International Journal of Sciences

Research Article Volume 5 – April 2016 (04)

A Complementary Food Formulation from Local Products and Exclusive Use of Watermelon (*Citrullus lanatus* (Thunb.) Juice for the Cooking: Nutritional and Health Interest

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Abstract: Malnutrition and diarrheal foodborne diseases that affect children at weaning age are public health problems in developing countries. The objective of this study was to formulate a nutritious complementary food (CF) from available local products and investigate the potential of watermelon juice as alternative to contaminated cooking water as a means of preventing diarrhea and associated malnutrition. Three CF were cooked as follows: the first (CF1) "control" with water, the second (CF2) with "Kaolack" watermelon juice and the third (CF3) with "Koloss" watermelon juice. Carbohydrate content was increased (81.20 ± 0.81g/100g and 75.81 ±1.54 g /100g dry weight), respectively in CF2 and CF3 samples compared with CF1 (46.23 ± 1.30 g /100g dw). The fat level of CF1 (13.44 ± 0.94 g/100g dw) was higher than CF2 (9.53 ± 0.27g/100g dw) and CF3 (7.54 ± 0.36 g/100g dw). The protein levels of CF1, CF2 and CF3 were respectively 34.51 ± 1.30 g/100g dw, 30.08 ±0.54 g/100g dw, 26.83 ± 0.20 g/100g dw. L-citrulline contents were increased in CF2 (209.54 ± 0.21 mg/100g dw) and CF3 (212.43 ± 1.14 mg/100g dw) when compared to CF1 (39.35± 0.15 mg/100g dw) sample. All protein contents were sufficient and above the recommended value of 1.7 g/100 kcal (WHO/FAO/UNU (2002). Energy content met expectations, with CF2 (530.89 ± 7.83 Kacl/100g) and CF3 (478.42 ± 10.2 Kacl/100g) energy contents were higher than CF1 (443.92 ± 18.86 Kacl/100g) and could help reach the WHO energy recommended daily allowance for weaning food. CF2 and CF3 contained more calcium, magnesium, phosphorus, potassium and iron than CF1. Calcium, magnesium and iron contents were far above recommended levels. Also, this study showed that it is possible to have concomitantly adequate energy density and a thin complementary food viscosity when it is cooked exclusively with watermelon juice.

Keywords: Malnutrition, Diarrhea, Children, Complementary food, Water contamination, Watermelon juice, Cooking

1. Introduction

Malnutrition is a public health problem in developing countries, (Amankwah et al., 2009; Elenga et al., 2012 : Houndji et al., 2013 ; Sanoussi et al., 2013), and is one of the major causes of mortality among children under 5 years of age (Elenga et al., 2009). Inadequate feeding practices and undiversified complementary feeding during the weaning period are two of various determinants of chronic child malnutrition (Houndji et al., 2013). The progressive weaning is the transitional period during which, child gradually abandons breast milk in favor of more or less solid foods (WHO, 1998 ; Chaudhry et Humayun., 2OO7 ; Onweluzo and Nwabugwu., 2009 ; Haque et al., 2013 ; Kavitha and Parimalavalli., 2014). Breast milk should be the only food for the first 4 to 6 months of child's life, after this period it becomes insufficient to maintain the

Published at: http://www.ijsciences.com/pub/issue/2016-04/
DOI: 10.18483/ijSci.996; Online ISSN: 2305-3925; Print ISSN: 2410-4477

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growth and development requirements (Kikafunda et al., 2003). Complementary foods (CF) need to be introduced in a child's diet after 6 months while continuing breast feeding up to 24 months. The weaning period is the most critical period in a child's life, as children transfer from nutritious and uncontaminated breast milk to the regular family diet, and become vulnerable to malnutrition and disease (Oyarekua., 2011), as traditional infant foods made of cereals and tubers may be low in several nutrients (Sharma., 2013). In Africa, CF are generally cereal-flours porridges (Ikeh et al., 2001 ; Addis et al., 2013). However homemade porridge does not always provide needed essential nutrients (Monilola and Bukola., 2012). Inappropriate feeding practices are the most serious obstacles to maintaining the adequate nutritional status of child (Satter et al., 2013). Thus, in developing countries, several experiments were conducted in order to improve the nutritional value of CF by adding other ingredients such as peanuts, cowpea, eggs (Ikeh et al., 2001), fruits and vegetables.

Foodborne diseases are a worldwide health problem largely attributed to microbiological, parasitic, or chemical contamination (Ismail et al., 2008; Aidoo et al., 2011; Kalantari et al., 2011 ; Rahimi et al., 2013; Matug et al., 2015). According to the WHO/FAO (2007) powdered infant formula has been associated with serious illness and death in infants due to infections with *Enterobacter sakazakii*. During production, powdered infant formula can become contaminated with harmful bacteria, such as *Enterobacter sakazakii* and *Salmonella enterica*. CF, even if enriched, can be a cause of acute diarrhea in children due to the poor microbiological quality of water used during preparation (Iroegbu et al., 2000; Natasha et al., 2005; Potgieter et al., 2005 ; Rahimi et al., 2013). Diarrheal diseases are one of the causes of morbidity and mortality among children under five in developing countries, particularly in poor and low incomes households (Monte et al., 1997; Agustina et al., 2013 ; USAID/ WASH., 2013). CF can be contaminated by pathogenic micro-organisms such as *Streptococcus viridans*, *Staphylococcus aureus*, *Bacillus cereus*, *Campylobacte*r jejuni, *Salmonella enterica*., *Shigella ; Enterobacter sakazakii)* or intestinal parasites *Ascaris lumbricoides*, *Enterobius vermicularis*, *Entamoeba histolytica*, *Giardia intestinalis*, *Clostridium perfringens*, *Vibrio cholerae* (Motarjemi et al., 1993; Ikeh et al., 2001 ; Potgieter et al., 2005 ; Sheth and Dwivedi., 2006 ; Rahimi et al., 2013; Palmieri et al., 2015). Germs can be spread in water, by flies and usually, in rural areas, water from open wells, springs and rivers is used (UNDP/WHO, 1994). Using contaminated water for CF can cause diarrhea by germs from faeces entering the mouth. Thus, among curative means to fight against diarrheal foodborne diseases that affect children in weaning age, WHO recommends Oral Rehydration Salts (ORS) with zinc supplementation. But, the focus should be on preventive measures. Several ways to prevent microbiological contamination of CF also exist including the provision of safe water supplies and sanitation (Motarjemi et al., 1993) notably during cooking. Nevertheless, in many cases, water used to prepare CF is contaminated and the microbial risk is even higher than the cooking temperature does not sufficient (less than 70 °C) to eliminate pathogens germs (Omemu et Omeike., 2010).

Watermelon (*Citrullus lanatus*) is a naturally rich source of water (91.5 %) (Erhirhie and Ekene., 2013), lycopene, amino acids (L-citrulline, L-arginine) (Collins et al., 2007) and many nutrients (Perkins-Veazie et al., 2001; Arvy and Gallouin, 2007; El-Badry et al. 2014). Also, watermelon seeds are loaded in vitamin B, minerals (magnesium, potassium, sodium, copper, zinc) (Rimando et Perkins-Veazie., 2005) proteins and fats (Okokon et al., 2010).

The main objective of the present study was therefore to formulate a nutritious CF from available local products which are inexpensive and to test the use of watermelon juice as alternative to the contaminated water cooking in order to prevent diarrhea and associated malnutrition.

2. Materials and Methods

2.1. Plant material

2.1.1. Watermelons

Red-fleshed watermelons ("Kaolack" and "Kolloss" varieties) were grown from seed in greenhouses and seedlings transplanted one week after germination to the Senegalese's Agricultural Research Institute plots in Dakar (Senegal). At maturity, watermelons were harvested and stored in a cold place (at 15°C) for three days.

2.1.1.1. Preparation of watermelon juice

Each watermelon was gently and completely hollowed and all components of the fruit (flesh, peels, juice, and seeds) except rinds were collected. Content of each watermelon was labeled and placed in a polyethylene bag, samples were sealed and packed in another black plastic bag and frozen. After removing from storage, samples were brought to room temperature by holding for one day. Thawed samples were pureed until completely changed into juice.

2.1.2. Parboiled rice (*Oryza sativa*)

An irrigated paddy rice 'Sahel 108' newly harvested from the Senegal River Valley was used in this study. Paddy rice was parboiled with watermelon juice in order to enhance his nutritional value.

2.1.2.1. Parboiling process

Paddy rice was first cleaned by winnowing and then washed with water in order to remove impurities (stones, sand and other foreign bodies) and immature seeds. Washing of paddy rice was performed in a basin containing two (02) paddy volumes for three (03) volumes of water. Immature grains that floated to the surface and heavy stones that fell to the bottom by densimetric separation were removed using a sieve. Paddy rice was then drained for a few minutes with a stainless steel drainer. Washed paddy rice was spread on cotton gauze fabric laid on trays as a solar dryer and exposed to the sun until the moisture content was below 13%. After sun drying, rice was kept in bags to prevent contamination.

The parboiling process described by Houssou and Amonsou (2005) was followed in our study as the most appropriate to ensure a better quality of parboiled rice. The same steps and procedure described for conventional parboiling paddy rice were followed except the soaking water which was replaced by "Kaolack" watermelon juice. The study design consisted of a time/temperature combination where rice samples were parboiled to a temperature of 80^{0}C then allowed to soak in watermelon juice up to 18 h. Samples of 3 kg (compared to the average amount of a hulled rice family's daily intake) of paddy rice were soaked (using a butane gas heater) in a pot without a lid and containing watermelon juice slightly exceeding the level of rice and was stirred occasionally. Temperature was monitored using a thermometer and once the desired temperature was reached, the operation was stopped, and the pot was removed from the stove. The paddy rice was kept in the covered pot and placed at room temperature (average 27°C) for 18h, the soaking time programmed to allow cooling overnight and migration of some nutrients inside seeds. Preheating and soaking operations were performed in early afternoon in order to obtain soaking time indicated and start steaming operation, solar drying in the next morning. After 18h, paddy rice was removed from soaking watermelon juice then drained.

2.1.2.2. Steaming paddy rice

Steaming was done using a perforated steamer and a pot full of water. Paddy rice was poured into the steamer, covered with a transparent fabric and the whole was placed on the pot. The charged device was warmed up to the appearance of steam followed by the bursting of some paddy grains, about 25 to 30 minutes.

2.1.2.3. Sun drying and shelling of parboiled paddy rice

Parboiled paddy rice was spread on trays to solar dry (28 ^{0}C) for two hours, then dried in the shade in a ventilated storage (25^{0}C). This system reduced moisture content of paddy rice below 12% for its conservation and shelling. The steamed paddy rice was then dried at room temperature (25^{0}C). Samples were packed and stored (in a ventilated storage at 25^{0}C).
The parboiled paddy rice with watermelon juice was dehulled.

2.1.3. Pearl millet (*Pennisetum glaucum*)

Pearl millet was obtained from local market at Dakar the Capital of Senegal, was cleaned with a sifter equipped with two sieves of 1.5 mm and 1 mm hole size respectively. Pearl millet was husked for 3 min using a Sheller equipped with a semicircular bottom peeling chamber with new abrasive discs and a chamber grain segregation with a circular sieve with 0,8 mm mesh size. A dehulling rate of 80% was used. After shelling, decorticated kernels were cleaned three times with water before sun dried. Pearl millet was transformed to flour using a hammer mill equipped with a sieve of 0.5 mm mesh size. Then millet flour was roasted during for 10 min at 80°C using a roasting machine operating on gas combustion.

2.1.4 Peanuts (*Arachis hypogea*)

Peanuts were purchased from local market at Dakar and delicately screened by hand, then roasted. Peanut roasting was carried out using a cylindrical grill, having a drum inside with fixed metal blades and equipped with a gas burner, peanut seeds were permanently in rotation for 15 minutes. After roasting and air cooling, peanuts were dehulled and the thin layer that coats the seed and germ removed by hand, and the skinned and roasted seeds were ground.

2.1.5. Beans (*Phaseolus vulgaris*) and Fruit pulp Baobab (*Adansonia digitata*)

Beans were purchased from a local market and were soaked in water during 21 h in order to eliminate anti-nutritional factors. Then, beans were dehulled by hand and seed coats removed. Finally, they were spread on trays to solar dry. Dried beans were roasted as described above, transformed into flour and roasted. Baobab Fruit pulp was also purchased from local market at Dakar,

2.1.6. Carrot (*Daucus carota*) and Green onion (*Allium fistulosum*)

Carrots and green onions were soaked in bleach separately for 10 minutes, after they were washed in running water, rinsed, then drained. Carrot peel was removed using a Y-peeler, then sliced on a cutting board into pieces with a sharp chef's knife. Firstly, roots of the green onion were removed. Green onions were peeled and thinly sliced with a sharp cook's knife on a cutting board. Sliced carrots and green onion were spread on trays in a mixed solar-gas dryer during 24 h at 60°C, then transformed into flours.

2.2. Formulation of the complementary food

2.2.1. Cereals and legumes flours preparation

From cereal grains (millet, rice) and legumes (peanuts, beans) flours were processed using a mill with hammers fixed to a rotational speed of 3000 rev / min with a sieve of 0.5 mm mesh width.

2.2.2. Vegetables flours preparation

Dried pieces of carrots and onion were milled during 5 mn with a small kitchen mill and screened with a very fine silk fabric.

Table 1. Complementary food formula (per 100 g)

Ingredients	Pearl millet flour	*PRKWm flour	Beans flour	Peanut butter	Baobab Fruit Pulp	Carrot flour	Green onion flour	Salt
Quantities (g)	30	27	15	10	10	5	2	1

*PRWm : Parboiled rice with "Kaolack" watermelon juice

2.2.3. Ingredients blending

150 g of CF were developed after obtaining different flours. CF was processed by combining flours of millet, rice, bean, pulp baobab fruit, carrot, green onion and peanut butter and salt. The various ingredients were weighed and mixed homogeneously in a stainless kitchen blender according to well defined proportions (Table 1).

2.3. Cooking of the complementary food

Three CF were cooked as follows: One "control" with water as usual in households Senegalese and two with watermelon juice. One hundred and fifty (150) g of CF were divided into three batches of 50 g : The first batch (CF1) was the control, it was diluted with 250 mL of running water (RW) then cooked exclusively with 500 ml of RW, the second (CF2) one was diluted into 250 ml of "Kaolack" watermelon juice (KKWmJ) and exclusively cooked with 500 ml of KKWmJ, the third (CF3) was diluted with 250 ml of "Koloss" watermelon juice (KLWmJ) before being cooked exclusively with 500 ml of KLWmJ.

The three firings have been carried out simultaneously for 10 minutes. The cooking parameters are shown in figure 1.

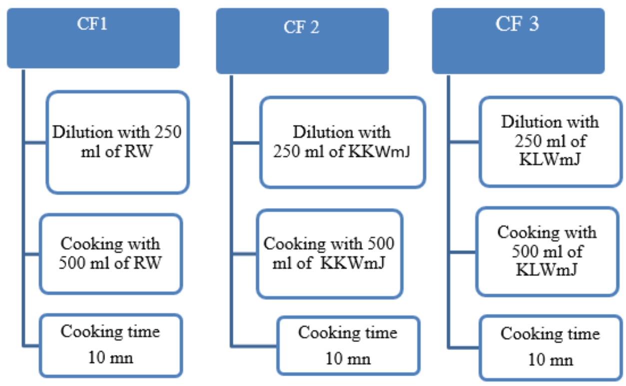

Figure 1: Cooking parameters of the CF1, CF2 and CF3

2.4. Chemical analysis

CF samples were analyzed for moisture, crude protein, crude fat, minerals (sodium, calcium, magnesium, phosphorus, potassium, iron) and amino acids (L-arginine, L-citrulline). Analysis were conducted at the " Laboratoire National d'Analyses et de Contrôle" in Dakar (Senegal) following NF EN ISO 20483, NF ISO 2911, NF EN ISO 3947, Régl (UE) No 1169/2011, ISO-712, NF EN 15505, NF EN 1134, NF EN 15505, NF EN 1136, NF EN 1134, NF EN 14084, NF EN ISO 13903, NF EN ISO 13903 respectively for proteins, carbohydrates, lipids, energy, water content, sodium, calcium, magnesium, phosphorus, potassium, iron, L-arginine and L-citrulline.

2.5. Microbiological analysis

Samples were collected immediately after cooking, placed in plastic sterile containers and transported to the laboratory. Microorganisms researched included the thermotolerant bacteria, *Escherichia coli (E. coli) and Salmonella* spp. commonly used as indicators of sanitary quality of water and foods. Microbiological analysis was performed using NF ISO 4832, NF ISO 16649-2, NF EN ISO 6579 methods respectively for thermotolerant bacteria, *E. coli* and *Salmonella* spp. All determinations were carried out in duplicate.

2.6. Viscosity measurement

Viscosities at different temperatures (50°C, 45°C, 40°C, 35°C, 30°C; 25°C) of CF1, CF2 were measured with a viscometer BRABENDER VISCOTRON values were calculated by using the following formula : Viscosity $\eta = ([B \times S \times K]/n)$ in which "B" represents a given range factor, it is equal to 3, "S" the digital display, "K" the calibration constant equals to 20,2 and "n" equals to 4 and represents the rpm (rounds per minute) of the inner cylinder. The reading value of "S" for each CF was performed after the displayed digits were stabilized and the viscosity was expressed as millipascals (mPa). At the end of cooking, CF1, CF2 and CF3 were left to cool at room temperature and measurements started at 50°C for each of them. The final or storage viscosity of each CF was measured at 25°C. The scale of viscosity reported by Gardner et al (2001) was used for the analyses and the CF viscosity were categorized into five groups: 500 mPa s (very thin), 500–1699 mPa s (thin), 1700–2899mPa s (medium), 2900–4000mPa s (thick), .4000 mPa s (very thick).

2.7. pH and °Brix measurement

The pH-value of different CF's was calculated by using a pH-meter Oakton high precision 0.05 PH Range 0~14 and °Brix were measured by using a °Brix meter Abbe Atago digital refractometer. To carry out °Brix measurements, a small amount of each CF was deposited on the prism with a pipette. At the start of next measurement, CF sample was removed from the prism using a soft cotton cloth and then rinsed with a little water.

Data analysis

Measurements were replicated twice and the data are presented as mean ± SD. Data related to CF viscosity were replicated in triplicate and statistical analyses were performed using Origin Pro version 8. Analysis of Variance ANOVA was conducted on the mean values to determine the significance of any differences between samples.

3. Results and Discussion

Results from chemical analysis are presented in Table 2. Carbohydrate contents were increased (81.20 ± 0.81g /100g and 75.81 ±1.54 g /100g dry weight), respectively in CF2 and CF3 samples compared with CF1 (46.23 ± 1.30 g /100g dry weight). These results suggest that cooking CF with watermelon juice could enhance the carbohydrates level of weaning food and consequently could help to reach the WHO energy recommended daily allowance for weaning food. The higher carbohydrate content of CF2 and CF3 samples can be explained by use of watermelon juice. Erhirhie et Ekene. (2013) reported that watermelon contains 7.2 g per 100 g of carbohydrates. Consequently, cooking CF with watermelon juice helps to increase the energy density of CF particularly where complementary foods given to children does not cover their needs.

The fat level of CF1 (13.44 ± 0.94 g/100g dry weight) was higher than CF2 (9.53 ± 0.27g/100g dry weight) and CF3 (7.54 ± 0.36 g/100g dry weight). The proteins levels of CF1, CF2 and CF3 were 34.51 ± 1.30 g/100g dry weight, 30.08 ±0.54 g/100g dry weight, 26.83 ± 0.20 g/100g dry weight. Unexpectedly, CF2 and CF3 cooked with watermelon juice had less fats and proteins contents compare to CF1 although using watermelon juice for cooking should increase fats and proteins. These differences could be attributed to Maillard reactions; under the action of protease enzymes provided by the watermelon juice, some proteins have been predigested, with a increased of free amino acids, which could react with other components (sugar particularly) to form unavailable nitrogen compounds. It is possible that thermal cooking of CF2 and CF3 may cause more Maillard reaction products than CF1 because of enzymes in the fruit juice and free amino acid (Kumar, 2015). So, future research should be done in order to investigate causes of the difference between fats and proteins content among CF1, CF2 and CF3. However, protein contents in all CF were sufficient and were above the recommended value of 1.7 g/100 kcal (WHO/FAO/UNU (2002). In contrast, fat contents did not meet the recommendation from 30-40 % of energy (FAO/WHO, 2008) but may predict a positive effect related to childhood obesity prevention as increased consumption of energy-dense diets high in fat is one of the obesity causes in children people which brings a number of additional problems (hyperinsulinaemia, poor glucose tolerance and a raised risk of type 2 diabetes etc.) (Lobstein et al., 2004).

L-arginine content of CF1 (1808.37 ± 0.15 mg/100g dry weight) was higher than CF2 (1220.28±1.36 mg/100g dry weight) and CF3 (1271.07 ± 2.54 mg/100g dry weight) but all were high indicating that CF1, CF2, CF3 could be an important source of L-arginine in critically ill infants. In fact, L-arginine is considered an essential amino acid in children with or with increased metabolic needs (De Betue et al., 2013). In contrast, L-citrulline contents were increased in CF2 (209.54 ± 0.21 mg/100g dry weight) and CF3 (212.43 ± 1.14 mg/100g dry weight) when compared to CF1 (39.35± 0.15 mg/100g dry weight). L-citrulline content of CF1 came from PRKWm an ingredient that represents 27% of the CF, while L-citrulline contents of CF2 and CF3 were from **P**RKWm, KKWmJ and KLWmJ respectively used in dilution and cooking. To our knowledge, this is the first study that shows an increase in L-citrulline and L-arginine in CF using watermelon juice for the cooking. Several studies have found that L-citrulline administration using watermelon puree or juice was associated with increased plasma concentrations of L-citrulline and metabolically related amino acids such as L-arginine ((Moinard et al., 2008; Schwedhelm et al., 2008). These results suggest that CF cooked with watermelon juice could be a means to increase plasma concentration of L-citrulline and L-arginine. In addition, our previous study demonstrated that rice parboiled with watermelon juice could be a good food vehicle for L-citrulline and L-arginine. In consequence, an adequate consumption of this food may increase plasma L-citrulline, and a means of slowing or preventing sarcopenia for elderly people in a context of poor access to pharmaceutical supplements (Sadji et al., 2015). That is why using parboiled rice with watermelon juice in complementary food presents a nutritional and health interest in weaning or aging. Furthermore, it has been demonstrated that plasma concentration of L-arginine and L-citrulline are low during illness in children and normalize again after recovery. Plasma L-arginine and L-citrulline are strongly related to the severity of inflammation indicated by plasma CRP concentration (Van Waardenburg et al., 2007). Also, it is necessary to increase consumption level of these amino acids in illness situations. Hence we recommend consumption of CF cooked with watermelon juice that could be used for undernourished or ill children. The results are consistent with expectations, in fact, CF2 (530.89 ± 7.83 Kacl/100g) and CF3 (478.42 ± 10.2 Kacl/100g) energy contents were higher than CF1 (443.92 ± 18.86 Kacl/100g). Cooking CF with KK watermelon juice brings more energy compare to CF1 or CF3, but consumption each of them only two times daily should allow children from 6 to 23 months of age to meet energy requirements. This is especially true given that the Codex Alimentarius (2008) recommends 2, 3, 4 or 5 daily feeding frequency, Energy intake among young children is often limited because of reduced stomach size (30-40 ml/kg) that prevents them from meeting their energy requirements if they are eating a low-energy density diet (Monte and Giugliani., 2004; Mouquet, et al., 1998). According to the Codex Alimentarius (2008), in developing countries, energy needs from complementary foods ranged from 200-550 Kcal and 600-900 Kcal per day for breastfed and not breastfed respectively. A breastfed child 6-8, 9-11 and 12-23 months of age needs 200, 300, 550 kcal per day respectively; while not breastfed 6-8, 9-11 and 12-23 months of age needs 600, 700, 900 kcal per day respectively.

Sodium contents of CF2 (143.51 ± 0.16 mg /100g dry weight) and CF3 (122.32 ± 0.10 mg /100 g dry weight) are lower than CF1 (149.7 ± 1.56 mg /100g dry weight).

This difference could be explained by the quantity of sodium water used for cooking CF1 on the one hand and by KKWmJ or KLWM on the other. Calcium, magnesium, phosphorus, potassium and iron values were respectively 445.13 ± 0.36 mg/100g dry weight; 55.39 ± 0.26 mg/100g dry weight; 83.56 ± 0.26 mg/100g dry weight; 568.06 ± 2.9 mg/100g dry weight; 2.93 ± 0.10 mg /100g dry weight in CF1. They were respectively 463.57 ± 0.43 mg/100g dry weight, 57.68 ± 0.16 mg/100g dry weight, 209.43 ± 2.51 mg/100g dry weight; 752.99 ± 0.71 mg/100g dry weight; 4.08 ± 0.10 mg/100g dry weight for CF2 and 449.01 ±0.25 mg/100g dry weight; 58.58 ± 0.25 mg/100g dry weight; 201.09 ± 2 mg/100g dry weight; 731.52 ±5.19 mg/100g dry weight; 4.37 ± 0.10 mg/100g dry weight for CF3. The high phosphorus and potassium contents of CF2 (209.43 ± 2.51 ; 752.99 ± 0.71 mg/100g dry weight) and CF3 (201.09 ± 2 ; 731.52 ± 5.19 mg/100g dry weight) were contributed respectively by KKWmJ and KLWmJ used for their dilution and cooking. However, even both are interesting from the point of view of mineral intake, cooking CF with KKWmJ brings more calcium, sodium, phosphorus and potassium than KLWmJ, also, iron contents of CF2 and CF3 were almost twice higher than CF1. If we consider, FAO/WHO (2001) calcium (400 mg /day), magnesium (54 mg/day), iron (0.7-0.9 mg/day) recommended intake for children, CF1, CF2, CF3 contents of those minerals were far above recommended levels.

In this study, results showed that cooking CF with watermelon juice could help increase calcium, magnesium, phosphorus, potassium and iron. These minerals play an important function in human metabolism especially in the growth of infants and young children. For example, calcium provides rigidity to the skeleton, and is essential for bone growth as it is required for the mineralization of bone (WHO/FAO, 2004). Theobald (2005) reported that diets containing insufficient amounts of calcium may lead to a low bone mineral density, which may have implications for bone health. Phosphorus intake is necessary for bone growth and mineralization, (Takeda et al., 2014; Lee et al. 2014; Heaney, 2009) also, dairy consumption has been positively linked to bone health (Takeda et al., 2014).

As indicated by the Pan American Health Organization (PAH) and the WHO (2001), during the first two years of life, nutrient needs of children are very high because of the rapid rate of growth and development. Therefore, according to PAH/WHO (2001) the period from birth to two years of age is a "critical window" for the promotion of optimal growth, health and behavioral development. Complementary foods should have sufficient energy and nutrients to cover infants' needs WHO (2001). Then, cooking with watermelon juice could a means to boost nutrients in complementary foods.

Results from microbiological analysis are given in Table 3. *Salmonella* spp was not present in any of the CF, also levels of *Escherichia coli* and Thermotolerant coliforms were conform to referenced Standards (NF ISO 16649-2 and GRET/ORSTOM). This can be explained by the hygienic quality of raw materials, the use of good hygiene practice during the preparation of CF but also by the fact that they have an acidic pH. The pH of CF could be due to the contribution of powder baobab fruit. Indeed Cisse et al (2009) reported that the beverage obtained from the pulp of the baobab fruit has a pH equal to 3.3. The acidity is a factor that limits the bacterial growth. It has been demonstrated that the proliferation of *Salmonella* spp can be reduced in an acidic medium (Diana et al., 2012 ; Skrivanova et al., 2006). The CF acidity in combination with heat cooking could slow or reduce the growth of *Salmonella* spp. Therefore the use of watermelon juice with a pH of 4.9 could be a means to control the microbial risk and diarrheal diseases that are high during the weaning period (Agustina et al., 2013) in developing countries. Authors of many studies reported contaminated food and water in transmitting diarrhoeal pathogens, especially contaminated food due to *Escherichia coli* (Potgieter,et al; 2005). It has been demonstrated that a high frequency of isolation of *Escherichia coli* was observed in a traditional maize-based weaning food in households using pipe-borne water in South Africa (Potgieter,et al; 2005). Therefore, watermelon juice can be used as an alternative to cook CF in case of absence of basic sanitation facilities in a low incomes households replacing contaminated water.
In this study, CF were not found to be contaminated with *Escherichia coli* another germ of impaired health quality of food products, this is very important because transmission of Enterotoxigenic *Escherichia coli* is known to be specifically associated with contaminated weaning foods among younger children in developing countries (Agustina et al.,2013).

In addition, thermotolerant Coliforms were less than 10/g. Accroding to the microbiological standards from the GRET and ORSTOM reported by Mouquet et al. (1998), total coliforms (number of cells per gram of flour) in infant flours requiring cooking should be less than 100. Then, the microbiological quality of CF1, CF2 and CF3 were acceptable.

The pH of CF are presented in Table 5, CF3 (4.9 ± 0.00) was more acid than CF2 (5.15 ± 0.05) and CF1 (5.13± 0.18), those values were under the optimum pH (7) growth of *Salmonella* spp. (FSAI., 2011; Viala et al., 2011).
The viscosities of porridge from CF are presented in Table 4. Different temperatures were used (25°C, 30°C, 35°C, 40°C, 45°C and 50°C). According to Trèche., (1996), CF with starchy foods that have not been subjected to a specific treatment before cooking, in order to modify the physicochemical properties of their starch, have a viscosity which increases very quickly according to their energy content. Then, our objectives were to investigate the direct effect of watermelon juice on cooked CF viscosity at temperatures ranging from 25°C to 50°C. The results showed that CF viscosity changes with temperature, CF2 and CF3 viscosities were more higher than CF1 whatever the temperature at which measurements were carried. Means of CF viscosity were significantly different (analysis of variance ANOVA $P < 0.05$), the viscosity of CF1 increased from high temperature (460.56 mPa at 50°C) to low temperature (652.96 mPa at 30°C and 668.11 mPa at 25°C), this means that as the temperature decreases, the more the viscosity increases. Amagloh et al. (2013), reported that complementary foods are usually left to cool between 40 and 45°C before served to infants. In this study, CF1 viscosity was thin (510.55 mPa at 40°C), very thin (481.77 mPa at 45°C) and particularly adapted to infants 6-8 months of age. The apparent viscosity of CF2 increased progressively from 1257.45mPa (at 50°C) to 1266.54 mPa (at 45°C). Unexpectedly from 45°C, instead of increasing the viscosity dropped from 1266.54 mPa to 925.66 mPa (35°C) , this is probably due to enzymatic action on starch. This finding may be explained by the fact that between 45°C and 40°C endogenous amylases from watermelon juice in this short time hydrolyzed the CF1 'starch as we could get with the malt addition (Srivastava et al., 2015; Kolawole and Kolawole., 2015 ; Sajilata et al., 2002), so the starch degradation would reduce viscosity before enzyme being inactivation. Thus, between 40°C and 35°C the viscosity of CF2 increased once more to 1278.66 mPa (at 35°C) and decreased slightly at 1266,54 mPa (30°C) then at 1257.45mPa (25°C). The increase in viscosity from 40°C to 35°C can be explained by the starch retrogradation that is a physico-chemical process that happens on cooling gelatinized starch pastes in which disaggregated amylose and amylopectin (starch molecules) chains reassociate to form more ordered structures (Wang et al., 2015 ; Tako et al., 2014;

Malumba et al., 2011). Consequently, starch retrogradation could be accompanied by an increased viscosity of foods (Wang et al., 2015; Tako et al., 2014; YU et al., 2014). According to Wang et al (2015), starch retrogradation is nutritionally desirable due to the slower enzymatic digestion of retrograded starch and moderated release of glucose into the cardiovascular system. Therefore, this study highlighted the interesting fact that was also noted with CF3 between 40°C and 35 °C: a viscosity inversely proportional to temperature occurred during the cooling when complementary foods were cooked using watermelon juice. The decrease of viscosity observed in CF3 was less compared to CF2, this difference could be explained by the nature and quantity of activated amylases because amylases from various sources degrade starch in a different mode of action (Bijttebier et al., 2008; Aiyer, 2005). It may be noted that the storage viscosity of CF3 (1265.02 mPa) at 25°C are similar to that of CF2 (1257.45 mPa), they were thin despite their considerable energy density and may be appropriate to infants 6-8 months of age in developing countries. The results suggested that it is possible to have concomitantly adequate energy density and a thin CF viscosity when it is cooked exclusively with watermelon juice. Then, cooking CF with watermelon juice could be used as alternative to the malting processing method that helps to reduce viscosity of bulky gruels due to amylolytic breack down of starch (Sajilata et al., 2002). However, further investigations should be done to understand the lowering effect of watermelon juice on complementary food viscosity.

°Brix measures the sugar content into CF1, CF2 and CF3, measurements were done at 70°C and values are presented in table 5. In comparison degrees of CF2 (11 °Brix) and CF3 (12°Brix) were twice higher than CF1 (5°Brix), consequently they contained more sucrose. This approach may give advantages because there is no need to add sugar to complementary foods cooked using watermelon juice

<u>Table</u> 2. Nutritional value (/100 g dry matter basis) of the Complementary foods

Complementary Food	Carbohydrate (g)	Fats (g)	Proteins (g)	Sodium (mg)	Calcium (mg	Magnesium (mg)	Phosphorus (mg)	Potassium (mg)	Iron (mg)	L-Arginine (mg)	L-Citrulline (mg)	Energy (Kcal)
CF1	46.23 ± 1.30	13.44 ± O.94	34.51 ± 1.30	149.7 ± 1.56	445.13 ± 0.36	55.39 ± 0.26	83.56 ± 0.26	568.06 ± 2.9	2.93 ± 0.10	1808.37 ± 2.6	39.35 ± 0.15	443.92 ± 18.86
CF2	81.20 ± 0.81	9.53 ± O.27	30.08 ±0.54	143.51 ± 0.16	463.57 ± 0.43	57.68 ± 0.16	209.43 ± 2.51	752.99 ± 0.71	4.08 ± 0.10	1220.28 ± 1.36	209.54 ± 0.21	530.89 ± 7.83
CF3	75.81 ±1.54	7.54 ± 0.36	26.83 ± 0.20	122.32 ± 0.10	449.01 ±0.25	58.58 ±0.25	201.09 ± 2	731.52 ±5.19	4.37 ± 0.10	1 271.07 ± 2.54	212.43 ± 1.14	478.42 ± 10.2

Values are means ± standard deviation for 2 repetitions

Table 3: Microbiological quality of the Complementary foods

Micro-organisms	CF1	CF2	CF3	Reference value (unit)	Reference method used
Therm Coliforms	< 10 g	< 10 g	< 10 g	< 1g	NF ISO 4832
E. coli	< 1 g	< 1 g	< 1 g	< 1 g	NF ISO 16649-2
Salmonella spp.	0 /25g	0/25g	0/25g	0/25g	NF EN ISO 6579

0: signifies an absence of *Salmonella* spp. ; therm Coliforms = thermotolerant Coliforms

Table 4: Viscosity of CF1, CF2, CF3 depending on temperatures

Températures (°C)	50	45	40	35	30	25
CF1 viscosity (mpas)	460.56 ±16.66	481.77 ± 1.51	510.55 ± 1.51	612.06 ± 4.54	652.96 ± 1.51	668.11 ± 0.75
CF2 viscosity (mpas)	1169.58 ± 7.57	1339.26 ± 15.15	925.66 ± 15.15	1278.66 ± 1.51	1266.54 ± 9.09	1257.45 ± 6.06
CF3 viscosity (mpa)	951.42 ± 7.57	963.54 ± 6.06	1313.50 ± 18.16	1236.24 ± 3.03	1263.51 ± 6.06	1265.02 ±3.03

Values are means ± standard deviation for 3 repetitions

Table 5: Values of pH and °Brix for CF1, CF2 and CF3

Parameters	CF1	CF2	CF3
pH	5.13 ± 0.18	5.15 ± 0.05	4.9± 0.00
°Brix	5	11	12

3. Conclusion

This paper demonstrates the possible functionality and use of watermelon juice in weaning food formulation for preventing infant malnutrition. This new technique has several advantages, the results showed that cooking with watermelon juice could be a means to boost nutrients in complementary foods and there is no need to add sugar in it. The results also suggested that it is possible to have concomitantly adequate energy density and a thin complementary food viscosity when it is cooked exclusively with watermelon juice. At last, watermelon juice could be used as an alternative to cook complementary foods in case of absence of basic sanitation facilities in a low incomes households replacing contaminated water which lead to foodborne diseases. However, future research should be focused on the sensory evaluation with panelists in order to investigate if complementary foods cooked with watermelon juice will be liked.

Conflict of interest

The authors have no conflict of interest.

Acknowledgments

The authors would like to thank the West African Agricultural Productivity Program (WAAPP) and DFATD ex CIDA through the project "Enhancing food security in Africa through the improvement of rice post-harvest handling, marketing and the development of new rice-based products'' led by Africa Rice Center in collaboration with National Research Institutes (ISRA/ITA) and Mc Gill University.

The authors also gratefully acknowledge the valuable technical assistance of Prof Penelope Perkins-VEAZIE at Plant for Human Health Institute (USA), Aïssatou Ngom NDIAYE, Nogaye Cissé DIA, Dr Lat Souk TOUNKARA, Dr Cheikh BEYE, Dr Nafissatou Diop NDIAYE, Noêl DIANDY at Institut de Technologie Alimentaire (Dakar-Senegal).

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