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Development and quality evaluation of healthy soup for children making from banana and other vegetables

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Abstract

Along with animal food sources, fruits and vegetables are also an important source of nutrients, adding abundant vitamins, minerals for the growth of children. This study used the "Xiêm" banana variety in combination with other vegetable sources to produce convenient and diverse sources of nutrients for children. The quality of bananas at three levels (more than 70% yellow on surface, fully yellow, yellow with some brown spots) was evaluated and the effect of blanching time on the quality of ingredients used for the recipes was investigated. Eight soup mixtures of banana and other vegetables were prepared. The product quality was assessed through chemical, energy and sensory analysis. It was observed that fully ripe yellow "Xiem" bananas had a few brown spots containing high levels of nutrients. A 5-min blanching time was suitable for raw materials, which inactivated the enzyme and achieved good structure and bright color. Based on chemical, energy value and distribution, together with sensory analysis, a formula containing 30% banana, 18% potato, 5% yellow flesh sweet potato, 12% fat filled milk powder, 5% plant-based organic protein, 9% carrot, 8% pumpkin, 3% spinach, and 10% green pea was selected with supplied energy 57 kcal/100 g product. The product had macronutrient proportions that were within the Acceptable Macronutrient Distribution Range (energy distribution of carbohydrates, protein and lipid was 65, 14 and 21%) recommended in the Dietary Reference Intakes. These soup mixtures with high acceptability and quality can provide children with a high fraction of their requirements from nutrients, especially supplementing fiber in the diet.

Keywords: "Xiêm" banana variety, Blanching, Healthy soup, Quality, Vegetables

1. Introduction

A child's development is greatly influenced by nutrition. As children get older, they form eating habits that will follow them for the rest of their lives. Encouraging healthy food choices is a good way to start developing healthy eating habits that they will follow as adults. The correlation between nutrients, food and diet is important, especially in the prevention and avoidance of chronic diseases [1]. Usually in the Vietnamese diet, too much meat is consumed, whereas little or not enough vegetables are included. The amount of vegetables used is estimated to be about half of that recommended by the World Health Organization. Therefore, community nutrition intervention programs are implemented with the aim of reducing malnutrition in rural children and also reducing the rate of weight gain and obesity among children living in urban areas. In addition, most children rarely use and often feel uncomfortable with vegetables in meals. As a result, they are often at risk of nutrient deficiencies. Fruits and vegetables contain high amounts of minerals and vitamins, especially vitamin C. In addition, vegetables contain vitamin B9 and are a good source of fiber and potassium [2]. The phytochemicals in fruits and vegetables are believed to be important for health, potentially in reducing the risk of cardiovascular disease and preventing cancer. When vegetables are combined to form an attractive and delicious product, children are encouraged to eat them more, ensuring that children have enough sources of important nutrients for growth and development.

"Xiêm" bananas are grown over a very large area in Vietnam: it has high nutritional value, providing a good source of fiber, vitamins (vitamin C, vitamin B6) along with a source of minerals (potassium) and phytochemicals [3]. With readily available nutrients and sweet taste, bananas can be selected as the main food source to be incorporated in a nutritious diet and suitable for children's taste. Carrots are rich in natural bioactive compounds as phenolic compounds, carotenoids and ascorbic acid. These substances aid in reducing the risk of cancer and cardiovascular diseases due to their antioxidant, anti-inflammatory, plasma lipid-modifying and anti-tumor properties. High levels of α- and β-carotene are commonly present in carrots [4]. Pumpkin contains high levels of carotenoids, carbohydrates and minerals: bioactive components, such as polysaccharides, para-aminobenzoic acid, oils, sterols, proteins and peptides are also found in them. Eating pumpkin can help to prevent skin diseases, eye disorders, reduce cell damage in the body, cancer and improve immune function [5]. Potatoes are considered a source of energy from carbohydrates present, but low in fat, high in vitamin C and a good source of B vitamins, potassium and dietary fiber. The protein content in potatoes is quite low, but has a high biological value, the polyphenol content in potatoes contributes to antioxidant activity, which benefits health [6]. In addition, spinach is one of the most nutritious vegetables consumed worldwide [7], due to its excellent source of essential minerals, vitamins, protein, fiber and chlorophyll [8]. Scientific studies are increasingly providing evidence of the health benefits of eating spinach such as boosting human immunity levels [9]. Yellow sweet potato is widely used in the preparation of bread and pasta products, due to the health benefits of its bioactive compounds [10].

Fruits and vegetables are often blanched in processing to change the texture and inactivate enzymes. However, blanching easily leads to tissue cell damage and color loss due to heat treatment. Hot steam is considered an effective heat source for blanching, especially for mass production systems. This method is more advantageous than blanching in hot water, but if the processing time is prolonged, it can lead to significant changes, such as discoloration and loss of nutrients. At the same time, the product structure is also changed [11].

Research on forming healthy diets, that combine fruits and vegetables with natural colors (source of phytochemicals) and essential nutrients, is still limited in Vietnam. This research, which will support good health, especially for growth and immunity boosting of children, is a matter of concern today. New products can supplement many required nutrients for children, save a mother's preparation time and take advantage of micronutrients from abundant agricultural products, available in the country, in the most effective way. Faced with malnutrition, the priority for preschool children is to promote good nutrition and healthy eating habits, to address and prevent nutrient deficiencies, especially in the micronutrient group, and to ensure that no one is left behind. This project created healthy soups for children from bananas and other vegetables. The finished products were fully analyzed for necessary nutrients, high sensory values and especially the balanced nutritional components in one serving was carefully calculated.

2. Materials and methods

2.1 Materials

"Xiêm" bananas *(Musa acuminate)* were used as the main ingredient. The quality at three levels of ripening was determined, before making soups, including (A) 2/3 yellow (more than 70% yellow on surface), (B) ripe (fully yellow) and (C) overripe (yellow with some brown spots). Other vegetables such as carrot (*Daucuscarota subsp. sativus*), potato, pumpkin, yellow flesh sweet potato and spinach were bought at a local supermarket. The plant-based organic protein (Leanfit, Canada) and fat filled milk powder (28% of fat - Natur'lait, France) were also used.

2.2 Effect of steam blanching time on chemical and physical characteristics of vegetables used in nutritional soup recipes

Bananas, potatoes, carrots, pumpkin and yellow sweet potatoes were peeled, washed, sliced and blanched with steam at 100°C for blanching times from 3 to 9 min. After intervals, a sample was removed and cooled rapidly with cold water (5°C). The ability to inactivate oxidizing enzymes and some quality aspects (firmness and pectin content) were identified.

2.3 Preparation and formulation of healthy soup making from banana and other vegetables

The tested formulae are presented in Table 1. All ingredients were mixed to formulate eight soup mixtures. All blanched ingredients are pureed and combined with others ingredients to form a nutritious soup product. The soup was cooked at boiling temperature for 5 min. Then 200 g was poured into a glass bottle and sterilized at 105°C for a holding time of 5 min. The product is cooled rapidly after removal from the sterilizer (DGS-280C, China). The nutritional composition and sensory value of the products were analyzed. Total energy intake, energy balance and percent daily value (%DV) along with nutrition information were determined.

After formulation, the sample was sterilized at 105°C for 3, 5, 7 and 9 min. The sterilized product was stored at 28 ± 2°C for 4 months and analyzed for total viable counts, on a Plate Count Agar medium [12].

Table 1 Formulae of the healthy soups from banana and other vegetables.

Ingredients (%DV)	F1	F2	F3	F4	F5	F6	F7	F8
Banana	24	26	28	30	30	28	26	24
Potato	24	22	20	18	5	5	5	5
Yellow flesh sweet potato	5	5	5	5	18	20	22	24
Fat filled milk powder	12	12	12	12	12	12	12	12
Plant-based organic protein	5	5	5	5	5	5	5	5
Carrot	9	9	9	9	9	9	9	9
Pumpkin	8	8	8	8	8	8	8	8
Spinach	3	3	3	3	3	3	3	3
Green pea	10	10	10	10	10	10	10	10
Total	100	100	100	100	100	100	100	100

2.4 Quality analysis

The nutritional composition of materials and final products including fat, fiber and protein was determined by AOAC methods [12]. The total carbohydrate content was analyzed following McCseady [13] and Dubois et al. [14] The minerals - calcium, sodium and potassium - were measured by flame photometry [15]. The iron content was determined using a UV-Vis Spectrophotometer following Hailu et al. [16]. Peroxidase activity was determined at 25°C with guaiacol [17], In the presence of H_2O_2, peroxidase catalyses the transformation of guaiacol to Tetraguaiacol (brown product).

Vitamin C was determined by the indophenol method [18]. Total carotenoid analysis used a UV-Vis Spectrophotometer to measure absorbance at 450 nm [19]. Pectin was determined as described by Wang et al. [20].

Sterilization values at given temperatures and times were calculated as described by Doornmalen JPCM, Kopinga K [21].

2.5 Total calories (kcal) and % DV

The total calories of the product were determined based on the macronutrients: fat, protein, and carbohydrates, with fat at 9 kcal/g; protein and carbohydrates at 4 kcal/g [22]. The %DV listed on the Nutrition Facts label is a guide to the nutrients in a serving. This %DV is based on a 2,000-calorie diet for healthy adults. The %DV for each nutrient was calculated by dividing the amount of a nutrient in a serving by its daily value, and then multiplying that number by 100 [23].

2.6 Sensory evaluation

Sensory evaluation used a Quantitative Descriptive Analysis (QDA) method with 20 selected members. They were mothers with children between the ages of 1 and 5. These mothers fed their babies and based on how much their babies ate and how the mother felt about the product; they determined a score following our guidelines. The products were evaluated through different intensity sensory criteria on an intensity rating scale of 0 to 5 (where 0 = not detected and 5 was extremely strong).

2.7 Data analysis and sensory analysis

STATGRAPHICS Centurion XV (USA) software was used to analyze collected data for means and standard deviations. Principal component analysis (PCA), using XLSTAT software (2007, Addinsoft, New York), was used to analyse sensory data obtained.

3. Results and discussion

3.1 Banana quality according to ripeness

The chemical composition of the “Xiêm” bananas variety changed significantly during ripening from 2/3 yellow, ripe and overripe (Figure 1 and Table 2). The acid content in ripe bananas increased from 0.20 ± 0.01 to 0.27 ± 0.01% when the bananas turned from 2/3 yellow to ripe, then decreased to 0.25 ± 0.01 for overripe bananas (Table 2). It took 7 days stored at ambient temperature (28 ± 2°C) for "Xiêm" banana variety to reach the ripe (fully yellow) and 8 days to reach the overripe state, with some brown spots [24].

(A) (B) (C)

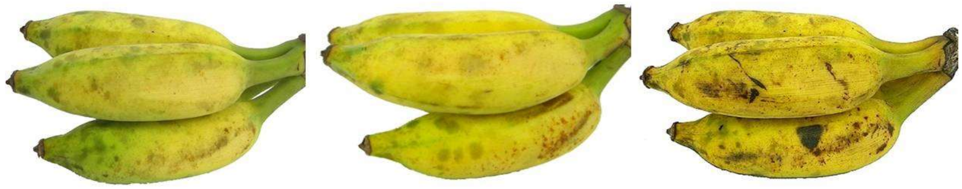

Figure 1 Three levels of ripeness of "Xiêm" bananas; (A) 2/3 yellow (more than 70% yellow), (B) Ripe (all yellow), and (C) Overripe (yellow with some brown spots).

Table 2 Chemical characteristics of "Xiêm" bananas at different ripeness levels (per 100 g).

Parameters	2/3 yellow	Ripe	Overripe
Acid content (g)	0.20±0.01*	0.27±0.01	0.25±0.01
Reducing sugar (g)	8.93±0.04	10.80±0.64	11.50±0.68
Starch (g)	11.81±0.98	1.84±0.12	0.55±0.01
°Brix	23.00±2.29	26.75±1.25	28.50±0.71
Vitamin C (mg)	9.50±0.42	8.70±0.04	8.20±0.23
β-carotene (μg)	343.28±1.77	294.87±2.35	298.65±3.48
Total polyphenol (mgGAE)	50.85±0.25	73.13±1.30	82.27±0.15
Potassium (mg)	282.57±3.25	376.14±2.89	380.05±4.75

*Values were expressed as mean ± standard deviation.

Our results were similar to a previous study: Chandra et al. reported that the concentrations of malic and citric acids in bananas increased and then began to decrease after they were fully ripe [25]. Adi et al. [26] reported that fruit acidity increased from stage 1 (0.06%) to stage 7 (0.29%), where it peaked during respiration, then decreased slightly at stage 8 and 9 (with 9 stages of ripening observed). The conversion of starch to sugar that occurs during ripening is related to the transformation of the fruit from an inedible state to a ready-to-eat state. Bananas contained 1.84±0.12% starch, when fully ripe, and 0.55±0.01% when overripe. The reducing sugar content was 8.93±0.04% when 2/3 ripe, rose to 10.80±0.68% when ripe and to 11.50±0.68 when overripe. The loss of pulp firmness was associated with an increase in reducing sugars and a decrease in starch content. Therefore, the total soluble solid content (°Brix) of banana in our study was found to be 26.75±1.25 at fully ripe and 28.50±0.71 when overripe. Although the vitamin C content decreased slightly with ripening, it still provides a part of vitamin C when used to prepare mixed dishes with concentrations between 8.20 0.23 when ripe to 8.7 ± 0.04 mg/100g when overripe. The total polyphenol compounds of was determined at 73.1±1.3 mg Gallic Acid Equivalent (GAE)/100 g when ripe and 82.3±0.1 mg GAE/100 g when overripe.

Our results were similar to those of Aquino et al. [27]: ripe fruit showed a greater increase in the content of phenolic compounds. Although fully ripe bananas are best eaten due to complete nutrient synthesis. However, with large banana production, the shelf-life can be prolonged and bananas may be overripe. Several studies have shown a positive and significant correlation between phenolic compounds content and antioxidant activities of fruits and vegetables [28]. When people consume 1.3 to 1.4 grams of potassium daily, they can reduce the risk of heart disease by 26% [29]. Ripe bananas also possess high levels of beta carotene, potassium and fiber (as indicated in the table). Nutritionally, fiber is important for digestion because it provides beneficial bacteria in the gut and can potentially help prevent blood sugar spikes after eating carbohydrate-rich meals. Both ripe yellow bananas and overripe ones can be used well to make nutritional products for children with many health benefits. The ingredients used to make the nutritious soup were also analyzed for macronutrients and fiber (Table 3).

Table 3 Macronutrients and fiber of fruits and vegetables used in soup formulae (per 100 g).

Ingredients	Carbohydrate (g)	Protein (g)	Lipid (g)	Fiber (g)
Fat filled milk powder	39.27±0.75	24.53±0.67	28.10± 0.36	0.00
Banana	23.97±0.15	0.80±0.10	0.25±0.00	2.20±0.02
Pumpkin	20.67±1.53	4.17±0.15	6.97±0.21	7.77±0.25
Spinach	4.08±0.10	2.85±0.05	0.43±0.06	2.53±0.06
Green pea	11.05±0.50	4.20±0.26	0.25±0.05	4.02±0.23
Potato	38.27±0.03	3.15±0.05	0.00	2.13±0.15
Yellow flesh sweet potato	21.80±0.20	1.52±0.49	0.00	3.20±0.10
Plant-based organic protein	7.00±0.00	21.40±0.10	0.00	4.97±0.06
Carrot	9.85±0.05	0.82±0.03	0.00	2.17±0.08

It was observed that that the ingredients used with high carbohydrate content included fat filled milk powder, potato, banana, yellow flesh sweet potato and pumpkin which ranged from 21% to 39%. The remaining ingredients constituted smaller proportions with concentrations ranging from 4% to 11%. High protein levels were found in fat filled milk powder and plant-based organic protein. Also, high lipid content was found in fat filled milk powder (28.1±0.4%) and pumpkin (7.0±0.2%). Other ingredients contained lower lipid content, ranging from 0.25 to 0.43%. Some vegetables and fruits had virtually no fat. Pumpkin and plant-based organic proteins contained high levels of fiber, 7.77±0.25% and 4.97±0.06%, respectively. These ingredients also contained a variety of vitamins, minerals, and bioactive compounds (as mentioned in the Introduction), so if they are combined in the diet, they will create a balanced and healthy nutritional food, which can be a supplement for children and others, to meet national community nutrition goals.

3.2 Effect of steam blanching on the physico-chemical properties of vegetables

Steam blanching not only destroys enzymes, that catalyze food spoilage and dehydrate vegetables and fruits, it also removes surface microorganisms, improves color and slows vitamin loss. In addition, blanching can soften the ingredients, facilitate fine grinding in the next step and increase the sensory value of the product when eaten. In our results, all materials that had been steam blanched had more attractive colors than untreated samples. The colours of carrots and pumpkin were lighter after the treatment compared to untreated sample. It could be suggested that blanching induces carotenoid isomerization that changes the structure from all trans to partially cis, creating a lighter hue. Severini et al. [30] showed that the green color in samples was increased when blanched with hot water and steam-similar to our results for spinach and peas. However, long-term blanching (9 min) tended to destroy color, nutrients and bioactive compounds. Hardness of the ingredients decreased with blanching time (3 to 9 min) (Table 4): the main reason was that insoluble protopectin were converted to soluble pectin. The reducing sugar content tended to decrease with blanching time from 3-9 min. The cause was probably the loss of solids with hot water blanching, that was mainly due to diffusion and leaching as explained by Mukherjee and Chattopadhyay [31]. The actual starch content was shown to be unaffected by steam blanching, with values being relatively stable for different blanching times. With blanching, starch gelatinizes and becomes more digestible [32].

Pectin has a great influence on the structure and is the determining factor in the consistency of nutritional products for children. The pectin content in all materials increased with blanching time (Table 4). PME in potato tissue was activated by heat during the first two min of blanching, and a longer heat treatment rapidly inactivated the enzymes in the vegetable tissue [33]. Protopectin in the raw material was converted to soluble pectin, which softens the product structure. Thus, the steam blanching of raw materials will lead to a soft structure and increase the amount of pectin needed. Further, peroxidase is the most thermostable enzyme in fruits and vegetables [34]. When blanching is adequate, enzymes are deactivated. Our data shows that steam blanching for 5 to 7 min led to visually attractive colors and peroxidase (POD) deactivation in all materials (Table 5).

Table 4 Effect of steam blanching time on quality of fruit and vegetables used for healthy soup making.

Raw materials	Blanching time (min)	Hardness (g force)	Starch (%)	Reducing sugar (%)	Pectin (%)
"Xiêm" banana	3	45.33^{d}	0.551^{a}	11.525^{d}	0.420^{a}
	5	33.00^{c}	0.551^{a}	11.330^{c}	0.513^{b}
	7	28.00^{b}	0.550^{a}	11.135^{b}	0.572^{c}
	9	18.33^{a}	0.551^{a}	10.981^{a}	0.616^{d}
Potato	3	764.67^{d}	14.204^{a}	3.332^{c}	0.387^{a}
	5	245.00^{c}	14.215^{a}	2.834^{b}	0.413^{b}
	7	182.67^{b}	14.193^{a}	2.755^{b}	0.433^{c}
	9	91.00^{a}	14.181^{a}	2.546^{a}	0.452^{d}
Yellow flesh sweet potato	3	880.67^{d}	24.550^{a}	6.256^{d}	0.381^{a}
	5	385.00^{c}	24.531^{a}	5.367^{c}	0.430^{b}
	7	257.33^{b}	24.550^{a}	4.770^{b}	0.482^{c}
	9	199.00^{a}	24.588^{a}	4.215^{a}	0.510^{d}
Pumpkin	3	333.33^{d}	1.815^{d}	1.317^{a}	1.815^{d}
	5	136.67^{c}	1.504^{c}	1.384^{b}	1.504^{c}
	7	98.67^{b}	1.430^{b}	1.423^{c}	1.430^{b}
	9	57.33^{a}	1.167^{a}	1.463^{d}	1.167^{a}

Means with different superscript letters in each column represent significant differences at a 95% confidence level.

Table 5 Effect of blanching time on peroxydase inactivation.

Blanching time (min)	Banana	Potato	Yellow flesh sweet potato	Pumpkin	Carrot
3	+	+	+	+	+
5	-	-	-	-	-
7	-	-	-	-	-
9	-	-	-	-	-

Note: (+) The enzyme was not inactivated and (-) the enzyme was deactivated.

However, to limit the long-term exposure to heat, 5 min of blanching was chosen to minimize thermal decomposition of the nutrients in the raw materials. The thermal stability of peroxidase POD and polyphenoloxidase (PPO) was also investigated during steam blanching of mango slices by Ndiaye et al. [35], who reported that POD was completely deactivated after 5 min and 7 min for PPO [34]. Severini et al. [30] showed that 90% of POD activity was lost within 30 sec in steam blanching. Xiao et al. [11] reported that steam blanching for 4 min was the best treatment, without altering the texture and reducing the enzyme activities of POD by 93.5% and PPO by 92.2%. Our results also showed that the raw materials, blanched for 3 min, were still hard, so that grinding was relatively difficult and caused discomfort when eating. The majority of participants accepted the product when the materials were blanched for 5 to 7 min. The 5 min blanching time can be considered the most appropriate time, both to improve the color and texture of the ingredients, to maintain the nutrient content and to facilitate subsequent processing.

3.3 Effect of mixing ratio of ingredients (from eight recipes) on nutritional and sensory value of products

The composition of macronutrients of healthy soup was measured for eight recipes. The protein content in all samples showed no significant difference and ranged from 1.80 to 1.98% (Table 6), because the protein content was mainly derived from the added plant-based organic protein. The total calories of all the products are shown in Table 7.

Table 6 Macronutrients of products in different recipes.

Formulas	Protein (%)	Carbohydrate (%)	Lipid (%)
F1	1.80^{a}	9.95^{c}	1.30±0.02^{a}
F2	1.82^{a}	9.30^{b}	1.32±0.02^{ab}
F3	1.90^{b}	9.30^{b}	1.35±0.05^{b}
F4	1.98^{c}	9.35^{b}	1.35±0.02^{b}
F5	1.97b^{c}	9.32^{b}	1.30±0.04^{a}
F6	1.82^{a}	9.21^{a}	1.30±0.02^{a}
F7	1.80^{a}	9.21^{a}	1.30±0.01^{a}
F8	1.80^{a}	9.22^{a}	1.32±0.01^{ab}

Means with different superscript letters in each column represent significant differences at a 95% confidence level.

Analysis showed that the carbohydrate content of the products from the eight formulations had slight differences. The high carbohydrate content was derived mainly from three sources - potatoes (20.4%), bananas (17.8%) and yellow sweet potatoes (17.6%). Therefore, with high proportions of three materials in the formulas, higher contents of carbohydrate in the products were observed, see formulas F1, F4 and F8. The lipid content the eight formulations ranged from 1.30 to 1.35%, mainly from the cream powder supplement.

The energy requirements for a child's growth depend on many factors, such as gender, growth and physical activity level. For children, the recommended levels of macronutrients and most micronutrients are usually higher relative to body size, than as adults. Therefore, children need to be provided with a variety of nutritious foods in main meals and snacks [22]. However, it is important not to overfeed a child as this can lead to obesity.

Table 7 Total calories from macronutrients and percentage of energy supply (for 100 g cooked soup).

Formulas	Energy-yielding macronutrients (kcal)			Total calories	Percentage of energy supply from macronutrients		
	Protein	Carbohydrate	Lipid		Protein	Carbohydrate	Lipid
F1	7.20	39.80	11.70	58.70	12.27	67.80	19.93
F2	7.28	37.20	11.88	56.36	12.92	66.00	21.08
F3	7.60	37.20	12.15	56.95	13.35	65.32	21.33
F4	7.92	37.40	12.15	57.47	13.78	65.08	21.14
F5	7.88	37.28	11.70	56.86	13.86	65.56	20.58
F6	7.28	36.84	11.70	55.82	13.04	66.00	20.96
F7	7.20	36.84	11.70	55.74	12.92	66.09	20.99
F8	7.20	36.88	11.88	55.96	12.87	65.90	21.23

Total calories provided from the eight soup recipes ranged from 55.7 to 58.7 kcal/100 g, with the highest value found in the F1 recipe (58.7 kcal/100 g) and the lowest in F7 (55.7 kcal/100 g). The higher energy value was due to the high carbohydrate and lipid content. The Acceptable Macronutrient Distribution Range (AMDR) for each nutrient (within the macronutrient group) is expressed as a percentage of the total calorie requirement for a person for the day. In addition, the food eaten every day provides many other essential nutrients, including minerals and vitamins. The AMDR for carbohydrates is 45-65%, for proteins 10-30% and fats 20-35% of the total daily energy requirement [23]. Our measurements showed that the percentage of energy provided ranged from 65.1-67.8% for carbohydrates, 12.3-13.8% for proteins and 19.9-21.3% for fat%, for the formulations in this study (Table 7). The percentage of energy distribution of protein and lipid were within the AMDR ranges; however, the percentage of carbohydrates was over the limit in some formulations, only formula F4 was in the recommended AMDR. High-fiber carbohydrates are important, because children must have a certain fiber intake each day. Protein is of particular importance for a child's development, with a recommended amount of 0.95 g of protein per kilogram of body weight daily [22]. Essential fatty acids also need to be provided to support growth, although not as high as needed by infants and toddlers.

Along with nutritional composition analysis, sensory evaluation from consumers to decide on product selection is also an important criterion for new products. It is desirable that a product have no strange taste or smell or a defective structure. The distribution of product samples and properties is shown in Figure 2. We observed that the different formulations had a great influence on the sensory properties. The samples and sensory attributes that were located close to each other showed the highest level of perception of that sensory attribute of the sample [36]. Formula groups F4, F5 and F2 were accepted by the majority of panelists with positive attributes, such as vegetable smell, green color and sweetness. Sample groups F1, F3, F7 and F8, showed an poor estimate of the color, smell and taste. According to sensory attributes, F6 was at an average level. Strange and sour taste attributes are undesirable attributes that negatively affect the quality of nutritional products.

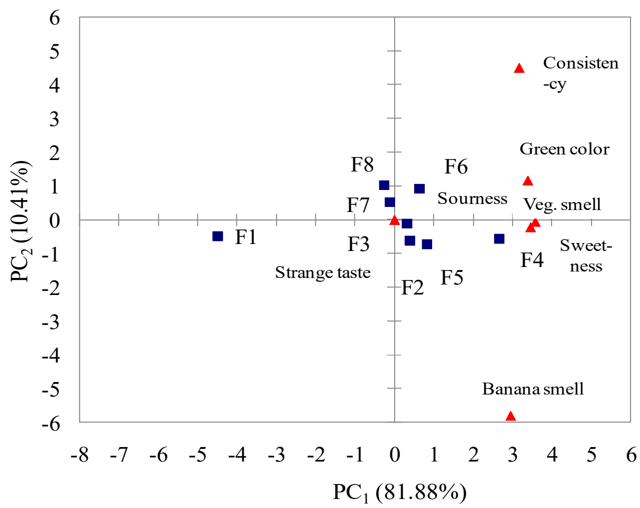

Figure 2 Correlation of sensory attributes with the samples.

The reference map also showed the same results (Figure 3). The healthy soups were rated according to preference scores, from 1 to 9. The reference map firmly confirmed that formulas F4, F5 and F2 were the most accepted by consumers (80-100%). These samples had bright green colors, good taste, and flavor. On the other hand, formulae F1, F7 and F8 had low consumer Overall, the healthy food product from formula F4 had the best quality in terms of nutritional and energy. The macronutrients content in F4 were within AMDR guidelines. This formula was characterized by positive quality attributes, and was well accepted by consumers.

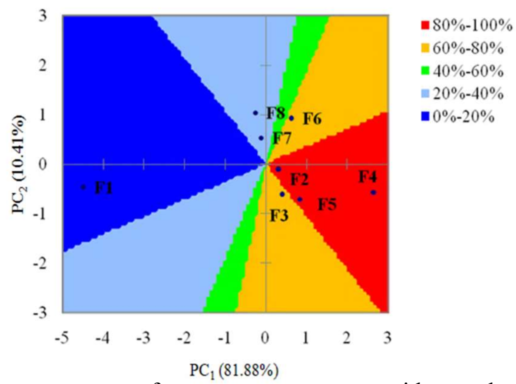

Figure 3 Reference map based on percentage of consumer acceptance with samples.

The nutrition details for a 200 g serving size and fraction of %DV are shown in Table 8. For children from 1 to 6 years old, the total energy required is in the range 1060-1350 kcal/day [22], so a nutritional product providing about 115 kcal in a 200 g serve can satisfy a good part of energy supply for meal. Because the product was mainly composed of bananas and vegetables, the proportion of calories from protein was relatively lower, so children need to be provided with an additional source of essential animal protein for growth. The %DV shows how much a nutrient in a serving of food contributes to a total daily diet. This can help you determine if a serving of food is high or low in a nutrient.

Table 8 Nutrition facts - 200g of nutritious soup made from bananas combined with other vegetables.

The nutrition source	Serving size/ 200g	% Daily value (DV)*
Potassium	0.00239	5.1
Vitamin A	0.00107	11.9
Sodium	0.0033	1.4
Calcium	0.0013	1.0
Vitamin C	0.009	11.0
Iron	0.00029	1.6
Total Carbohydrate	18.7	6.8
Dietary fiber	1.45	
Total fat	2.7	3.4
Protein	3.96	
Trans fat	0	
Cholesterol	0	0
Total Carbohydrate		5.1
Calories	114.94	
Calories from fat	24.30	

*%DV represents the fraction of nutrients in one serving needed for a daily diet following general nutritional advice for 2,000 calories per day.

As a general guideline, a %DV≤ 5%, for each individual nutrient in a serving, is considered low and values of 20% or more are considered high [22]. The calculated %DV showed less fat, iron and calcium per serving (% DV< 5), but vitamins A and C, potassium and fiber were satisfactory (5% ≤ %DV≤ 20%). In general, the F4 formula was completely suitable for the requirements of balanced nutrition, and can well support growing children .This could help consumers choose products that are suitable for their health and nutritional status - if the product was developed into a commercial product. Viscosity is an important property of liquid food. The viscosity was measured after cooking as 4280±36 cP, the product had a moderate consistency, was homogeneous and smooth and was highly scored by the panellists.

3.4 Effect of sterilization on quality

The F4 recipe was chosen for assessment of sterilization due to consumer acceptance and nutritional properties. Samples were sterilized at 105°C for 3-9 min to determine the appropriate time, as well the product shelf-life. Sterilization, a common method in the food industry, may prevent the development of spoilage bacteria as well as prolong storage time [37,38]. The results showed that the product could be sterilized at 105°C from 3, 5, 7 and 9 min with calculated sterilization values 3.14, 5.21, 7.17 and 9.30, rescpectively. However, to ensure consumer acceptance, the 5 min sterilization was chosen. In addition, microbiological analysis is important to confirm product safety. No coliform bacteria were found and the number of viable counts in the soup was 1.1×10^2 colony-forming unit (CFU)/mL after 3 months and 1.6×10^2 CFU/mL after 4 months. Thus, these soups could be stored at ambient temperature (28 ± 2°C) for 4 months without changing the nutritional and sensory values and maintaining food nutrients, confirming that the heat treatment could prevent microbial growth.

4. Conclusion

After analyzing the important macro- and micronutrients, calculating the energy balance and obtaining sensory evaluations, a new healthy soup was developed from varied fruits and vegetables in one recipe. This soup was especially diverse in nutritional composition, rich in fiber, thus it can be a component of main meals for a child. This is an appropriate choice to meet the nutritional needs that are often lacking or in short supply in child care. This can play a significant role in reducing malnutrition in Vietnam. The product also supports children in rural areas, improving the distribution of macronutrients by reducing fat and increasing carbohydrate intake for young children. This is a convenient and quick product to prepare children's meals. In addition, safely processed foods help children avoid foodborne illnesses.

5. References

[1] Bowen KJ, Sullivan VK, Etherton KPM, Petersen KS. Nutrition and cardiovascular disease-an update. Curr Atheroscler Rep. 2018;20(2):1-11.
[2] Slavin JL, Lloyd B. Health benefits of fruits and vegetables. Adv Nutr. 2012;3(4):506-516.
[3] Sidhu JS, Zafar TA. Bioactive compounds in banana fruits and their health benefits. Food Qual Saf. 2018;2(4):183-188.
[4] Ahmad T, Cawood M, Iqbal Q, Ariño A, Batool A, Tariq RMS, et al. Phytochemicals in *Daucus carota* and their health benefits. Foods. 2019;8(9):424.
[5] Dar AH, Sofi SA, Rafiq S. Pumpkin the functional and therapeutic ingredient: a review. Int J Food Sci Nutr. 2017;2(6):165-170.
[6] Akyol H, Riciputi Y, Capanoglu E, Caboni MF, Verardo V. Phenolic compounds in the potato and its byproducts: an overview. Int J Mol Sci. 2016;17(6):835.
[7] Morelock TE, Correll JC. Spinach. In: Prohens J, Nuez F, editors. Vegetables I: Asteraceae, Brassicaceae, Chenopodiaceae, and Cucurbitaceae. 1st ed. New York: Springer; 2008. p. 189-218.
[8] Nutritionix [Internet]. Washington: The Company; c2020 [cited 2021 Nov 01]. Spinach. Available from: https://www.nutritionix.com/food/spinach.
[9] Aslam MF, Majeed S, Aslam S, Irfan JA. Vitamins: key role players in boosting up immune response - a mini review. Vitam Miner. 2017;6(1):2376-1318.
[10] Amaya DBR, Nutti MR, Carvalho JLV. Carotenoids of sweet potato, cassava, and maize and their use in bread and flour fortification. In: Victor R, Watson RR, Patel VB, editors. Flour and breads and their fortification in health and disease prevention. 1st ed. Massachusetts: Academic Press; 2011. p. 301-311.
[11] Xiao HW, Pan Z, Deng LZ, Mashad HM, Yang XH, Mujumdar A, et al. Recent developments and trends in thermal blanching - a comprehensive review. Infor Procesin Agri. 2017;4(2):101-127.
[12] Horwitz W, Latimer GW. Official methods of analysis of AOAC International. 18th ed. Washington: AOAC International; 2005.
[13] McCseady RM. Determination of starch and dextrin. In: Joslyn AM, editor. 2nd ed. In methods in food analysis. New York: Academic Press; 1970. p. 522-557.
[14] Dubois M, Gilles KA, Hamilton JK, Rebers PA, Smith F. Colorimetric method for the determination of sugars and related substances. Anal Chem. 1956;28(3):350-356.
[15] Arunkumar D, Avinash NG, Rao H, Robin KB, Samshuddin S. Estimation of calcium, potassium and sodium contents in commonly consumed food of Karnataka coastal belt region, India. Chem Sin. 2015;6(4):100-103.
[16] Hailu T, Solomon D, Worku E, Sisay S, Demissie K. Determination of iron and moisture content in commonly consumed. Chem Sci J. 2019;10(1):198.
[17] Zhang J, Cui S, Li J, Wei J, Kirkham MB. Protoplasmic factors, antioxidant responses, and chilling resistance in maize. Plant Phys Biochem. 1995;33(5):567-575.
[18] Zvaigzne G, Karklina D, Seglina D, Krasnova I. Antioxidants in various citrus fruit juices. Chem Technol. 2009;3(52):56-61.
[19] Parrish DB. Determination of vitamin a in foods-a review. Crit Rev Food Sci Nutr. 1977;9(4):375-394.
[20] Wang F, Du C, Chen J, Shi L, Li H. A new method for determination of pectin content using spectrophotometry. Polymers. 2021;13(17):2847.
[21] Doornmalen JPCM, Kopinga K. Temperature dependence of F-, D-and z-values used in steam sterilization processes. J Appl Microbiol. 2009;107(3):1054-1060.
[22] Thuy NM, Tuyen NTM. Human Nutrition. 2nd ed. Can Tho: Can Tho Publishing House; 2017.

[23] Thompson J, Manore M. Nutrition: an applied approach. 5th ed. London: Pearson; 2017.
[24] Thuy NM, Linh MN, My LTD, Minh VQ, Tai NV. Physico-chemical changes in "Xiem" banana cultivar (cultivated in Vietnam) during ripening and storage at different temperatures. Food Res. 2021;5(6):229-237.
[25] Chandra RD, Siswanti CA, Prihastyanti MN, Limantara L, Brotosudarmo TH. Evaluating provitamin a carotenoids and polar metabolite compositions during the ripening stages of the agung semeru banana (*Musa paradisiaca* L. AAB). Inter J Food Sci. 2020;12:8503923.
[26] Adi DD, Oduro IN, Tortoe C. Physicochemical changes in plantain during normal storage ripening. Sci Afr. 2019;6:e00164.
[27] Aquino CF, Salomão LCC, Pinheiro-Sant'ana HM, Ribeiro SMR, Siqueira DLD, Cecon PR. Carotenoids in the pulp and peel of bananas from 15 cultivars in two ripening stages 1. Rev Ceres. 2018;65(3):217-226.
[28] Sarawong C, Schoenlechner R, Sekiguchi K, Berghofer E, Ng PK. Effect of extrusion cooking on the physicochemical properties, resistant starch, phenolic content and antioxidant capacities of green banana flour. Food Chem. 2014;143:33-39.
[29] D'Elia L, Barba G, Cappuccio FP, Strazzullo P. Potassium intake, stroke, and cardiovascular disease: a meta-analysis of prospective studies. J Am Coll Cardiol. 2011;57(10):1210-1219.
[30] Severini C, Giuliani R, De Filippis A, Derossi A, De Pilli T. Influence of different blanching methods on colour, ascorbic acid and phenolics content of broccoli. J Food Sci Tech. 2016;53(1):501-510.
[31] Mukherjee S, Chattopadhyay PK. Whirling bed blanching of potato cubes and its effects on product quality. J Food Eng. 2007;78(1):52-60.
[32] Ratnayake WS, Jackson DS. Starch gelatinization. Adv Food Nutr Res. 2008;55:221-268.
[33] Martínez GG, Ahrné L, Gekas V, Sjöholm I. Analysis of temperature distribution in potato tissue during blanching and its effect on the absolute residual pectin methylesterase activity. J Food Eng. 2004;65(3): 433-441.
[34] Arnnok P, Ruangviriyachai C, Mahachai R, Techawongstien S, Chanthai S. Optimization and determination of polyphenol oxidase and peroxidase activities in hot pepper (*Capsicum annuum* L.) pericarb. Inter Food Res J. 2010;17:385-392.
[35] Ndiaye C, Xu SY, Wang Z. Steam blanching effect on polyphenoloxidase, peroxidase and colour of mango (*Mangifera indica* L.) slices. Food Chem. 2009;113(1):92-95.
[36] Kitsawad K, Tuntisripreecha N. Sensory characterization of instant tom yum soup. Appl Sci Eng Prog. 2016;9(2):145-152.
[37] Gaillard S, Leguérinel I, Savy N, Mafart P. Quantifying the combined effects of the heating time, the temperature and the recovery medium pH on the regrowth lag time of bacillus cereus spores after heat treatment. Int J Microbiol. 2005;105(1):53-58.
[38] Thuy NM, Banyavongsa A, Tai NV. The effect of homogenization and sterilization on the stability and nutritional evaluation of Vietnamese purple rice milk supplemented with sesame, soybean and water caltrop. Food Res. 2020;4(6):2289-2295.