).

The greatest destruction of ascorbic acid or vitamin C occurs at temperatures of 85 to 95°C. After 2 minutes of cooking time the two kinds of porridges lost more than 95 % of their content of vitamin C. The initial value decreases from 66.67 mg to 2.64 mg for 10Nx10 flour. It decreases from 67.74 mg to 3.04 mg for 10Ne 10 flour. In 2014 Donkor and al have also shown the degradation of vitamin C in baobab pulp from 29.99 mg to 10.67 after 1 hour of time at 80°C (Donkor et al., 2014). Their results confirm the degradation of vitamin C by heat. Abioye and al in their study in 2013, demonstrated the effect of pasteurization on the degradation of vitamin C in baobab pulp drinks. Their work confirm our results and show a high destruction of vitamin C between 80 and 90°C (Abioye et al., 2013).

The analysis of the preservation of vitamin C by a progressive decrease of temperature by effet of cooling of the porridges, shows a slight degradation after 10 minutes of cooling when the temperature is between 60 and 80°C. The initial values of porridges have been decreased from 66.67 mg to 52.20 mg for 10NX10 and from 67.74 mg to 60.30 mg for 10Ne10.

These results on the degradation of vitamin C, allowed to set up a new production flowchart for preparation of enriched flours in ascorbic acid or vitamin C with baobab and parkia pulp.

Conclusion:-

The influence of cooking temperature on vitamin C degradation was evaluated in this study. The heat destroys almost all the vitamin C contained in the flours during the preparation of the porridges at temperatures of 85 to 95°C, especially after 10 minutes of cooking time. It becomes necessary to incorporate the baobab pulp rich in vitamin C only after preparation and cooling of the porridges between 60 and 80°C to avoid a total degradation of this vitamin.

References:-

1. Abioye, A.O., Abioye, V.F., Ade-Omowaye, B.I.O., Adedeji, A.A., 2013. Kinetic modeling of ascorbic acid loss in baobab drink at pasteurization and storage temperatures. *IOSR J. Environ. Sci. Toxicol. Food Technol. IOSR-JESTFT* 7, 17–23.
2. Bouka Goto, C.E., Bangana, A., Sidi-Touré, S., 2015. Fortification of baby with local foodstuffs, in: *Grains for Feeding the World*. Presented at the EXPO MILANO 2015, Le Università per expo 2015, Comitato Scientifico Del Comune Di Milano, Milan, Italie, pp. 29–34.
3. Diouf, S., Folquet, M., Mbofung, K., Ndiaye, O., Brou, K., Dupont, C., N'dri, D., Vuillerod, M., Azaïs-Braesco, V., Tetanye, E., 2015. Prévalence et déterminants de l'anémie chez le jeune enfant en Afrique francophone – Implication de la carence en fer. /data/revues/0929693X/v22i11/S0929693X15003267/.
4. Donkor, A.-M., Tei, M., Suurbaar, J., Yakubu, A., Addae, D., 2014. Stability evaluation and degradation kinetics of ascorbic acid in baobab fruit pulp formulated with the seed oil.
5. FAO, 2019. State of food security and nutrition in the world 2019: safeguarding against economic slowdowns... and downturns. *FOOD & AGRICULTURE ORG, S.I.*
6. Fellers, P.J., 1988. Shelf life and quality of freshly squeezed, unpasteurized, polyethylene-bottled citrus juice. *J. Food Sci.* 53(6), 1699–1702.
7. Fennema, O., 1977. Loss of vitamins in fresh and frozen foods. *FoodTechnology* 31(12), 32 – 38.
8. Gordon, L.R., Samaniego-Esguerra, M.C., 1990. Effect of soluble solids and temperature on ascorbic acid degradation in lemon juice stored in glass bottles. *J. Food Qual.* 13, 361–374.
9. Huelin, F.E., 1953. Studies on the anaerobic decomposition of ascorbic acid. *Food Res.* 18, 633 – 639.
10. Johnson, J.R., Braddock, R.J., Chen, C.S., 1995. Kinetics of ascorbic acid loss and nonenzymatic browning in orange juice serum: Experimental rate constants. *J. Food Sci.* 60(3), 502–505.
11. Lee, H.S., Coates, G.A., 1999. Vitamin C in frozen, fresh squeezed, unpasteurized, polyethylene-bottled orange juice: A storage study. *Food Chem.* 65, 165 –168.
12. Lee, H.S., Nagy, S., 1988. Quality changes and nonenzymatic browning intermediates in grapefruit juice during storage. *J. Food Sci.* 53(1), 168–171.
13. MS, Ministère de la Santé, 2012. Le Plan Stratégique National pour l'Alimentation et la Nutrition (PSNAN) <https://www.afro.who.int/fr/news/le-plan-strategique-national-pour-l'alimentation-et-la-nutrition-psnan-valide> (accessed 9.19.19).
14. Nicoletti, J.F., Silveira-Júnior, V., Telis-Romero, J., Telis, V.R.N., 2007. Influence of drying conditions on ascorbic acid during convective drying of whole persimmons. *Dry. Technol. Int. J.* 25(5), 691 – 899.
15. Nour, A.A., 1980. Chemical composition of baobab fruit (*Adansoniadigitata* L.). *Trop Sci* 22, 383–388.

16. Nutrition W.P., 1998. Complementary feeding of young children in developing countries : a review of current scientific knowledge.
17. Robertson, G.L., Samaniego, C.M.L., 1986. Effect of initial dissolved oxygen levels on the degradation of ascorbic acid and the browning of lemon juice during storage. *J. Food Sci.* 51(1), 184 –187.
18. Smith, G.C., Clegg, M.S., Keen, C.L., Grivetti, L.E., 1996. Mineral values of selected plant foods common to southern Burkina Faso and to Niamey, Niger, West Africa. *Int. J. Food Sci. Nutr.* 47, 41–53.
19. Solomon, O., Svanberg, U., Sahlström, A., 1995. Effect of oxygen and fluorescent light on the quality of orange juice during storage at 8 oC. *Food Chem.* 53, 363–368.
20. SUN, 2017. Annual Progress Report 2017. The Scaling Up Nutrition (SUN) Movement.
21. Sunetra, R., 2018. Vitamins, in: *Food Science and Nutrition*. New Delhi, India, pp. 297–310.