

Sensory and Nutritional Properties and Stability of Formulated Organic Food Flavour Enhancers

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Abstract

Most food flavours have been shown to contain high quantities of cooking salt, followed by flavour enhancers such as sodium glutamate, disodium inosinate, disodium guanylate and hydrogenated oils. Excess of these substances is associated with cardiovascular diseases and neurodegenerative disorders. In an effort to reduce the harmful effects of these synthetic substances, this study therefore aimed to formulate organic, nutritious food flavours with good storage stability from less harmful locally available food ingredients. A survey was carried out in 130 households and restaurants in the city of Yaoundé Cameroon, in order to evaluate the level of consumption of industrial flavours. Certain ingredients such as prawns, onions, garlic, white peppers, ginger and salt were used in some households as organic flavours. These ingredients and others were used to prepare 5 organic flavours. Their sensory and nutritional analyses and stability to storage within 90 days were evaluated. The survey revealed that 74.6% of respondents consume industrial flavours, with the cube flavour being the most widely consumed (81%). Two of the 5 organic flavours (434 and 634) had highest scores for general acceptability. The nutritional analyses of the formulae retained (434 and 634), showed that they contained: 11.08% and 10.68% fresh weight for moisture, 47.63% and 43.53% protein, 16.52% and 13.62% lipids, 2.20% and 2.44% fibres, 11.69% and 16.39% carbohydrates. Formula 434, the most accepted, had higher contents of Ca (257.97), Mg (115.91), K (1163), Zn (2.98), Cu (1.02) and Fe (12.43 mg/100g DM) while the second (634) had higher contents of sodium (3270.48) and manganese (2.18 mg/100g). Their water activity during storage in polypropylene bags for 90 days ranged from 0.39 - 0.58 at a temperature of 26.6°C - 37°C. The oxidative stability (90 days), determined by the acid and peroxide indices, was 9.18 - 14.13 mg KOH/g and 1.98 - 6.46 meq O₂/Kg, respectively indicating good stability for 90 days of storage. The high levels of

proteins and minerals in our two products justify their umami taste and can be used as highly nutritional food flavour enhancers to prevent cardiovascular diseases, especially in the elderly.

Keywords

Organic Food Flavour, Monosodium Glutamate, Proteins, Minerals, Stability

1. Introduction

Food consumption has changed in recent decades due to the need for ready-to-eat foods and characteristic flavours that are made possible by food technology [1]. The compounds responsible for flavours in foods are made up of a large number of volatile molecules. The molecules perceptible by direct olfaction define odour and those perceptible by retronasal olfaction concern the aroma. The combination of these two perceptions constitutes flavour [2]. The aromas present in foods have a significant influence on the decision-making process of consumers, since smell is a fundamental parameter for evaluating the sensory quality of foods [3]. Bouillon cube contents of aromas can play a very important role especially in foods that are not very tasty, giving them the necessary taste [4]. Many foods and ingredients rich in free amino acids or made up of protein hydrolysates have been used in cooking for centuries to improve the sensory qualities of different foods, such as seasoning food flavours [4] and flavour cubes produced in Nigeria [5]. Seasoning food flavours are prepared from animal and/or vegetable products with or without the addition of flavour enhancers, hydrolysed edible fats, aimed at improving flavour [6] [7]. Cube food flavours were put on the Swiss market in 1908 by Julius Maggi and were introduced in Africa during the colonial era when they became popular in Sub-Saharan Africa, particularly in West and Central Africa [8] [9]. Their consumption in households is estimated at 93% in Africa, more than 90% in Central Africa and 96% in Cameroon [9]. The cube food flavour contains mainly cooking salt (40% - 70%), flavour enhancers (15%) such as sodium glutamate, disodium inosinate and disodium guanylate, and hydrogenated oils (9%), vegetable proteins and starch (2% - 3%), sugar, spices (3%) and flavourings (0.5% - 2%) [9] [10]. Flavour enhancers interact with food matrices, enhancing and intensifying the natural flavour of foods, bringing out the umami taste [11]. A study of the taste properties of several glutamate salts such as those of calcium, potassium, ammonium and magnesium revealed that ionized glutamic acid is the ingredient which is most responsible for the umami taste [12].

However, these flavour enhancers produced with synthetic sodium glutamate (contain carcinogenic substances and impurities in addition to sodium) and salt, which in excess, causes high blood pressure which is associated with cardiovascular diseases and stroke, neurodegenerative disorders and diabetes [13] [14]. Disodium inosinate is broken down into uric acid. Excess uric acid could pro-

mote gout in predisposed people. Disodium guanylate is generally considered a safe food additive. However, people who are sensitive to monosodium glutamate (MSG), suffer from gout, or have a history of kidney stones should avoid it [15] [16].

In an effort to reduce the toxicity associated with these substances (sodium and synthetic monosodium glutamate of LD configuration which can cause health problems) as opposed to biological monosodium glutamate which has no harmful effects), researchers have shown that the formulation of organic food flavour from local food materials: tomatoes, potatoes, garlic and mushrooms, was rich in natural glutamate and could partially replace the consumption of food flavour cubes with synthetic monosodium glutamate [17] [18]. This is also the case of the formulation vegetable flavour powders without MSG using potatoes, wheat flour, vegetable oil, carrots, lentils, tomatoes, sugar, spices (garlic, white pepper, onions), rosemary and celery [19]. All these formulations were made from plant-based materials only. This study was therefore aimed to formulate an organic food flavour from local animal and vegetable materials, such as mushrooms, chicken, shrimps, tomatoes, onions, garlics, white pepper, salt, ginger, and to determine its acceptability, nutritional value and stability during storage.

2. Materials and Methods

A survey was carried out in three districts of the city of Yaoundé, Cameroon, in order to identify the different types of industrial food flavours used, the composition of the most widely used food flavour and the ingredients used locally for the formulation of organic food flavours or as food flavour enhancers. The survey population consisted of households and restaurants using a random sampling method with a sample size of 130 people. People who had no knowledge of industrial food flavour or the ingredients that could replace it, were not included in the study.

The foods (vegetable and animal origin) for the formulation of the organic food flavours (food flavour powder) were made up of oyster mushroom (*Pleurotus ostreatus*), chicken (*Galus domesticus*), shrimp (*Palaemon serratus*), tomato (*Solanum lycopersicum*), local spices and iodised salt. The formulation was carried out using the linear programming of the Excel solver add-in. Five organic food flavour formulae (powder food flavour) were selected using different proportions of the ingredients.

Each of the ingredients were cleaned and dried in an air-ventilated oven at 50°C for 48 hours. The chicken was cleaned and boiled in water at 100°C for 30 minutes, muscle extracted and dried at 50°C for 48 hours. The ingredients were then ground into powder with a Moulinex (brand HV8). The powders was packed in polypropylene bags for sensory and biochemical analyses. The different formulae were named: 434, 256, 851, 634 and 512. The sensory properties were taken into account to obtain two final formulae.

2.1. Preparation of Food for Sensory Analysis of the Food Flavours

The preparation of rice seasoned with organic food flavour enhancer powders consisted of preparing a mixture containing 500 g of rice, 15 g of refined oil, 2 l of drinking water and 50 g of organic flavour enhancer powder from 5 flavour enhancer powders (512, 434, 851, 634 and 256) and 4 g of commercial food flavour (728) taken as a control, in a covered pot, until it was ready (30 minutes). No other spices were added to complement the taste. The stock powder was previously dissolved in 250 ml of water, and this water was added gently until the end of the cooking time [20].

2.2. Sensory Analysis

In order to select the best formula, the rice seasoned with organic flavours and industrial commercial food flavour were presented to 60 untrained panellists to test for colour, taste, odour and general acceptability on the nine-point hedonic scale.

2.3. Determination of Nutritional Value

The water, fat, protein, crude fibre, ash, total carbohydrates and mineral contents were analysed. The water content was determined by the oven drying method at 105°C [21] and the lipid content using the Russian method with hexane in a Soxhlet extractor [22]. The protein content was determined after digestion of the samples by the Kjeldahl method [21] and assay by the colorimetric technique [23]. The crude fibre and ash contents were determined by the method of AOAC [24]. The total carbohydrate content was determined by the difference method [25]. The mineral content (calcium, magnesium, potassium, iron and zinc) was carried out by atomic absorption spectrophotometry [26].

2.4. Evaluation of Stability during Storage

The relative humidity was measured using the electronic moisture analyser (Yuyhuan brand). The water activity was deduced from its expression according to AFFATA [27]. The extraction of the lipid fraction was carried out by the method of Folch [28] modified by Xanthopoulou [29] and the extracted oils were used to analyse the acid and peroxide indices [30].

2.5. Statistical Analysis

The results were analysed by IBM/SPSS 20.0 for Windows using the ANOVA test followed by a post-hoc Tukey test (for surveys and sensory analyses) and T-test for independent sample (for nutritional analyses and stability) to compare the means. The results were presented as mean \pm standard error with a significance level of 5%. Microsoft Office Excel 2016 was used for the graphical representations and its solver complement to determine the quantities of the ingredients.

3. Results and Discussions

This survey took place in some restaurants and households in the city of

Yaoundé. A total of 130 people took part, made up of 92 women and 38 men. The results show that men used industrial stock cubes more than women, with a percentage of 94.7% for men and 66.3% for women (**Table 1**). This may be due to the fact that industrial cubes are easier to use and less expensive, taking less time compared to natural stocks.

3.1. Industrial Food Flavours and Their Rates of Consumption

From the survey on the rate of consumption of flavour cubes used, the Maggi cube brand was the most widely consumed at 81%, followed by the Maggi shrimp brand at 18% (**Table 2**) Maggi cube brand therefore served as control for the preparations and sensory analysis in this study.

3.2. Number of Flavour Cubes Used in a Meal

For the preparation of meals, approximately two Maggi cubes (8g) were used for a 4 litre pot of meal by the majority of people who used the stock cubes making 46% while the number of people who used at least 5 cubes was the lowest (8%) (**Table 3**). This result is different from that of previous studies on a survey on the consumption of culinary food flavour cubes in Mali, which showed that households consume averagely 20 g of culinary food flavours in a meal [12].

3.3. Level of Knowledge of Monosodium Glutamate (MSG) in Flavour Cubes

Of the 130 people questioned, 96 people (73.8%) did not know or had never heard of monosodium glutamate (MSG), while 34 people, (26.2%), knew or have heard of the presence of MSG in flavour cubes (**Table 4**). The high consumption of flavour cubes may be due to ignorance of this compound which is nowadays

Table 1. Consumption of industrial stock cubes by gender.

| Response | Men | | Women | |
|----------|--------|----------------|--------|----------------|
| | Number | Percentage (%) | Number | Percentage (%) |
| Yes | 36 | 94.7 | 61 | 66.3 |
| No | 2 | 5.3 | 31 | 33.7 |

Table 2. Rate of consumption of flavour cubes.

| Types of food flavour | Rate of consumption (%) |
|-----------------------|-------------------------|
| Maggi cube | 81 |
| Maggi shrimp | 18 |
| Others | 1 |

Table 3. Number of flavour cubes used in a meal.

| Number of stock cubes | 1 | 2 | 3 | 4 | 5 |
|-----------------------------|----|----|----|----|---|
| Percentage of Consumers (%) | 15 | 46 | 19 | 12 | 8 |

Table 4. Level of Knowledge of MSG in cubes.

| Response | Yes | No |
|--|------|------|
| Level of knowledge of MSG in Cubes (%) | 26.2 | 73.8 |

associated to one of the causes of non-transmissible diseases and allergies with excessive consumption of MSG.

3.4. Knowledge of the Health Effects of Excess Monosodium Glutamate

Many people questioned (77%) did not know that monosodium glutamate contained in cubes is dangerous for health (Table 5). Only 22.3% of respondents knew about the dangers of excess monosodium glutamate to health. This can be explained by the ignorance on the composition of flavour cubes.

3.5. Ingredients Most Commonly Used in the Formulation of Natural Food Flavours

People who did not use flavour cubes formulated their own flavours using certain ingredients. The most common in order of appearance were: white pepper, garlic, onion, *country-onions* and ginger (Table 6). These ingredients served as a base for the formulation the organic food flavour in this study (powder flavour).

3.6. Sensory Analyses of Organic Food Flavours

Sensory evaluation showed that there is no significant difference ($p > 0.05$) in the colours and taste of the food flavours 434, 634, and 728 (commercial) which were 6.05, 6.45 and 6.22 respectively for colour and 5.82, 5.51 and 5.95 respectively for taste (Table 7). For the odour, only that of the food flavour 434, was not significantly different ($p > 0.05$) from that of 728 (commercial cube), with values of 5.77 and 6.57 respectively. For the general acceptability, 434 and 634 were the most appreciated after the commercial food flavour 728, with a score of 6.70. This may be due to the eating habits of respondents who represent about 81% of this commercial flavour users, according to the survey carried out in the three districts of the city of Yaoundé. Hence, the two biological flavour enhancers 434 and 634 were retained as final products for the nutritional analyses.

3.7. Proximate Composition of Organic Food Flavours

Table 8 shows the average water content of the organic food flavours (food flavour powders). It can be seen that these contents are 10.68% and 11.08% respectively in samples 634 and 434. These values are significantly different from each other ($p < 0.01$). However, this result is higher than that of the commercial cube, 728 (3.05) [31] and 2.72% - 3.72% dw for the water content of the most widely consumed cube food flavours in South Benin [8]; and 2.83% - 5.46% dw for commercial flavour cubes in Nigeria [32]. However, these values are lower than those for the formulation of food flavours from local materials in Sri Lanka (14.03%

Table 5. Knowledge on the dangers of excess monosodium glutamate.

| Response | Yes | No |
|--|------|------|
| Knowledge on dangers of MSG in Cubes (%) | 22.3 | 77.7 |

Table 6. Ingredients most commonly used for the formulation of natural food flavours.

| Ingredients | Ginger | country-onions | Onion | Garlic | White pepper |
|------------------------------------|--------|----------------|-------|--------|--------------|
| Level of Consumption of ingredient | 13 | 17 | 20 | 20 | 30 |

Table 7. Results of sensory analyses of organic food flavours.

| Criteria Sample | Colour | Taste | Odour | General acceptability |
|--------------------|--------------------------|--------------------------------|----------------------------|--------------------------------|
| 512 | 6.29 ± 0.1 ^b | 4.74 ± 0.18 ^a | 4.60 ± 0.15 ^{ab} | 5.2 ± 0.17 ^b |
| 434 | 6.05 ± 0.18 ^b | 5.82 ± 0.20^b | 5.77 ± 0.17 ^{cd} | 5.84 ± 0.19^b |
| 851 | 5.84 ± 0.15 ^b | 5.64 ± 0.21 ^b | 5.34 ± 0.17 ^{bc} | 5.44 ± 0.19 ^b |
| 634 | 6.45 ± 0.15 ^b | 5.51 ± 0.21 ^b | 5.19 ± 0.17 ^{abc} | 5.57 ± 1.90^b |
| 256 | 4.17 ± 0.24 ^a | 4.75 ± 0.23 ^a | 4.42 ± 0.21 ^a | 4.88 ± 0.21 ^a |
| 728 | 6.22 ± 0.21 ^b | 5.95 ± 0.16 ^b | 6.57 ± 0.14 ^d | 6.70 ± 1.49 ^c |

Values are expressed as means ± SD; values with the same letters in the same column are not significantly different ($p > 0.05$). The flavours coded 512, 434, 851, 634 and 256 are the formulated organic food flavours and 728 is the commercial food flavour (cube).

Table 8. The average nutritional and energy value of the selected food flavours (g/100g of dry weight).

| Parameter per 100 g of organic flavours | 434 | 634 | 728 (Control) (% MS) [31] |
|---|----------------------------|----------------------------|---------------------------|
| Water (g/100 fresh weight) | 11.08 ± 0.11 ^a | 10.68 ± 0.03 ^a | 3.05 |
| Lipids | 16.52 ± 0.197 ^b | 13.62 ± 0.13 ^a | 9.02 |
| Proteins | 47.63 ± 0.57 ^b | 43.53 ± 0.33 ^a | 6.05 |
| Crude fibre | 2.20 ± 0.03 ^a | 2.44 ± 0.57 ^a | 3.02 |
| Ash | 10.57 ± 0.12 ^a | 13.34 ± 0.3 ^b | 5.29 |
| Total carbohydrates | 12 ± 0.69 ^a | 16.39 ± 0.17 ^b | 20.05 |
| Energy value (Kcal/100g) | 387.2 ± 1.91 ^a | 362.24 ± 0.82 ^a | 187.38 |

The results are expressed as means ± standard error ($n = 3$). The values with the same letters in the same column are not significantly different ($p > 0.05$). 434 and 634 = organic food flavours.

dw) [17]. Water has several effects on the stability, palatability and overall quality of foods. It can affect physical properties such as hardening or coagulation in the powder or powdered product. For example, if the water content of dehydrated foods is less than 8%, micro-organisms will not grow, whereas when the water content is higher than 18%, some micro-organisms may gradually repro-

duce [33]. Therefore, these formulated food flavours are not very prone to microbial attack.

The average lipid contents are 13.62 g/100g and 16.52 g/100g dw respectively in the formulated organic flavour 634 and 434. These values are significantly different ($p < 0.05$). Food flavour 434 is higher in fat than 634, which may be due to the fact that it contains slightly higher amounts of chicken meat, shrimps and onions. These values are higher than 9.02 g/100g dw for commercial cube (728) [31] and 3.8 and 4.7 g/100g dw for mushroom and chicken food flavours respectively [5]. These values are closed to 12.16 g/100g for organic food flavour formulations [17]. Lipids provide the human body with the fatty acids it needs and can improve the absorption of fat-soluble vitamins (vitamins A, D, E, K) [34]. The two formulated food flavours provide 17.23% to 20.39% of energy intake from lipids compared to the average requirement for an adult (2600 kcal/d) which could be supplemented by other foods to meet 30% - 35% of total energy intake in lipids [35]. However, high fat intake increases the total energy intake, thus increasing the risk of weight gain and obesity.

The average protein contents in samples 434 and 634 are 47.63 g/100g and 43.53 g/100g respectively. These values are significantly different from each other ($p < 0.05$). This can be explained by the higher amount of proteins (from chicken and shrimp) in sample 434 than in sample 634. They are higher than that of the commercial cube 728 (6 g/100g) in Nigeria [31] as well as 36.96 g/100g for commercial monosodium glutamate in South Benin and in the cube and liquid food flavour ranges whose values are between 7.56 - 14.84 g/100g dw [8]. They are closed to 42.5 g/100g in the fermented condiment *okpeye* in Nigeria [31] and also to 46.33 g/100g DM for fermented cowpea in Nigeria [36]. Furthermore, these results are higher than those of natural formulations (3.782 g/100g DM) [17] and 6.92 - 16.05 g/100g DM, for the protein content of vegetable soup powders supplemented with soybean, mushroom and Moringa leaves in Bangladesh [32]. This can be explained by the fact that the composition of these two food flavours contains ingredients with animal (chicken, shrimp) and vegetable (mushrooms, tomatoes, garlic and onions) proteins. Proteins are essential for the construction and repair of cellular structures and for the development of the body's resistance [34] [37]. The requirements of proteins per day are 10% - 15% [35]. The protein energy intake of the formulated organic food flavours is 6.69% - 7.1%. This represents half the protein requirement for 100 g of organic flavours and could be supplemented with other foods.

The mean crude fibre contents were 2.20 g/100g and 2.44 g/100g dw in samples 434 and 634, with no significant differences ($p > 0.05$) between them. These values are lower than that of 728 (3.02%) [31] in chicken stock cubes and higher than 0.02 g/100g for flavour cubes in Nigeria [38]. They are lower than that 3.78 g/100g for natural flavour enhancers formulated from local food materials [17] and closed to that of 2.70 g/100g for formulated instant vegetable soup blend without MSG [19]. Fibres are food components of plant origin that are not transformed by digestive enzymes. They are essential for proper intestinal transit

[35]. However, fibre is absent (0 g) in beef stock cubes [39].

The ash contents (**Table 8**) in samples 434 and 634 are 10.57 and 13.34 g/100g DM respectively. These values are significantly different ($p < 0.05$). Sample 434, the most preferred sample, has a lower amount of ash than sample 634. These values are higher than that of 728 (5.29%) [31] but lower than 19.6% to 30.8% for five flavour cubes in Saudi Arabia [5] and 57.51 ± 4.27 for flavour cubes in Nigeria [36]. These values are also lower than 15.16 for formulations from natural local materials [17] but higher than 9.5 - 9.7 g/100g for formulated food flavours in Colombia [40]. The ash levels in these samples show that they can provide a non-negligible amount of minerals to the body.

The average total carbohydrate contents are 12 g/100g and 16.39 g/100g DM in samples 434 and 634 respectively (**Table 8**). These values are significantly different ($p < 0.05$) from each other. This can be explained by the fact that sample 434 contains low amounts of carbohydrate foods in contrast to protein foods such as chicken, shrimp, tomatoes and onions). These values are lower than that of 728 (20.05) [31] and those of flavour cubes (mushroom, vegetable, chicken and beef) which range from 35.1 to 40.2 g/100g [5] as well as in the natural formulation which is 52.36 g/100g [17]. This could be explained by the low levels of carbohydrate constituents in the two formulated organic food flavours. However, carbohydrates provide necessary energy for the body's cells and represent at least 50% of total energy intake [34] [41]. These samples can provide about 1/5 of the carbohydrate needs of the body.

The average total energy value of the two formulae are 387.20 (434) and 362.24 kcal/100g (634). These values are not significantly different ($p > 0.05$) from each other. Food flavour 434, the most preferred, has a higher energy value than flavour 634. They are significantly higher than that of 728 (187.38 kcal) [31] in their study on the evaluation of the nutritional quality of commercial flavour cubes in Nigeria. The values of the formulated flavours are also higher than 174.15 kcal/100g for different ranges of food flavours in Nigeria [38]. On the other hand, these values are closed to 319.29 kcal/100g for natural millet-based formulated soup powder in India [1]. The formulated food flavours have a higher energy value than the commercial flavour cubes (190 kcal) [39] and could contribute to the body's energy requirements.

In general, the 2 formulated organic food flavours (434 and 634) have high macronutrient values except for fibre and could provide more energy to the body than the commercial cube flavour (dry beef cube).

3.8. Mineral Analysis

The mineral contents of the food flavours obtained are presented in mg/100g of dry weight.

The organic flavours 434 and 634 contain higher amounts of all the minerals analyzed than the commercial flavour cube (728), except sodium.

The calcium contents are 257.95 and 243.09 mg/100g in samples 434 and 634

respectively (**Table 9**). These values are higher than 9.97 mg/100g for the commercial cube, 728 [31] as well as 4.35 mg/100g for natural formulation [17]. This can be explained by the fact that the formulated food flavours contain various ingredients with significant amounts of calcium. Calcium is a major constituent of bones and is the most abundant mineral in the body (1% - 2% of body weight) with an average requirement of 1000 mg/day in adults [42]. Therefore, 100g of these organic food flavours can cover about a quarter (1/4) of the body's daily requirement.

The magnesium content in flavours 434 and 634 are 115.91 mg/100g dw and 98.51 mg/100g respectively (**Table 9**). The difference between these values is not significant ($p > 0.05$). These values are higher than 2.17 mg/100g for the commercial cube, 728 [31] and 45.8 - 54.9 mg/100g for commercial flavour cubes [40]. This may be due to the presence of magnesium-rich ingredients such as garlic (32 mg/100g), onion (25 mg/100g) and chicken (15 mg/100g) in the formulated flavours [38]. Magnesium (Mg) is essential for ATP metabolism, formation and maintenance of bones and skeleton. It is a cofactor of several enzymes that help mineral metabolism [43]. The recommended requirement is 370 mg/day in women and 440 mg/day in men [42]. Therefore, 100 g of these organic flavours can cover about a quarter (1/4) of Mg needs per day.

The potassium contents are 1663.07 and 1420.22 mg/100g in samples 434 and 634 respectively (**Table 9**). These values are significantly different ($p < 0.05$) from each other. The formulated flavour 434 (the most preferred) has a higher value. However, both values are higher than 9.33mg for the commercial cube, 728 [31] and 11.24 mg/100g for formulated flavour enhancers from natural food materials [17]. This can be justified by the fact that our ingredients contain a high amount of potassium especially garlcs (533 mg/100g), chicken (308 mg/100g) and tomatoes (222 mg/100g) which are in higher proportions in the formulae (434 and 634) [39]. The values are within the range of values (5.6 - 420.3 mg/100g)

Table 9. Mineral contents of organic food flavours, (434 and 634) and Commercial food flavour (728) (mg/100g dry dw).

| Mineral (mg/100g dry dw). | 434 | 634 | 728 |
|---------------------------|-----------------------------|------------------------------|-------------|
| Calcium | 257.95 ± 0.05 ^a | 243.09 ± 0.05 ^a | 9.97 [31] |
| Magnesium | 115.91 ± 0.16 ^a | 98.51 ± 0.22 ^a | 2.17 [31] |
| Potassium | 1663.07 ± 0.29 ^b | 1420.22 ± 0.05 ^a | 9.33 [31] |
| Sodium | 2511.26 ± 0.05 ^a | 3270.48 ± 0.005 ^b | 15,450 [36] |
| Zinc | 2.98 ± 0.001 ^a | 2.50 ± 0.00 ^a | 1.15 [4] |
| Copper | 1.02 ± 0.00 ^a | 0.59 ± 0.00 ^a | 0.35 [39]. |
| Manganese | 1.48 ± 0.05 ^a | 2.18 ± 0.00 ^a | 0.32 [31] |
| Iron | 12.43 ± 0.005 ^b | 5.13 ± 0.005 ^a | 0.38 [31] |

The results are expressed as mean ± standard deviation. Values with the same letters in the same column are not significantly different ($p > 0.05$).

for seasonings used in Nigeria [32]. Potassium (K), an essential mineral, is the main intracellular cation in the body. It plays a fundamental role in nerve transmission, muscle contraction and heart function [35]. The recommended dietary allowance is 3500 mg/d for an adult [42]. Therefore, 100 g of these food flavours can cover about one third (1/3) of potassium requirements, hence compared to the commercial cube, these food flavours with much higher potassium values are preferable for people with cardiovascular diseases or to prevent cardiovascular diseases such as hypertension.

The sodium contents of the food flavours 434 and 634 are 2511.25 and 3270.48 mg/100g respectively (Table 9). These values are significantly different ($p < 0.05$) from each other. The preferred formula, 434 has a lower value than sample 634. These values are higher than 244.05 mg/100g for natural flavour enhancer without MSG or added salt [17]. These values are much lower than 15,450 mg for commercial cube, 728 from Brazil [44], 14,923 - 21,467 mg/100g in Benin [8] and 24,000 mg/100g for cubes from North Central Nigeria [38]. These sodium levels are also lower than the sodium standards for food flavour cubes, which should not exceed 10,670 mg/100g [45]. When food flavour cubes are exposed to the air, they quickly absorb moisture and tend to become pasty. This is due to the Na^+ and Cl^- ions contained in the salt, which oxidise and tend to liquefy food flavour cubes [8]. Sodium (Na) is the main cation in extracellular fluid and plays a key role in regulating osmotic pressure. It also plays an important role in the intestinal absorption of chlorine. The recommended dietary allowance is 2000 mg/day for adults [39]. These food flavours with lower sodium values are preferable for people with cardiovascular diseases or to prevent cardiovascular diseases such as hypertension.

The zinc content of the two formulae (434 and 634) is 2.98 and 2.50 mg/100g respectively (Table 9). The formula (434) has higher zinc content than the formula 634, but these values are not significantly different ($p > 0.05$) from each other. Sample 434 contains higher amounts of zinc-rich ingredients such as chicken (3 mg) and mushrooms (3 mg) than 634. These values are higher than 1.15 mg/100g for the commercial cube 728 from Nigeria [4]. The zinc value of the preferred formula (434) is closed to 3.3 mg/100g DM for natural formulations [17]. Zinc (Zn) is an essential trace element involved in numerous catalytic, structural and regulatory cellular functions [35]. The nutritional requirement is 13.2 - 17 mg/day in adults [42]. Hence, these formulated organic food flavours can contribute to about one third (1/3) of the daily zinc intake that could be supplemented with meals.

The copper contents of the two formulae, 434 and 634 are 1.02 and 0.59 g/mg/100g respectively (Table 9). The value of sample 434 is higher than that of 634 but with no significant difference ($p > 0.05$). The Cu value in these food flavours is within the standards set for the Cu needs of adult men (1 mg/day) and women 0.8 mg/day [32]. Copper (Cu) is an essential trace element subject to homeostatic regulation. It is involved as a component of numerous metalloenzymes (cuproenzymes) involved in redox reactions such as Cytochrome C oxi-

dase, amine oxidases, superoxide dismutase. Copper is involved in the quality of cartilage and the integrity of connective tissue, bone mineralisation, regulation of neurotransmitters, cardiac function, immune mechanisms and iron metabolism. Copper also plays an ambivalent role in oxidative stress [35]. 100 g of formula 434 can cover the copper needs per day for adults. These food flavours could therefore greatly contribute to better heart function and strengthening of the immune system.

The manganese (Mn) content of 434 and 634 are 1.48 and 2.18 mg/100g respectively (Table 9). The value of sample 634 is higher than that of sample 434, but with no significant difference ($p > 0.05$). These values are higher than 0.32 mg/100g for the commercial cube, 728 but closed to 2.03 mg/100g for traditional fermented condiment [31]. They are also closed to 1.97.0 mg/100g for formulated soup and 1.2 mg/100g for commercial soup [40]. This is due to the presence of ingredients such as onions, garlic, salt, tomatoes and white pepper in the formulated organic flavours. Manganese (Mn) is the component or activator of many enzymes. It is involved in carbohydrate and lipid metabolism, cartilage and bone formation, wound healing, nitric oxide synthesis and antioxidant protection [35]. The Adequate manganese intake in men and women is 2.8 mg/day and 2.5 mg/day respectively [35]. These food flavours can provide almost 50% of the Mn requirements per day. They are therefore important sources of manganese that could help prevent manganese deficiency.

The iron contents of the two samples 434 (12.43 mg/100g) and 634 (5.13 mg/100g) (Table 9) are significantly different ($p < 0.05$) from each other. The iron content is higher in the preferred formula, 434 than in 634. These values are much higher than 0.38 mg/00g for the commercial cube, 728 [31] and 0.001 mg - 0.004 mg/100g for cubes in Nigeria [38], despite being iron supplemented. The values are also higher than 4.35 mg/100g dw for the natural flavour enhancer formula [17]. This can be explained by the variability of the food flavour ingredients used which are both from animal and plant origin. Iron (Fe) plays an essential role in many biological functions: in respiration (constituent of haemoglobin which is involved in gas exchange with the external environment), muscle function (constituent of myoglobin, the muscle's oxygen reserve form) and in the activity of enzymes involved in many metabolic pathways such as mitochondrial activity (electron transport), free radical defence (co-factor of catalase and peroxidases), DNA synthesis The Fe requirements for adults are 19 to 23 mg/day [39]. 100 g of organic flavour 434 can cover more than half (1/2) the RDA for Fe in adults and pregnant women.

The high levels of proteins and minerals in the two formulated organic flavours in this study helped to enhance their umami taste [12], indicating that glutamate salts such as those of calcium, potassium, ammonium and magnesium generate umami taste.

3.9. Evaluation of the Stability of Organic Food Flavours

Table 10 shows the evolution of the water activity (Aw) in the two samples with

Table 10. Evolution of water activity and temperature with the storage time in the two organic food flavours.

| Storage time (days) | 0 | | 30 | | 60 | | 90 | |
|---------------------|--------------------------|--------------------------|--------------------------|-------------------------|--------------------------|---------------------------|---------------------------|---------------------------|
| Samples | 434 | 634 | 434 | 634 | 434 | 634 | 434 | 634 |
| Temperature (°C) | 30.5 | 31.1 | 37 | 30.5 | 31.6 | 31.4 | 26.6 | 27.1 |
| Water activity | 0.25 ^a ± 0.00 | 0.40 ^a ± 0.00 | 0.47 ^a ± 0.00 | 0.4 ^a ± 0.00 | 0.50 ^a ± 0.01 | 0.39 ^a ± 0.002 | 0.58 ^a ± 0.002 | 0.56 ^a ± 0.002 |

Values with the same letters in the same row are not significantly different ($p > 0.05$).

Table 11. Evolution of the acid and peroxide indices of the organic food flavours during storage.

| Storage time (days) | 0 | | 30 days | | 60 days | | 90 days | |
|---|---------------------------|--------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Samples | 434 | 634 | 434 | 634 | 434 | 634 | 434 | 634 |
| Acid index (mg KOH/g) | 10.21 ± 3.39 ^a | 9.18 ± 3.96 ^a | 12.29 ± 0.87 ^a | 11.06 ± 3.26 ^a | 12.96 ± 3.70 ^a | 13.06 ± 2.37 ^a | 14.13 ± 4.63 ^a | 13.71 ± 0.40 ^a |
| Peroxide index (meq O ₂ /Kg) | 2.088 ± 0.59 ^a | 1.98 ± 0.40 ^a | 2.16 ± 0.11 ^a | 2.01 ± 0.15 ^a | 2.76 ± 0.11 ^a | 2.27 ± 0.06 ^a | 6.46 ± 1.31 ^a | 5.32 ± 0.78 ^a |

The values with the same letters in the same column are not significantly different ($p > 0.05$).

temperature during storage. The water activity ranges from 0.47 to 0.58 in sample 434 (the most preferred) and from 0.39 to 0.56 in sample 634, within the period of 3 months. There are no significant differences ($p > 0.05$) in water activity of the two samples within the 90 days of study. The very low Aw values are important for the prevention of lipid oxidation. Almost all microbial activity is inhibited below Aw = 0.6, most fungi are inhibited below Aw = 0.7, most yeasts are inhibited below Aw = 0.8, and most bacteria below Aw = 0.9 [46].

Therefore, since these organic food flavours have lower Aw values than the optimum values for microbial growth Aw (0.7 - 0.9), microbial attack is inhibited within 90 days of storage at a temperature of 26°C - 37°C.

The acid indices for 0, 30 days, 60 days and 90 days of storage are shown in **Table 11**. These values varied from 10.21 to 14.13 mg KOH/g and from 9.18 ± 3.96 to 13.71 ± 0.40 mg KOH/g in samples 434 and 634 respectively. There is no significant difference ($p > 0.05$) between the acid indices of the two samples within 90 days of storage.

The values for peroxide index increased within 90 days of storage and are lower than the standard values which are 10 meq O₂/Kg of fats and oils [6]. This could be explained by the fact that the ingredients onions, garlic, and white peppers are associated with the inhibition of lipid peroxidation [47] [48].

4. Conclusions

This work which was aimed to evaluate the sensory and nutritional quality and stability during storage of an organic food flavour made from some local Cameroonian food ingredients showed that:

From the five organic food flavours formulated, two of them were chosen from sensory analysis, coded 434 and 634. These food flavours had a similar taste and

smell to the most widely commercial food flavour in Yaounde.

The two organic flavour enhancers (434 and 634) had higher macronutrient values (except crude fibre), than the commercial cube flavour and could help provide some amount of energy needed to the body. These organic flavours also contained significantly higher amounts of all the minerals analyzed than the commercial cube flavour 728, except sodium. The high levels of K, Cu, Mn, Fe and low levels of Na are highly beneficial to health and could have potential in preventing hypertension and other cardiovascular diseases, strengthening the immune system and respiration (building haemoglobin for oxygen transport).

Water activity, acid and peroxide values increased with storage time. However, the values are below the threshold values for microbial growth and lipid oxidation. Both formulae therefore have good stability for up to 90 days of storage at room temperature.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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