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Physicochemical and sensory properties of soy-yellow corn yoghurt spiced with ginger

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Abstract

The aim of this study was to produce and evaluate the quality characteristics (physicochemical and sensory) of yoghurt from soy-yellow corn milk spiced with ginger. 5.5 g of powdered ginger was used to spice the yoghurts. Fresh cow milk was used for the production of the control yoghurt sample. Soy milk and yellow corn milk was extracted from soy beans and fresh yellow corn. Eight yoghurt samples were produced and coded L0 (control, 100:0), L1 (100:0), L2 (100:0), L3 (90:10:5.5), L4 (80:20:5.5), L5 (70:30:5.5), L6 (60:40:5.5), and L7 (50:50:5.5); cow milk, soy milk, yellow corn milk and soy-yellow corn milk spiced with ginger variations respectively. The physicochemical and sensory properties of the yoghurt samples were analysed. The results of the physico-chemical analysis revealed pH values of 4.55 to 4.70, total soluble solids, TSS: 8.76 to12.77%, Total Titratable Acidity, TTA: 0.48 to 0.56%, syneresis: 2.4 to 3.4%, moisture: 85.62 to 90.33%, fat contents: 1.87 to 3.00%, protein: 2.23 to 4.6%, fibre: 0 to 0.25%, ash: 0.28 to 0.83%, and carbohydrate values from 3.69 to 8.05%.

Keywords: Yoghurt; Soy Milk; Yellow Corn Milk; Ginger

1. Introduction

Yoghurt is a coagulated milk product obtained from the fermentation of milk by lactic acid bacteria namely *Streptococcus thermophiles* and *Lactobacillus bulgaricus.* It is one of the most widely produced and popular fermented milk products [1]. It has nutritional benefits beyond those of milk, because of its increased digestibility hence people who are moderately lactose intolerant can enjoy yoghurt without ill effects [2].

The sensory characteristics of yoghurts vary based on three main aspects which are: composition of milk as raw material, which differs according to the milk source (e.g cow, goat, buffalo or sheep; conventional or organic) and the fat content that can be adjusted to obtain full-fat, low-fat, or non-fat products; the addition of ingredients that allow modification of the sensory properties (flavour, colour, and texture) of the products, such as sweetening agents (sugar or other sweeteners for low-calorie products), flavouring agents (fruit aromas or vanilla) or fruits (small pieces enriched with sugar or jam), stabilizers (pectin, starch, or gelatin), or emulsifiers; and the technology employed for the manufacture, which may vary depending on the operations during milk pretreatment (fat and non-fat solid standardization, homogenization, or heat treatment) or yoghurt post treatment (stirring, concentration, mixing, cooling, drying, or freezing) [3].

Yoghurt can be manufactured from several raw materials both animal and plant sources (cow, goat, buffalo milk, and sheep) and plant sources (soy beans, yellow corn, coconut milk) [4].

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Soy bean (*Glycine max*) is a plant based protein which is cheaper and could serve as an alternative to cow's milk. It contains up to 40% protein compared with 1.0 to 5.6% protein content of most animal milk [5].

Corn (*Zea mays*) is one of the most popular cereals in the world and forms a staple food [6]. It has a high fibre content which helps to prevent gastrointestinal problems (constipation, colon cancer) and contributes to the well-being of the gut.

Soy -yellow corn milk is legume-cereal based milk which is produced by extraction of soy bean and corn blends. They have been developed as a result of finding solution to the problems of lactose intolerance and saturated fat of cow milk; and as sources of relatively inexpensive protein. Soy-yellow corn milk blending offers dual nutritional advantages in combating protein and vitamin A deficiency, improves the overall acceptability by both adults and children; and improves the digestibility [7,8].

The use of spices (e.g. ginger, garlic) in the production of yoghurt could be useful as they are plants rich in bioactive components with health benefits and constitute a potential source of minerals and vitamins. They are also characterized by their antimicrobial properties and could consequently positively affect the shelf life of yoghurt [9].

Ginger (*Zingiber officinale*, Roscoe) is a spice commonly used culinary for its taste, aroma and flavour [9]. Due to its antimicrobial nature, ginger could increase the shelf-life of foods [10].

It is therefore necessary to find a local substitute for cow's milk which is readily available thereby reducing post-harvest losses of legumes and cereals.

2. Materials and methods

2.1. Procurement of Raw Materials

Soy beans, fresh yellow corn, ginger roots, and sugar were purchased from Wurukum/ Wadata market Makurdi Nigeria. Cow milk was bought from farmer at Wadata market and yoghurt starter culture (freeze dry culture) containing *Lactobaillus bulgaricus* and *Streptococcus thermophilus* bacteria was bought from Modern market, Makurdi Benue state, Nigeria. The procured materials were taken to the Chemistry department laboratory, Benue State University Nigeria laboratory for processing.

2.2. Preparation of soy milk

Soy bean seeds (variety TX 1440-1E) were sorted to remove bad grains and unwanted material. The seeds were weighed and soaked in water for 12hrs; overnight (500 g/ 3 litres of water) after which they were removed and rinsed with portable water. The soaked seeds were blanched with sodium bicarbonate (1.25% $NaHCO_3$ for 30 minutes). This was to ease dehulling and also prevent bloating by expelling some gases and anti-nutrients [11]. The dehulled seeds were then wet milled by adding water (3:1 water to beans on weight basis). The extract was sieved with the aid of a sieve (0.5 mm) to obtain the milk. The milk was pasteurized at 71^{o}C for 30 minutes. The soy milk was rapidly cooled and stored at 18^{o}C for future use in the production of yoghurt.

2.3. Preparation of yellow corn milk

Maize variety DMR SLR yellow was harvested at milking stage (just at maturity), the silks were removed and the grains separated from the cobs [12]. The grains were rinsed with portable water to remove any remaining silk. 500 g of corn grains were wet milled (50 mL per 100 g of yellow corn). The mixture was then sieved using a 0.5 mm sieve to obtain the extract. The extract was pasteurized (80^{o}C for 15 mins), cooled, packaged and stored at 18^{o}C for future use to produce yoghurt.

2.4. Preparation of Ginger powder

Fresh ginger roots (*Zingiber officinale Roscoe*) were washed, peeled, rewashed, sliced, weighed and dried with a stainless steel tray drier at 50^{o}C/72hrs until moisture content was less than 10% (weight basis). The dried sliced ginger was milled to powder using an electric grinder and sieved to pore size < 300 μm. The sieved ginger powder was then put in plastic bags, stored at room temperature in a close cupboard to avoid UV light [13, 14].

2.5. Sample Formulation

Various yoghurt samples were prepared by varying the concentration of cow milk, corn milk and soy milk. Yoghurt samples were spiced with an equal amount of ginger (5.5 g), but for the control samples. This is indicated on table 1.0

Table 1 Yoghurt samples

Samples	Cow milk: soy milk: yellow corn milk: ginger
L0(Yoghurt)	100:0:0:0
L1	0:100:0:0
L2	0:0:100:0
L3	0:90:10:5.5
L4	0:80:20:5.5
L5	0:70:30:5.5
L6	0:60:40:5.5
L7	0:50:50:5.5

2.6. Production of cow milk yoghurt

Yoghurt was prepared according to the method described by Lee and Lucey (2010) [15]

2.6.1. Procedure

Firstly, fresh milk was filtered using a 0.5 mm sieve to remove unwanted particles like fur which might have gotten into the milk during milking. The milk was then measured using a graduated cup, followed by homogenization and standardization. This was followed by pasteurization at a temperature of 85^{o}C for 30 minutes and rapidly cooled to 45^{o}C. 3% v/v yoghurt starter culture was added. The mixture was then kept in the incubator for 3hrs for fermentation to occur and for the coagulum to be formed. After this the mixture was removed from the incubator and kept in the refrigerator at 4-6^{o}C for 8hrs for proper cooling. 6.5% w/v of sugar was added to the mixture and stirred properly. Proper mixing was done and the yoghurt packaged. It was stored in the refrigerator at < 6^{o}C for consumption and use.

2.7. Production of soy yoghurt.

This follows the same steps like in production of yoghurt from cow milk but the main ingredient used is soy milk.

2.7.1. Procedure

Already prepared soy milk was heated to inoculation temperature (45^{o}C). 3% v/v of yoghurt starter culture was added and the mixture incubated at 45^{o}C for 3hrs for fermentation to occur and also for the coagulum to be formed, after which it was kept to cool for 8hrs. Mixing was then done during which 6.5% w/v powdered sugar was added and 5.5 g ginger powder added for the spiced samples. The yoghurt was then packaged in clean sterilized bottles and stored at below 6^{o}C [12].

2.8. Production of yellow corn milk yoghurt

2.8.1. Procedure

The already prepared yellow corn milk was heated to inoculation temperature (45^{o}C), and 3% v/v of yoghurt starter culture was added. The mixture was incubated at 45^{o}C for 3hrs for fermentation to occur and also for the coagulum to be formed, after which it was kept to cool for 8hrs. Mixing was done during which 6.5% w/v powdered sugar and 5.5 g ginger powder was added. It was then packaged in clean sterilized bottles and stored in the refrigerator at below 6^{o}C [7].

2.9. Production of soy-yellow corn milk yoghurt spiced with ginger

Already prepared soy-yellow corn milk was heated to inoculation temperature (45^{o}C), and 3% v/v of yoghurt starter culture was added. The mixture was incubated at 45^{o}C for 3hrs for fermentation to occur and also for the coagulum to be formed, after which was kept to cool for 8hrs. 6.5% w/v powdered sugar and 5.5 g powdered ginger was added and mixed properly. It was then packaged in clean sterilized bottles and stored in the refrigerator at below 6^{o}C. [16]

2.10. Physicochemical analysis of yoghurts

Physicochemical analysis of the yoghurt samples was determined by methods described by AOAC (2012) [17] and carbohydrates by difference.

2.10.1. Sensory evaluation

Yoghurt samples were presented to 30 untrained panelists comprising of MSc/PhD students of the Food Science and Technology course of the Chemistry Department in Benue State University Makurdi, Nigeria. A nine point hedonic scale was used for the evaluation with 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, 9=like extremely. Panelist were given palette cleanser to rinse their mouth before proceeding with the next sample. The appearance, aroma, taste, mouth feel, and overall acceptability were evaluated by panelist.

2.10.2. Statistical analysis

The statistical package for social science V21 (SPSS) computer software was used to analyze the data obtained. Mean and standard deviation was calculated where appropriate. Analysis of variance (one way ANOVA) was used to determine the treatments that were different from the others in the various parameters tested; differences were considered at 95% ($p < 0.05$) significant level.

3. Results and Discussion

3.1. Physical properties of yoghurt samples

The results of the physical properties of yoghurts are shown in table 2. pH values ranged between 4.55 to 4.70. This could be due to the composition of the milk, the ingredient used and the activity of lactic acid bacteria [9].This was in accordance with the standard which states that yoghurt should have a minimum standard of ≤ 4.6 [18]. Similar results were obtained by Gabriel *et al.,* in their work on Production of probiotic yoghurt flavoured with the spice *Aframomum danielli*, straw being and vanilla. Sample L3 containing 90:10:5 soy-yellow corn milk spiced with ginger recorded the highest value 4.77 for pH. This may be due to the presence of organic acids and fermentable sugars. There was a gradual decrease in pH with addition of yellow corn milk and ginger powder. This could be due to the presence of high level amino acids in yellow corn milk [19**]** and also the acidic nature of ginger powd**er [19]**. Similar results were recorded by Ihemeje *et al.,* 2014 in Production and quality evaluation of flavoured yoghurts using carrot, pineapple, and spiced yoghurts using ginger and pepper fruit **[20**]. Results of Total Titratable Acidity (TTA) ranged between 0.48 to 0.56%. The control sample, L0 had TTA value 0.56% higher than those containing soy- yellow corn milk spiced with ginger. This could be as a result of the presence of different kind of substrate. Soy yellow corn milk contains fructose sugars and sucrose as a result of the addition of sugar, unlike cow milk in the control which contains only lactose as the major substrate. *S. thermophillus* and *L. bulgaricus* has an ability to consume lactose and fructose and convert them into lactic acid via Embden-Meyerhof-Parnas (EMP) pathway, but *L. bulgaricus* unable to consume the sucrose into lactic acid via EMP pathway because the bacteria do not produce invertase [21]. TTA depends mostly on the availability of nutrients, water activity and the activity of lactic acid bacteria which fermented the sugars to lactic acid. The decrease in TTA for the samples spiced with ginger could be due to more availability of lactose to the fermenting microbes. However, these values were within the range 0.6% recommended for plain yoghurts [22]. Syneresis values ranged between 2.50 to 3.40%. There was a drop in the syneresis with addition of yellow corn milk and ginger powder compared to the sample containing 100% soy milk (L1). This might be due to the presence of more total solids in the soy-yellow corn milk. Corn is known to contain high amounts of starch about 10-11% starch and this amount is higher in sweet yellow corn, compared to other varieties Also, ginger is known to contain considerable amounts of starch. These act as stabilizer in the yoghurt thereby preventing high level syneresis [9, 23]. Total soluble solids ranged between 8.76 to 12.77%. Increasing the quantity of corn milk lead to increase in total soluble solids. Samples containing Yoghurt produced from 100% soy milk had a lower value compared to that produced from soy-yellow corn milk spiced with ginger. This might also be due to the presence of suspended particles in the soy-yellow corn milk. Sweet yellow Corn is very high in fermentable sugars(sucrose), thus increasing the soluble solid content of the yoghurt [20]. Sweet corn is also known to contain about 9-16% of sugar in general[24]**.**

Table 2 Physical properties of yoghurt samples

Sample C:S:Y	TTA (%)	pH	Total Soluble solids (%)	Syneresis (%)
L0 100:0:0	0.56^{a}±0.03	4.70^{a}±0.00	8.76^{d}±0.04	2.50^{c}±0.00
L1 0:100:0	0.48^{c}±0.00	4.70^{a}±0.00	10.77^{c}±0.04	3.40^{a}±0.14
L2 0:0:100	0.48^{c}±0.01	4.60^{a} ±0.28	11.77^{b}±0.03	2.50^{b}±0.28
L3 0:90:10:5.5	0.54^{ab}±0.01	4.77^{a} ±0.00	10.77^{c}±0.00	2.60^{c}±0.00
L4 0:80:20:5.5	0.55^{ab}±0.06	4.70^{a} ±0.00	12.77^{a}±0.00	3.00^{ab}±0.71
L5 0:70:30:5.5	0.50^{bc}±0.01	4.67^{a}±0.00	11.77^{b}±0.00	3.20^{b}±0.00
L6 0:60:40:5.5	0.52^{abc} ±0.03	4.65^{a}±0.00	12.77^{a}±0.00	2.70^{c}±0.28
L7 0:50:50:5.5	0.56^{a} ± 0.01	4.55^{a}±0.00	12.77^{a}±0.00	2.90^{ab}±0.00

All values are means of triplicates. Means with the same superscript within the same column are not significantly different (p>0.05).; **Key:** C: cow milk, S: soy milk, Y: yellow corn milk, G: Ginger powder in grams

Table 3 Results of Proximate Composition of Yoghurt Samples

Sample C:S:Y:G	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fibre (%)	Carbohydrate (%)
L0 100:0:0	85.88^{fg}±0.05	0.83^{a}±0.04	2.23^{e}±0.06	3.00^{a}±0.10	0.00±0.00	8.05^{a}±0.05
L1 0:100:0	90.33^{a}±0.11	0.28^{d}±0.01	3.07^{d}±0.06	2.50^{b}±0.00	0.13^{c}±0.00	3.69^{d}±0.17
L2 0:0:100	88.20^{d}±0.07	0.35^{c}±0.03	3.53^{c}±0.12	1.87^{f}±0.06	0.15^{c}±0.01	5.90^{b}±0.16
L3 0:90:10:5.5	89.22^{b}±0.01	0.30^{d}±0.03	3.50^{c}±0.12	2.30^{c}±0.00	0.20^{bc}±0.02	4.48^{c}±0.02
L4 0:80:20:5.5	88.64^{c}±0.46	0.29^{d}±0.00	4.16^{b}±0.06	2.10^{d}±0.01	0.24^{b}±0.01	4.57^{c}±0.52
L5 0:70:30:5.5	87.05^{e}±0.01	0.36^{bc}±0.04	4.60^{a}±0.06	1.98^{e}±0.13	0.25^{a}±0.06	5.76^{b}±0.16
L6 0:60:40:5.5	86.14^{f}±0.00	0.38^{bc}±0.01	4.57^{a}±0.06	2.00^{e}±0.15	0.24^{a}±0.15	6.67^{b}±0.62
L7 0:50:50:5.5	85.62^{g}±0.31	0.40^{b}±0.01	4.17^{b}±0.12	1.98^{e}±0.02	0.25^{a}±0.03	7.58^{a}±0.17

Values are means ± SD triplicate determinations Values with different superscript within the same column are not significantly different (p>0.05); **Key:** C: cow milk, S: soy milk, Y: yellow corn milk, G: Ginger powder in grams

Table 4 Sensory evaluation of yoghurts

Sample C:S:Y:G	Appearance	Aroma	Taste	Mouth feel	General Acceptability
L0100:0:0	8.23^{a}±0.73	5.43^{c}±1.11	8.03^{a}±1.00	7.80^{a}±1.06	8.07^{a}±1.01
L1 0:100:0	6.10^{de}±0.71	5.47^{c}±0.86	5.80^{d}±0.85	5.97^{c}±0.81	6.37^{b}±1.03
L2 0:0:100	6.03^{e}±1.00	5.87^{b}±0.78	5.87^{d}±0.82	5.57^{c}±0.86	6.33^{b}±1.03
L3 0:90:10:5.5	6.73^{bc}±1.17	6.77^{a}±0.97	6.20^{bcd}±1.24	6.57^{b}±0.82	6.37^{b}±1.13
L4 0:80:20:5.5	7.13^{b}±0.97	6.83^{a}±1.18	6.77^{b}±1.14	7.03^{b}±1.03	6.60^{b}±1.43
L5 0:70:30:5.5	6.57^{ed}±0.86	6.77^{a}±1.50	6.73^{bc}±1.08	6.70^{b}±0.95	6.57^{b}±1.28
L6 0:60:40:5.5	6.80^{bc}±1.32	6.47^{a}±1.33	5.67^{d}±1.09	5.90^{c}±1.16	6.07^{b}±1.08
L7 0:50:50:5.5	6.63^{bc}±0.93	6.73^{a}±1.20	6.17^{cd}±1.23	5.90^{c}±1.21	5.93^{b}±1.20

All values are means ± SD of triplicates. Means with the same superscript within the same column are not significantly different (p>0.05); **Key:** C: cow milk, S: soy milk, Y: yellow corn milk, G: Ginger powder in grams

The results of proximate composition are shown in table 3 above. The moisture content of yoghurt samples ranged between 85.62% to 90.33%. Yoghurt containing 50% yellow corn milk spiced with ginger, L7 had the lowest moisture content (85.62) and this value was just slightly different from the control sample, L0 (85.88%). Addition of yellow corn milk and powder ginger thickened the yoghurt[25] The sample containing 100% soy milk (L1) recorded the highest moisture content 90.33%. This could be due to the dilution factor during processing of soy milk. Samples produced from soy-yellow corn milk spiced with ginger had higher moisture content compared to the control sample, L0 (100% cow milk). This is also as a result of the dilution effect during the processing of soy milk and yellow corn milk. Addition of yellow corn milk and ginger powder lead to reduction in moisture content. This could be as a result of starch present in ginger acting as natural stabilizer and thickener in the product [25,9]. This are similar to those obtained by Olakunle *et al.* and Joel *et al.* in production and quality assessment of functional yoghurt enriched with coconut [16,26].

Protein contents ranged between 2.23% to 4.60%. Protein contents increased with addition of yellow-corn milk. Soy beans and yellow corn especially are rich in proteins [27**]**

Fibre contents of yoghurts ranged from 0 to 0.25%. The low fibre content could be as a result of the extraction process of the milk. This value recorded is less than that reported by Joel *et al.* in production and quality assessment of functional yoghurt enriched with coconut who recorded higher values for fibre content of yoghurt with addition of coconut-cake [26]. No fibre was detected in the control sample L0 (100% cow milk). This is due to the absence of fibre in animal milk [28].

Results of fat contents ranged between 1.87 to 3.00%. This was within the range of the standard <3.5 reported by Saint-Eve and Joel *et al.*[29, 26]. The control sample L0, recorded the highest value for fat content. This is because the milk was not skimmed before use. High fat content leads to quick deterioration of the product due to rancidity thereby influencing the stability and shelf-life of the produc**t**[30]. Sample L2 containing pure 100% corn milk recorded the lowest fat content. This accounts for the fact that corn is rich in proteins but low in fats. Addition of corn milk and ginger powder lead to decrease in the fat content of the yoghurts. This is in accordance with findings by Njoya *et al.,* Yousef *et al.* who showed that use of additives low in fat content lead to reduction of fat content of yoghurt [31,32]. Low fat contents may contribute to increase shelf-life of the yoghurts as a result of decrease rancidity [16].

Ash content of yoghurt samples ranged between 0.83% in the control sample, L0 to 0.28% in the sample containing purely yellow corn milk (L2). High ash content is an indication of the presence of more minerals [16]. Addition of yellow-corn milk and powder ginger lead to a gradual increase in ash content. This could be due to the minerals present in yellow corn and ginger, leading to increase ash content [16, 20]. With respect to the control sample, there was a decrease in ash content with addition of ginger powder. This could be due to the dilution factor. Ash content depends on the composition of the milk, the quantity and number of ingredients used [9].

Carbohydrate contents ranged between 3.69% for soy milk yoghurt (L1) to 8.05 for pure cow milk yoghurt (L0) this results are similar to those reported by Olakunle *et al.* [16]

3.2. Sensory properties of yoghurts

The mean scores of the organoleptic attributes of yoghurts are shown in table 4. There was a significant difference ($p<0.05$) among the yoghurt samples. In terms of appearance, the control sample L0 was rated best (8.23) followed by L4 (80% soy milk: 20% corn milk spiced with ginger). Panelist still preferred the creamy colour of cow milk compared to the spiced yoghurt samples. The spiced yoghurt samples were rated best in terms of aroma. This confirms to the findings of Njoya *et al.* in the work Effect of ginger extracts on the physicochemical and sensory properties of yoghurt. Also, corn milk is known for its aroma, therefore addition of corn milk and ginger powder greatly enhanced the aroma of the yoghurts [9]. The control sample L0 was rated best in terms of taste. Unspiced 100% soy milk yoghurt and 100% yellow corn milk yoghurt were rated least in terms of taste compared to those spiced with ginger. This shows that ginger powder and yellow corn milk greatly improved the taste of the yoghurts. In terms of texture sample L0 had the highest score and it was closely followed by L4, and L5. Samples L1, L2, L6, and L7 were rated least and were not significantly different. All samples were generally accepted by panelist with sample L0 being significantly different ($p>0.05$) from all the other samples. Sample L1 and L2 were scored least for all the parameters while there was no significant difference between samples L3, and L6. All yoghurt samples were generally accepted by panelist.

4. Conclusion and Recommendations

The findings from this study shows that yoghurt produced from soy-yellow corn milk spiced with ginger has great nutritional and health benefits to consumers compared to that produced from cow milk. The results of the

physicochemical and sensory properties revealed yoghurt with better quality characteristics and overall acceptance compared to the conventional yoghurt (cow milk yoghurt). It therefore shows that yoghurt can be produced from soy-yellow corn milk spiced with ginger in various ratios, with 80:20:5.5 and 70:30:5.5 soy milk: yellow corn milk: ginger ratio being the best.

Therefore, the population should be sensitized on the nutritional and health benefits of yoghurt produced from soy-yellow corn yoghurt spiced with ginger. Also more processing plants should be employed for the production of soy-yellow corn milk for yoghurt production. Yoghurt should be largely produced from soy-yellow corn milk spiced with ginger in the ratio 80:20:5.5 and 70:30:5.5 soymilk: yellow corn: ginger.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Authors Contributions

E. L. C carried out the experiment and collected the data and analysed them; D. A and B. A. K contributed supervision in the experiment, paper formatting, helped to check the English, grammar and also processing process during submission to the journal.

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