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Minerals, Antioxidant Activity and Consumer Preference of Ginger Spiced Yoghurt

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Abstract

The aim of the present study was to evaluate the effect of form of ginger incorporated into yoghurt during production on its mineral content, antioxidant activity and consumer preference. Spiced and unspiced yoghurt samples were obtained by incorporation into plain yoghurt, ginger powder (0.5% m/v) and different extracts (5% v/v) of ginger. The mineral content of the spiced and unspiced yoghurt samples were determined using standard methods. The antioxidant activity were also determined using the DPPH and FRAP methods and the consumer preference evaluated using 102 untrained panellists. From the results obtained, incorporation of ginger powder increased the iron, copper and manganese contents of yoghurt while incorporation of aqueous ginger extract led to an improvement in iron and copper content. Yoghurt spiced with ginger powder showed the highest antioxidant activity ($P<0.05$) while the yoghurt spiced with decocted dry ginger and the unspiced yoghurt had the lowest antioxidant activity ($P<0.05$). All spiced yoghurt samples had similar ($P>0.05$) ferric reduction power. The yoghurt spiced with 0.5% of ginger powder was least preferred. The yoghurt made with macerated dry ginger at room temperature had a lower level of preference compared to the samples of other yoghurt spiced with ginger extracts. The form of incorporation of ginger affects the mineral profile, the antioxidant activity and the consumer preference of yoghurt. The use of ginger extracts in the production of yoghurt can therefore be considered in the milk industry with little prospects for the incorporation of powder ginger into yoghurt.

Keywords: Antioxidant Activity; Consumer Preference; Ginger; Mineral Profile; Yoghurt

Introduction

Yoghurt is one of the most popular dairy products wide-spread all over the word. It is highly consumed due to its functional capacity attributed to its nutritive properties and its ability to provide useful bacteria to the body **[1]**. It is rich in proteins, carbohydrates, vitamins and minerals such as phosphorus and calcium **[2, 3]**. It also contain prebiotics and probiotics (lactic acid bacteria) with beneficial effects on health like the digestion of lactose, improvement of gastro-intestinal function, prevention of colon cancer, arthritis and cardiovascular diseases and reinforcement of immune system **[4-6]**.

In order to satisfy the consumer, yoghurt taste and form are diversified by use of different additives. Flavoring with fruits or fruit flavors (mostly the synthetic forms) have contributed to improve the flavor and taste of yoghurt. Natural flavors have the advantage to provide bioactive compounds such as carotenoids, phenolic compounds and tocopherols with antioxidant activity. Spiced yoghurt is

less valorized compare to fruited yoghurt. Fruits and spices are also rich in bioactive compounds with health benefits **[7]**. They are characterized by their flavor and could contribute to increase the level of yoghurt consumption, providing additional nutrients to meet body needs.

Ginger (*Zingiber officinale*) is a spice widely use in food industry because of its flavor and pungent taste. It is rich in proteins, minerals and essential amino acids **[8, 9]**. It also contains many compounds biologically active such as 6-gingerol, 6-shogoal, zingiberene, and bisabolene which are responsible of diverse medicinal properties; pungent taste and stimulant effect [**10-12]** and contain antioxidant properties **[13-15]**.

Many studies on ginger spiced yoghurt have shown its ability to increase the shelf-life of yoghurt **[16, 17]** because of its antimicrobial properties and enhanced antioxidant properties **[18-20]**. With increasing concentration, ginger powder has also been shown to improve the nutritive value of yoghurt **[16, 20]** as oppose to the ginger extract **[17]**. Although ginger contribute to improve some sensory properties of yoghurt **[20, 21]**, at high concentrations, it is not highly appreciated **[16, 17, 22]**. It is therefore imperative to determine its best form of incorporation of ginger in yoghurt production which will have positive effect on yoghurt properties and well appreciated.

The aim of the present study was to evaluate the effect of form of ginger incorporated into yoghurt during production on its mineral profile, antioxidant activity and consumer preference.

Material and Methods

Preparation of ginger powder

The roots (rhizomes) of ginger (*Zingiber officinale*) from Bafut (Bafut Sub-Division, Mezam Division, and Cameroon) were purchased from the Bamenda Food Market in the North-West Region of Cameroon and brought to the Food Technology Laboratory of the Regional Centre of IRAD-Bambui, Cameroon. The ginger was washed several times with tap water (Potable water). Then, it was peeled, rewashed using tap water, sliced into small sizes of 2-3 mm diameter thick and dried in a vacuum oven at 60-65 °C for 72 hours **[8]**. The dried ginger was blended into powder using a kitchen blender. The powder obtained was then sieved to pore size ≤ 300 µm. The sieved ginger powder was put in plastic bags, stored at room temperature in a close cupboard to avoid UV light.

Preparation of Ginger Paste

The ginger paste was obtained after successively washing, peeling, rewashing and grating of the ginger roots.

Preparation of Ginger Aqueous Extract

Ginger extracts was obtained from ginger powder and ginger paste by modified methods described by Kaushik and Goyal **[23]** and Abd El-Aziz et al. **[24]**.

Decoction

Decoction was done by boiling 100 g of ginger paste in 3.2 L of potable water (drinkable water) till one fourth (1/4) of the initial volume was attained. The solution was filtered twice using a muslin cloth, and then allowed at room temperature for sedimentation and the supernatant collected. The same procedure was used with ginger powder but using 100 g in 4 L of drinkable water.

Maceration

Maceration was done at room temperature and at refrigerated conditions (6° C). The ginger paste (100 g each) was soaked for 1 hour in 800 mL of hot portable water previously boiled and cooled at 80 °C. After cooling at room temperature, the mixture was allowed to macerate for three (03) days and filtered twice using a muslin cloth. Ginger powder was also macerated as indicated above to ginger paste but using 100 g of powder in 1 L of portable water previously boiled and cooled to 80 °C.

All the extracts collected were pasteurized at 75 °C/3-5 s, cooled at room temperature and kept in the freezer at ≤4 °C for further uses. The following extracts were obtained:

- Extract 1: Maceration of ginger paste at refrigerated conditions
- Extract 2: Maceration of ginger paste at room temperature
- Extract 3: Decoction of ginger paste
- Extract 4: Maceration of ginger powder at refrigerated conditions

- Extract 5: Maceration of ginger powder at room temperature
- Extract 6: Decoction of ginger powder

Preparation of Ginger Spiced Yoghurt

Fresh cow's milk collected from the dairy unit of the Research Centre was used to produce four yoghurt samples in five replicates. The yoghurt was made according to the modified method of Lee and Lucey **[25]**. The milk was pasteurized by heating at 85-90 °C for five minutes in a boiling water bath during which 6.5% (w/v) of sugar was added. The milk was then rapidly cooled to inoculation temperature (42-45 °C) followed by addition of 2.5% (w/v) yoghurt starter culture (CHR HANSEN YF – L811) comprising *Streptococcus thermophilus* and *Lactobacillus bulgaricus* in a 1:1 ratio and incubation at 42-45 °C for 3 hours. The yoghurt produced was directly cooled in a refrigerator (4-6 °C for 06-12 hrs) before manual stirring. After stirring, yoghurt was spiced as recommended by Njoya et al. **[16]** and Njoya et al. **[17]**. Each ginger extract was added to the yoghurt at the concentration of 5% (v/v). The ginger powder was also added at the concentration of 0.5% (w/v). The 8 experimental yoghurt samples obtained are listed as:

- Sample A: unspiced yoghurt
- Sample B: yoghurt spiced with 5% of extract 1
- Sample C: yoghurt spiced with 5% of extract 2
- Sample D: yoghurt spiced with 5% of extract 3
- Sample E: yoghurt spiced with 5% of extract 4
- Sample F: yoghurt spiced with 5% of extract 5
- Sample G: yoghurt spiced with 5% of extract 6
- Sample H: yoghurt spiced with 0.5% of ginger powder.

Determination of Mineral Profile

The mineral content (Ca, K, Na, Fe, P, Mg, Mn, Cu and Zn) of the spiced and unspiced yoghurt samples were determined as described by Benton and Vermon **[26]**. 5 g of sample was incinerated at 550 °C for 6 hours. The resultant ash was dissolved in HCl/HNO_3 and the absorbance read using absorption atomic spectrophotometer (AALAE S11). Phosphorus content was determined according to the method described by Murphy and Riley **[27]**.

Determination of Antioxidant Activity of Ginger Spiced Yoghurt

Yoghurt sample was centrifuged at 5000 tr/min at 4 °C for 20 min **[28]**. The supernatant was filtered using a membrane of 0.45 nm thick and the filtrate served for the determination of the antioxidant activity. The antioxidant activity was obtained by determination of DPPH (1,1-DiPhenyl-2-PicrylHydrazil) radical-scavenging capacity and ferric reducing antioxidant power (FRAP).

DPPH Method

The DPPH radical-scavenging capacity of yoghurt samples was determined according to Brand-Williams *et al*. **[29]**. The working solution was prepared by mixing 10 mL of stock solution (24 mg of DPPH dissolved in 100 mL of methanol stored at -20 °C until needed) with 45 mL of methanol to obtain absorbance of one unit at 517 nm using a spectrophotometer UV-VIS.50-200 µL of sample (filtrate) or 10-60 µM of catechin (positive control) were added to diluted DPPH solution to a final volume of 2000 µL and the absorbance read at 517 nm after incubation for 30 min in darkness and against the blank (methanol).The DPPH radical scavenging activity was calculated and the results were expressed as the ability of yoghurt sample to scavenge 50% (IC_{50}) of free radical DPPH.

$$\text{DPPH radical-scavenging activity} = \frac{(A0-A1)X100}{A0}$$

A0: Absorbance of the DPPH solution A1: Absorbance of the sample or standard solution

FRAP Method

The ferric reducing antioxidant power (FRAP) of yoghurt samples was obtained as described by Benzie and Strain **[30]**. FRAP working solution was prepared freshly each time and is made of 0.3 M acetate buffer (pH=3.6), 0.01 M TPTZ (2, 4, 6-tripyridyl-s-triazine) in 0.04 M HCl and 0.01 M $FeCl_3*6H_2O$ mixed in 10:1:1 (v/v/v) ratio and stored in an amber bottle. Then 2 mL of the FRAP working solution were mixed with 75 µL of sample (filtrate) and the absorbance read at 593 nm after 20 min of incubation at 37 °C against blank (acetate buffer). The FRAP content was expressed as mg catechin equivalents used as standard solution (50-600 µM).

Consumer Preference

Consumer preference of yoghurt samples was done with 102 panellists randomly chosen and made of researchers, technicians, teachers, students, housewife, etc. Yoghurt samples coded with three digital numbers were served simultaneously at 10-14 °C with commercial water (mineral water) for mouth rinsing. Panellists were asked to rank the yoghurt samples according to their preference and starting with the most preferred (first choice) to the less preferred (last choice) after testing several times. A classification scale was adopted from 1 (most preferred or first choice) to 8 (less preferred or last choice).

Data Analysis

Data collected were expressed as Means ±SD and subjected to analysis of variance (one-way ANOVA) using the Statgraphics Plus, version 5.0 statistical package. Means obtained were separated using the Fischer test (LSD) at 95% confidence level. Dendrogram was used to regroup yoghurt samples by affinity according to their order of preference.

Results and Discussion

Mineral Profile of Ginger Spiced Yoghurt

The mineral profile of spiced yoghurt samples is presented in **Table 1**. The results show that calcium, phosphorus, magnesium, potassium zinc and sodium contents of yoghurt were not affected (P>0.05) by incorporation of ginger independent of the form in which it was incorporated. The incorporation of 0.5% ginger powder (sample H) and 5% of fresh ginger extract (samples B, C and D), caused an increase (P<0.05) in iron content when compare to the unspiced yoghurt (sample A). Manganese content of yoghurt was also enhanced (P<0.05) by addition of ginger powder while ginger extracts had no effect. The copper content of yoghurt was also improved by incorporation of macerated fresh ginger at room temperature (sample C) and incorporation of decocted dry ginger (sample G) while the incorporation of other ginger extracts and ginger powder showed no significant effect (P>0.05). Yoghurt has low level of iron content **[31]** and this level have been shown to improve with the incorporation of ginger powder and extracts from fresh ginger. The effect of ginger extracts and powder on mineral profile of the yoghurt could be due to the mineral composition of the ginger. Ihemeje et al. **[32]** showed that the mineral profile of yoghurt is affected by the mineral content of the supplement used.

Minerals (mg/100g)	Yoghurt samples							
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Calcium	110.06±12.21^{a}	104.61±12.30^{a}	104.73±12.32^{a}	111.73±12.29^{a}	104.31±12.27^{a}	108.47±11.93^{a}	111.07±12.22^{a}	108.90±11.98^{a}
Potassium	128.53±14.14^{a}	125.83±13.84^{a}	123.41±13.58^{a}	115.22±13.55^{a}	124.10±13.65^{a}	113.45±13.34^{a}	114.54±13.47^{a}	131.25±14.44^{a}
Phosphorus	91.89±10.81^{a}	90.62±9.97^{a}	85.10±10.01a	94.23±10.37a	92.17±10.14a	89.27±9.82a	86.47±10.17a	94.35±10.38a
Magnesium	10.11±1.11a	9.04±1.06a	9.32±1.09^{a}	9.85±1.08^{a}	9.19±1.08^{a}	9.48±1.04^{a}	10.09±1.11^{a}	10.84±1.19^{a}
Sodium	11.42±1.25^{a}	11.44±1.25^{a}	11.08±1.22^{a}	9.90±1.16^{a}	11.08±1.30^{a}	10.38±1.14^{a}	10.59±1.34^{a}	10.13±1.19^{a}
Iron	0.08±0.01^{c}	0.16±0.01^{a}	0.14±0.01^{a}	0.15±0.01^{a}	0.08±0.00^{c}	0.10±0.01^{bc}	0.08±0.00^{c}	0.11±0.01^{b}
Manganese	0.017±0.001^{b}	0.016±0.001^{b}	0.016±0.001^{b}	0.017±0.001^{b}	0.024±0.002^{b}	0.022±0.002^{b}	0.016±0.001^{b}	0.126±0.013^{a}
Copper	0.023±0.002^{cde}	0.019±0.002^{e}	0.036±0.004^{a}	0.025±0.002^{cd}	0.022±0.002^{de}	0.020±0.002^{de}	0.032±0.003^{a}	0.029±0.003^{bc}
Zinc	0.39±0.04^{a}	0.43±0.04^{a}	0.41±0.04^{a}	0.39±0.04^{a}	0.42±0.04^{a}	0.39±0.04^{a}	0.38±0.04^{a}	0.44±0.04^{a}

Values with the same superscript letter in the same row are not significantly different (P>0.05).

A : Unspiced yoghurt;
B : Yoghurt spiced with 5% of extract 1;
C : Yoghurt spiced with 5% of extract 2;
D : Yoghurt spiced with 5% of extract 3;
E : Yoghurt spiced with 5% of extract 4;
F : Yoghurt spiced with 5% of extract 5;
G : Yoghurt spiced with 5% of extract 6;
H : Yoghurt spiced with 0.5% of ginger powder.

Table 1: Mineral profile of ginger spiced yoghurt.

Antioxidant Activity of Ginger Spiced Yoghurt

Yoghurt sample spiced with ginger powder with the lowest value of IC_{50} showed the highest ($P<0.05$) antioxidant activity while the unspiced yoghurt with the highest IC_{50} had the lowest ($P<0.05$) antioxidant activity **(Table 2)**.

Yoghurt Samples	FRAP (mEqof catechin)	DPPH radical-scavenging IC50 (µM)
A	45.32 ± 10.16^{ab}	664.39 ± 49.39^{a}
B	28.26 ± 2.20^{b}	138.73 ± 32.1^{cd}
C	37.70 ± 13.86^{ab}	179.53 ± 21.48^{c}
D	40.72 ± 8.77^{ab}	154.27 ± 26.74^{cd}
E	47.01 ± 11.59^{a}	149.43 ± 4.72^{cd}
F	45.20 ± 11.28^{ab}	109.84 ± 13.06^{de}
G	41.08 ± 7.54^{ab}	343.14 ± 41.53^{b}
H	54.51 ± 10.70^{a}	75.34 ± 13.12^{e}

Values with the same superscript letter in the same column are not significantly different ($P>0.05$).

A : Unspiced yoghurt;
B : Yoghurt spiced with 5% of extract 1;
C : Yoghurt spiced with 5% of extract 2;
D : Yoghurt spiced with 5% of extract 3;
E : Yoghurt spiced with 5% of extract 4;
F : Yoghurt spiced with 5% of extract 5;
G : Yoghurt spiced with 5% of extract 6;
H : Yoghurt spiced with 0.5% of ginger powder.

Table 2: Antioxidant activity of ginger spiced yoghurt.

Amongst the yoghurt spiced with ginger extract, yoghurt spiced with extract 6 that is the decocted dry ginger (sample G) had the highest ($P<0.05$) IC_{50} value expressing the lowest antioxidant activity. Moreover, incorporation of extract 2 that is macerated fresh ginger at room temperature (sample C) led to a lower antioxidant activity ($P<0.05$) than that of extract 5, that is dry ginger macerated at room temperature (sample F). Nevertheless, with respect to the ferric reducing antioxidant power (FRAP) values, no significant difference ($P>0.05$) was observed for all yoghurt samples. With the highest IC_{50} value and the highest FRAP value; sample H (yoghurt spiced with ginger powder) had the highest antioxidant activity amongst all the yoghurt samples. Generally, spicing of yoghurt with ginger increased the antioxidant activity. Ginger is known to have antioxidant properties due to presence of 6-gingerol, 6-shogaol, 10-gingerol, (n)-gingerol, (n)-shogaol, zingerol and paradols **[33-35]**. These properties have been shown in ginger spiced yoghurt resulting to the increase of its antioxidant activity [**20, 21, 36]**.

Consumer Preference

The results of consumer preference show that unspiced yoghurt (sample A) with 20.59% was the most preferred as first choice of the panellists **(Figure 1a)**. As first choice, the unspiced yoghurt (sample A) and the yoghurt spiced with decocted of fresh ginger (sample C) constituted one group closer to the group formed by yoghurt spiced with macerated dry ginger at refrigerated conditions (sample E) and the yoghurt spiced with decocted dry ginger (sample F). All the four samples were considered as first choice by more than 12.5% of the panellists. The yoghurt spiced with macerated dry ginger at room temperature (sample F) with 2.94% was less preferred when compared to the samples of the first choice. This constitute another group with the yoghurt spiced with ginger powder (sample H), the yoghurt spiced with macerated fresh ginger at room temperature (sample C) and yoghurt spiced with 5% of extract (sample B). Samples A and G with 17.65% and 18.63% respectively also presented high percentages as second choice **(Figure 1b)**.

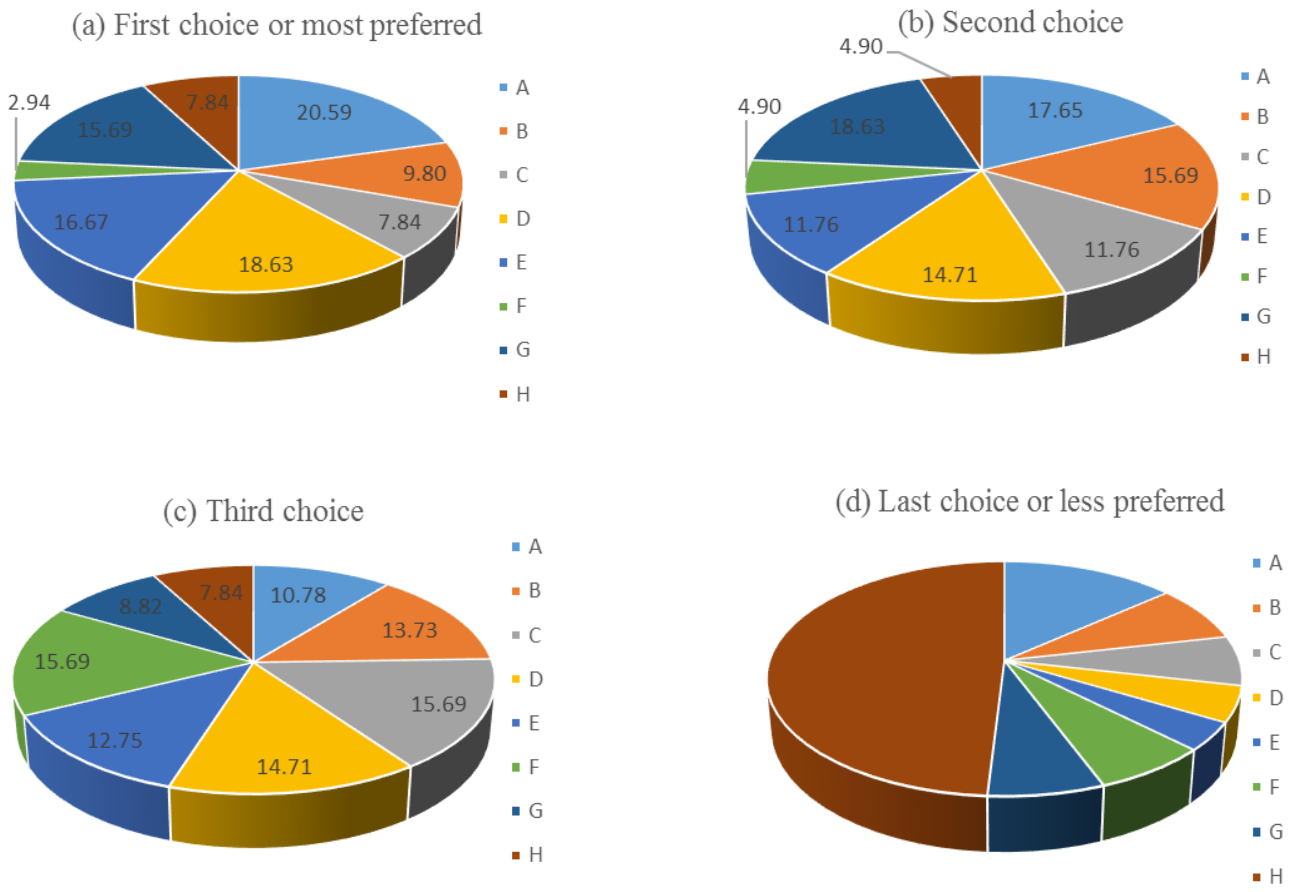
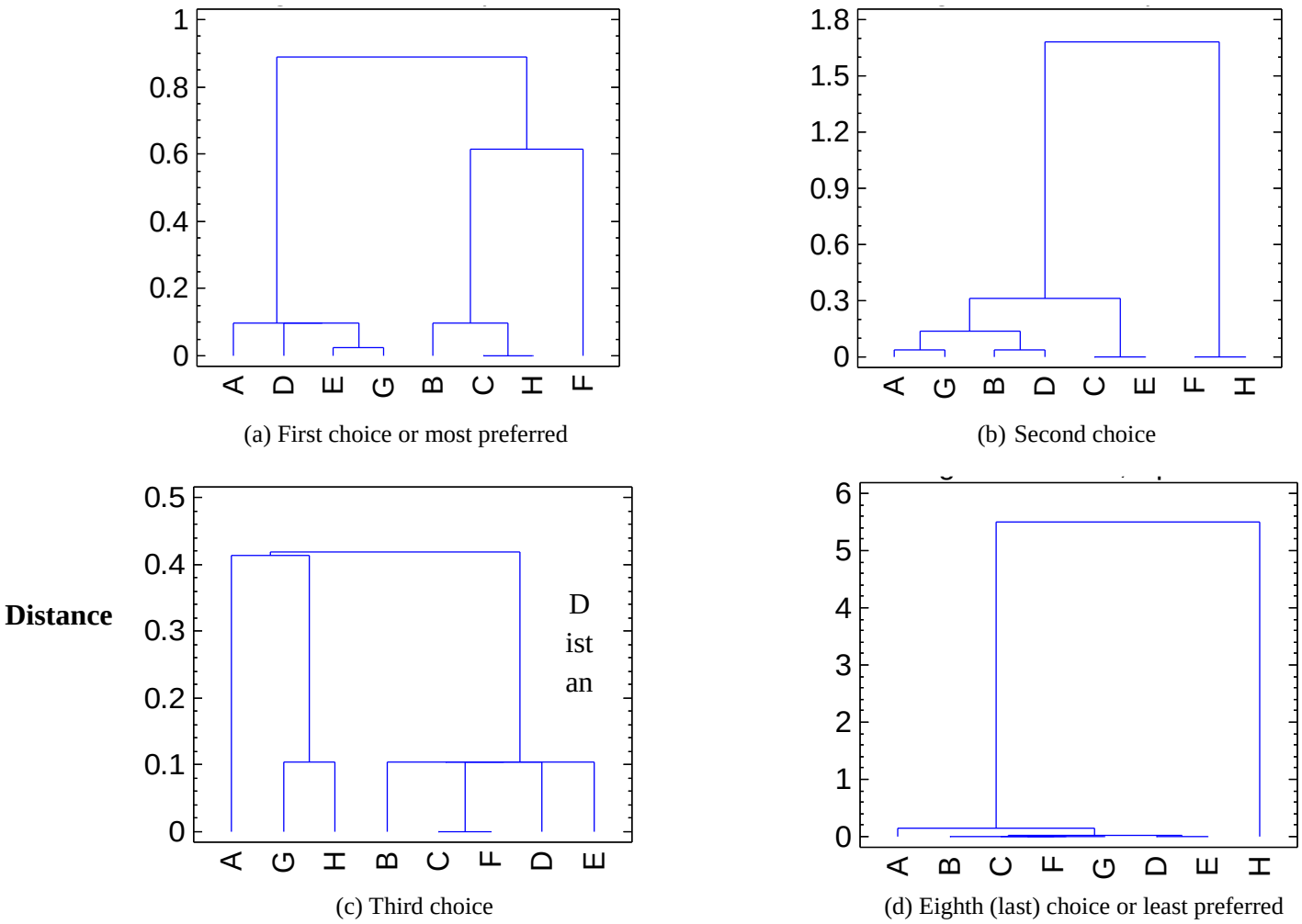


Figure 1: Circular diagram of choice (%) according to the preference level of yoghurt samples:

A	**:**	Unspiced yoghurt;
B	**:**	Yoghurt spiced with 5% of extract 1;
C	**:**	Yoghurt spiced with 5% of extract 2;
D	**:**	Yoghurt spiced with 5% of extract 3;
F	**:**	Yoghurt spiced with 5% of extract 4;
G	**:**	Yoghurt spiced with 5% of extract 5;
H	**:**	Yoghurt spiced with 5% of extract 6;
H	**:**	Yoghurt spiced with 0.5% of ginger powder.

They represented a sub-group closed to that made of samples B and D (yoghurt spiced with decocted fresh ginger) **(Figure 2b)**. Samples F and H with 4.90% were less considered as second choice by panellists and represent one group different from that made of other yoghurt samples. From the panelists, samples C and F with 15.69% were considered mostly as third choice **(Figure 1c)**. Samples B, D and E, represented a close group of samples **(Figure 2c)**. On the other hand, samples G (8.82%) and H (7.84%) were the less chosen in the third position and with sample A. Sample H (yoghurt spiced with ginger powder) was highly considered by the panellists as the least preferred yoghurt sample. This sample was chosen as least by almost 50% of the panelists as compared to 3.92% for sample E to 13.73% for sample A **(Figure 1d)**.



(a) First choice or most preferred

(b) Second choice

(c) Third choice

(d) Eighth (last) choice or least preferred

Figure 2: Dendrogram of choice according to the preference level of yoghurt samples:

A	**:**	Unspiced yoghurt;
B	**:**	Yoghurt spiced with 5% of extract 1;
C	**:**	Yoghurt spiced with 5% of extract 2;
D	**:**	Yoghurt spiced with 5% of extract 3;
E	**:**	Yoghurt spiced with 5% of extract 4;
F	**:**	Yoghurt spiced with 5% of extract 5;
G	**:**	Yoghurt spiced with 5% of extract 6;
H	**:**	Yoghurt spiced with 0.5% of ginger powder.

Yoghurt samples spiced with 0.5% of ginger powder (sample H) and 5% of extract 5 (sample F) showed high mean ($P<0.05$) in classification compare to the unspiced yoghurt (sample A) **(Figure 3)**. Thus, they were less preferred by panellists compare to the unspiced yoghurt. Incorporation of other ginger extracts did not significantly ($P>0.05$) affect the consumer preference of yoghurt. Yoghurt spiced with 0.5% of ginger powder (Sample H) was ($P<0.05$) least preferred amongst all the yoghurt samples while sample F was the least preferred ($P<0.05$) amongst yoghurt samples spiced using ginger extract except that spiced with extract 2.

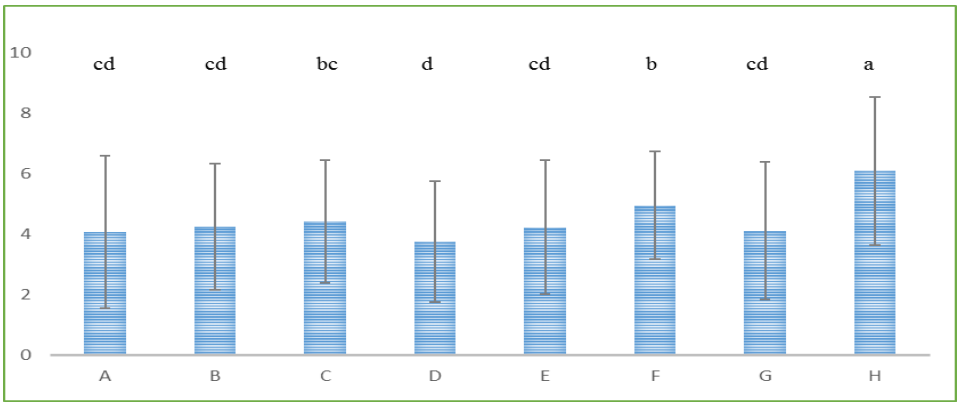


Figure 3: Means of rank of classification of yoghurt samples. (a,b,c,d): Values with the same letter in the same column are not significantly different (P>0.05); A: Unspiced yoghurt; B: Yoghurt spiced with 5% of extract 1; C: Yoghurt spiced with 5% of extract 2; D: Yoghurt spiced with 5% of extract 3; E: Yoghurt spiced with 5% of extract 4; F: Yoghurt spiced with 5% of extract 5; G: Yoghurt spiced with 5% of extract 6; H: Yoghurt spiced with 0.5% of ginger powder.

Yoghurt spiced with ginger powder was least preferred amongst all the yoghurt samples and this could be related to the pronounced ginger flavor and pungent taste which altered the original taste and flavor of yoghurt. The level of preference of yoghurt supplemented with ginger extract was generally similar to that of unspiced yoghurt and could be due to the low incidence of ginger extract on sensory properties (flavor, color, taste, etc.) of yoghurt which is not negatively affecting the yoghurt consumption. The lowest consumer's preference of yoghurt spiced with ginger powder could be related to the pronounced pungent taste of ginger which is due to the presence of 6-gingerol (1-{4'-hydroxy-3'-methoxyphenyl}-5-hydroxy-3-décanone), 6-shogaol, zingerol and zingeberol **[34, 37]**. According to Yang et al. **[20]**, Felfoul et al. **[21]**, and Larasati et al. **[22]**, ginger has negative effect on sensory properties of yoghurt at higher doses. This could be associated to the modification of texture and colour in addition to the taste of yoghurt. Ginger powder is highly concentrated than ginger extract and therefore, could reduce sensory properties of yoghurt and subsequently its consumers preference. The level of preference of supplemented yoghurt with ginger extract was generally similar to that of unspiced yoghurt and could be due to the low incidence of ginger extract on sensory properties (flavour, colour, taste, etc.) of yoghurt which can be tolerated by consumers.

Conclusion

Ginger powder enhances the iron, manganese and copper contents of yoghurt while the extract increases the iron and copper content. Ginger increases the antioxidant activity of yoghurt and this effect is more pronounced with ginger powder than ginger extract. The level of preference of yoghurt spiced with ginger powder is low compare to unspiced yoghurt whereas yoghurt spiced with ginger extracts presents similar trends than the unspiced yoghurt except the yoghurt spiced with macerated dry ginger at room temperature. Considering the benefit effect of ginger on the mineral composition and antioxidant activity of yoghurt, yoghurt spiced with ginger extract could be recommended for production at large scale.

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