

Original Research Paper

Chemical Composition, Texture and Sensory Evaluation of Yogurts Supplemented with Amaranth Flour

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Abstract: This study aimed to assess the effect of adding non-roasted and roasted amaranth flour to yogurt at a dose of 5 g per 100 mL on the approximate composition, storage stability, texture and sensory evaluation of yogurt. Yogurt without supplementation was used as control. The products were evaluated for moisture, carbohydrate, protein, fat, ash and mineral content. In order to assess the rheological properties, the following indicators of PH, acidity and syneresis of yogurts were measured after 1, 7, 15 days of storage. To analyse and evaluate such indicators of yogurts as color, texture, taste, aroma and overall acceptability, ten faculty members used a hedonistic scale. The results showed that samples with supplements were significantly higher in protein, carbohydrate and fat. Thus, the study arrived that yogurt from goat's milk could be used. However, adding more than 5 g 100 mL non-roasted amaranth flour had undesirable effect on gel stability (increasing of total acidity and syneresis). Still, adding roasted amaranth flour increased sensory properties: Improved aroma and gave a nutty taste to the finished product.

Keywords: Chemical Composition, Texture, Sensory Evaluation, Yogurt Amaranth Flour

Introduction

It is now well established from various studies that amaranth (lat. *Amaranthaceae*) is a genus of flowering plants of the amaranth family, a cereal crop domesticated since ancient times (Czaplicki *et al.*, 2012). In the past few years, there has been renewed interest in grain amaranth as healthy and nutritive source. The reason of that, if compared to such basic grains as wheat and rice, amaranth holds more protein with a well-balanced amino acid composition, vitamins, minerals and phytochemicals (Alvarez-Jubete *et al.*, 2010; Collar *et al.*, 2014; Curti *et al.*, 2017; Singh and Punia, 2020).

Many authors (Sun *et al.*, 1999; Xu and Sun, 2001; Aguilar *et al.*, 2013; Singh and Punia, 2020) state that Amaranth species, being widely distributed in places as diverse as Africa, India, China, North and Central America and the South American Andes, are likely to have different domestication and origin centers. By all the species, *Amaranthus caudatus*, *Amaranthus hypochondriacus* and *Amaranthus cruentus* are mainly grown for seed production (Capriles *et al.*, 2008; Repo-Carrasco-Valencia *et al.*, 2009). According to (Barrio and Añón, 2010) these species consider as pseudocereals, with a high content of seed

protein, lysine content and versatile usage. It has been documented that amaranth seeds are benefited for food and feed use (Lyon and Becker, 1987; Zhang *et al.*, 2019). Despite the fact that in amaranth seeds the oil content is only 5-8%, amaranth seed oil is gaining increasing attention due to its high content of unsaturated fatty acids and a large number of biologically active compounds, especially squalene (2.4-8.0%) (Cicero *et al.*, 2018; Zhang *et al.*, 2019). Thus, several studies (Hlinková *et al.*, 2013; Zhang *et al.*, 2019) have shown that "amaranth seed generally contains 12.6-18.0% of protein, 5-8% fat, 60-65% saccharides and 3-5% crude fibre". The amaranth grain can be used in different types: Toasted, popped, milled into flour. Therefore, it could be consumed as such or be included in other products as crackers, cookies, etc. (Rastogi and Shukla, 2013; Shinde *et al.*, 2020). Previous research has confirmed that amaranth seeds are helpful for patients with coronary heart disease and hypertension (Martirosyan *et al.*, 2007; Zhang *et al.*, 2019).

Goat's milk with increased content of bioactive components constituted a valuable raw material for the production of Ayran based on the process of lactic milk fermentation. The beneficial health properties of Ayran are linked to the fatty acid profile of goat milk

(Shunekeyeva *et al.*, 2021). Compared to regular milk, fermented milk is more nutritious and has a higher content of proteins, vitamins and minerals (Hashemi *et al.*, 2015; Curti *et al.*, 2017).

Fermented milk is a high-consumed foods in the world. For the consumer such characteristics as general properties of the yogurt, the acidity level, the formation of aromas, appearance, color and texture (sensory profile) are important to make a choice (Sfakianakis and Tzia, 2014; Curti *et al.*, 2017). The present work aims to determine texture, composition, stability during storage and sensory evaluation of yogurts supplemented with non-roasted and roasted amaranth flour. The data presented here are of great importance for the development of yogurts from amaranth flour.

Materials and Methods

Amaranth Grain Processing

Experimental samples of amaranth seeds were taken from Shokan Ualikhanov Kokshetau University, department of Plant Growing and Soil Science (Variety "Cherginsky", *Amaranthus fruentus*), then were manually sorted and rinsed under tap water for 30 min (Chemeda and Bussa, 2018; Shinde *et al.*, 2020). The washed grains were dried for 5-6 h at $55\pm 5^\circ\text{C}$, then packed in plastic bags and stored at room temperature $20\text{-}25^\circ\text{C}$ (Sushil and Suneeta, 2008; Sindhu *et al.*, 2019; Shinde *et al.*, 2020). To obtain unroasted amaranth flour, the seeds were ground with a coffee grinder and then sieved in 250 μm . Roasted flour was obtained in oven (Gorenje, Slovenia) at $127\pm 1^\circ\text{C}$ for 5-6 min or till golden brown color and cooled to $20\text{-}25^\circ\text{C}$ (Shinde *et al.*, 2020). The Fig. 1 depicts the preparation of flour from roasted amaranth grain (Shinde *et al.*, 2020).

Yogurts Formulation

Goat's milk was obtained from the breeding farm "Zerenda" (Akmola region, Kazhymukan village). The goat milk was obtained from the goats of the Saanen (Shunekeyeva *et al.*, 2021; Shunekeyeva, 2021). The preparation of amaranth flour supplemented yogurts were as follows: 5 g.per 100 mL sugar and different concentrations of non-roasted amaranth flour (hereafter, F1: 5 g.per 100 mL) and roasted amaranth flour (hereafter, F2: 5 g.per 100 mL) were added to pasteurized goat milk, mixed during 2 min, then heated at 44°C and injected the amount recommended by the manufacturer which is 0.02 g.per 100 mL of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* YO-MIX 883 50 DCU from Danisco France SAS, Paris, France (commercial lyophilized culture). The samples were added 0.20 mL of vanilla per 100 mL, packed in sterile plastic cups and incubated in an oven at $43\text{-}45^\circ\text{C}$ until a pH of 4.6 was reached. At the end of the fermentation, the yogurts were cooled in a refrigerator to 5°C

and stored for 15 days. As a control treatment was used an yogurt without additives.

Proximate Composition

Total solids, protein, fat, ash, sensory evaluation and titratable acidity were determined in accordance with the methods described by the standard methods:

- GOST 23327-98 (1998) "Milk and dairy products. Method for measuring the mass fraction of total nitrogen by Kjeldahl and determining the mass fraction of protein"
- GOST 32940-2014 (2015) "Goat raw milk. Technical conditions"
- GOST 3624-92 (1994) "Milk and dairy products. Titrimetric methods for the determination of acidity"
- GOST 3625-84 (1985) "Milk and dairy products. Methods for determining the density"
- GOST 3626-73 (1974) "Milk and dairy products. Methods for determining moisture and dry matter"
- GOST 5867-90 (1991) "Milk and dairy products. Methods for determining fat"

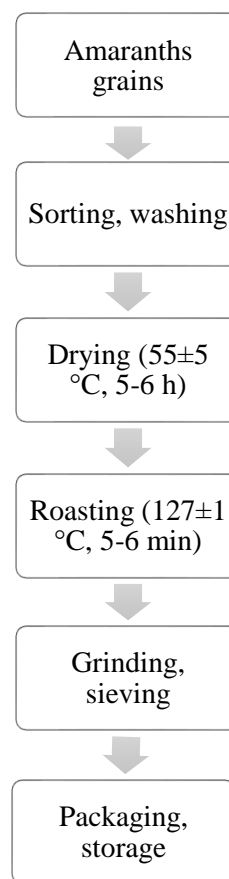


Fig. 1: Flow chart for the preparation of roasted amaranth grain flour

Yogurts Stability During Refrigerated Storage

During storage at 5°C at 1st, 7th, 15th days the pH were recorded using a digital pH-meter (Russia) and total acidity by titration of yogurt samples ("Milk and dairy products. Titrimetric methods for the determination of acidity", 2009). Contingent viscosity measurements were taken at 20°C with a simple method: By-product leaking time from a pipette (100 mL) with outlet diameter (5 mm). The time of the clot leaking (at the end of fermentation) should be at least 20 sec. Whey was collected from a yogurt cup and the results were presented as a percentage of the original yogurt weight (GOST 31981-2013, 2013). The average value of 3 measurements was taken.

Yogurts Instrumental Texture

After one day of storage, a texture profile analysis was carried out by employing a Reokon-2 texture analyzer (Russia). The yogurts were pressed in the original containers using a flat indenter and an acrylic cylindrical probe at a depth of 2 mm at a compression rate of 7.6 mm/sec. (Shunekeyeva *et al.*, 2020).

Sensory Evaluation

The yogurts with the addition of amaranth flour were evaluated for acceptability by a faculty members (men: 4; women: 6), recruited from among the teachers of the Polytechnical Faculty, Shokan Ualikhanov Kokshetau University, Kazakhstan. Panelists were asked to taste the yogurts without being told which ingredient was added. 30 mL of each of the two experimental samples and control sample were introduced simultaneously in disposable plastic cups. The panelists were asked to rate their preferences for taste, aroma, color, texture and overall acceptability. All samples were served at 5±1°C and filtered tap water was used to clean the mouth between samples. The rating scale was nine-point, ranging from "like extremely" to "dislike extremely".

All panelists gave written informed consent to participate in the study (Hekmat and Reid, 2006).

Statistical Analysis

One-way Analysis Of Variances (ANOVA) was used to test for differences between the proximate composition of the yogurt samples. A chi-squared test used to determine the magnitude of differences in scores assigned on a hedonic scale to sensory attributes and a p-value <0.05 was assented as significant. Data are presented as mean ± standard deviation. Statistical analyses were conducted using statistical program Statistica (StatSoft, Russia).

Results

Proximate Composition

Chemical composition: Moisture (9.7%), dry mass for carbohydrates (59.5%), ashes (1.85%), fats (4.5%) and proteins (9.8%) of amaranth flour (Alekseeva, 2013).

Chemical composition: Ca (0.9-1.0g), P (0.5-0.6%) and proteins (14.1%) of amaranth flour (Derkanosova *et al.*, 2016).

The proximate composition of non-roasted amaranth flour corresponded to data from different sources (Alekseeva, 2013; Derkanosova *et al.*, 2016) for moisture, dry mass for carbohydrates, ashes, fats and proteins. Table 1 shows physical and chemical indicators of amaranth flour, Ca, Na and P contents in mg 100 mL.

It was possible to formulate yogurts supplemented with amaranth flour at 5 g 100 mL. According to the results, there were significant differences in carbohydrate, protein and fat content between the control and the supplemented yogurts (Table 2). The decrease in moisture content was observed as an increase in flour concentration, although ash (except F2) and minerals (mainly Na and P) did not differ significantly between samples (Table 2). The lowest calcium content was found in F2.

Stability of Yogurts During Refrigerated Storage

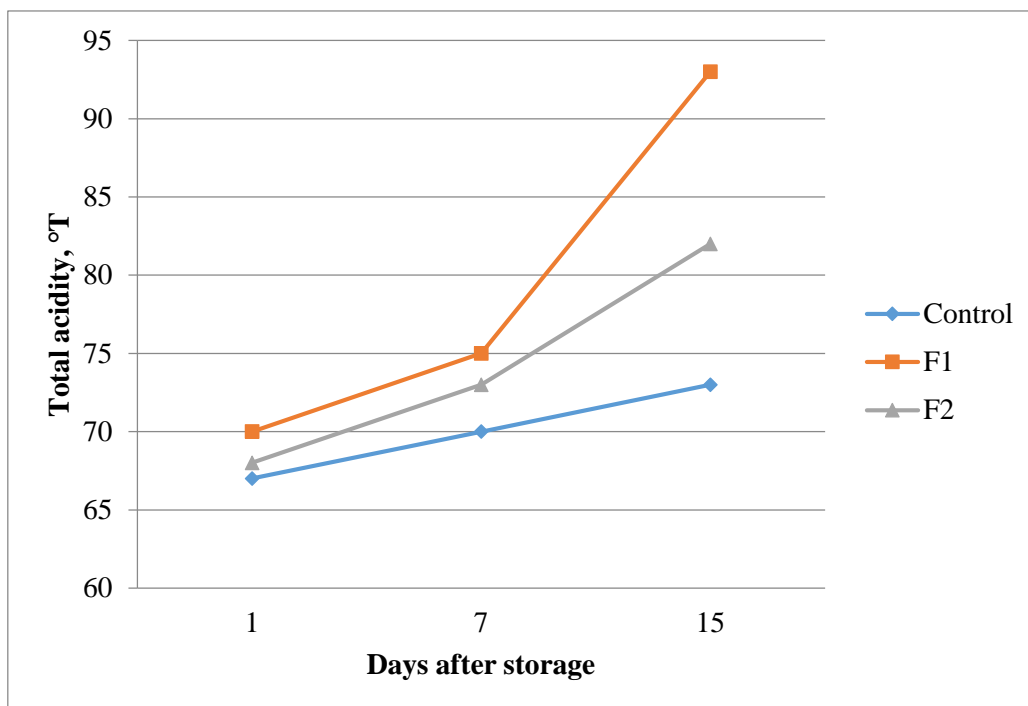
A higher increase in total acidity values was observed in the samples with a larger amount of amaranth flour (F1) than in the control and yogurt with the addition of fried amaranth flour (Fig. 2). The pH values of all products dropped during storage (Fig. 2) and the largest decrease was observed in F1 as a consequence of the increase in total acidity (Fig. 2). Syneresis was noticed in yogurt supplemented with non-roasted amaranth flour and control sample and percentages of whey separation corresponded to 0.41 and 0.37% at 15 d of storage respectively.

Instrumental Texture of Yogurts

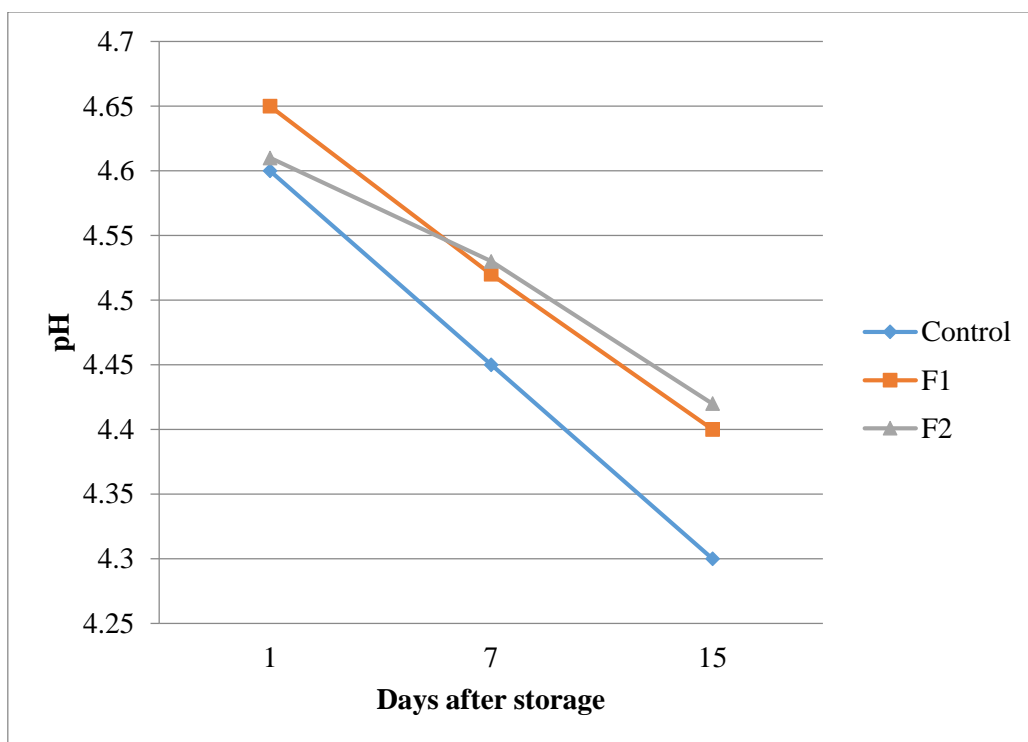
Samples of finished products with amaranth flour were probed using by Reokon-2 (Fig. 3). The steeper the graph rises, the stronger the clot formed (Shunekeyeva *et al.*, 2020; 2021). According to the data received, the strongest yogurts clot is obtained by adding amaranth flour (F1, F2).

Sensory Evaluation

In terms of sensory score, F2 performed better on all sensory features and was significantly different from F1 and the control sample (Table 3). However, there were minor differences between F1 and F2 (Table 3). The mean score for overall acceptability in F2 was 7.15 which corresponds to "like the product moderately".



(a)



(b)

Fig. 2: Total acidity values (a) and pH values (b) of supplemented yogurts. Yogurts supplemented with amaranth flour (non-roasted and roasted)

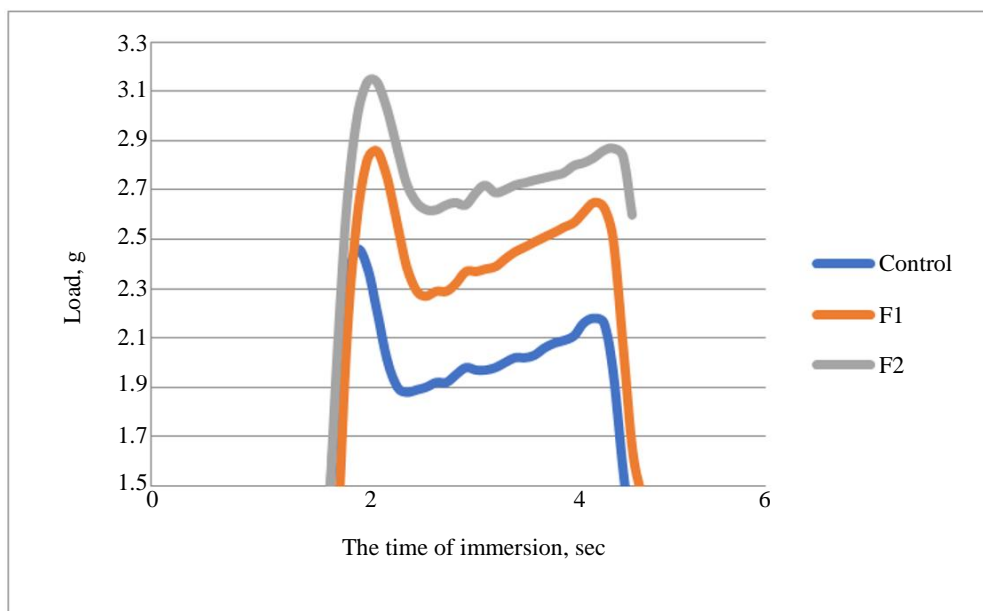


Fig. 3: Structural and mechanical properties of yogurts samples

Table 1: Physical and chemical indicators of non-roasted and roasted amaranth flour

Traits	Moisture	Carbohydrates	Proteins	Fats	Ashes	Ca	Na	P
Non-roasted amaranth flour	9.7±0.1	60±0.46	6.5±0.1	3.3±0.6	1.8-1.9	87.9±10	71.1±10	287.7±10
Roasted amaranth flour	7.9±0.3	79±1.1	9.76±0.57	1.6±0.6	1.7±0.22	19.7±10	16.2±10	128.4±10

Table 2: The Proximate composition of the control and yogurts with the addition of amaranth flour

Traits	Yogurts		
	Control (SD)	F1(SD)	F2(SD)
Moisture	79.23 (0.05)	82 (1.1)	85.1(0.8)
Carbohydrates	11.7 (0.1)	7.3(0.02)	7.41(0.12)
Proteins	4.24(0.02)	5.3(0.2)	5.1(0.02)
Fats	3.41(0.11)	3.24(0.23)	3.3(0.01)
Ashes	0.87(0.03)	0.7(0.01)	0.84(0.02)
Ca	187(8.7)	165(11.1)	112.5(3.17)
Na	82.52(0.37)	82.17(1.4)	78.17(2.2)
P	92.2(5.43)	59.4(1.2)	58(0.9)

p<0.05. Moisture, carbohydrates, proteins, fats and ashes are expressed in g 100 mL, whereas Ca, Na and P in mg 100 mL

Table 3: Sensory quality of yogurts of non-roasted and roasted amaranth flour and control sample

Attributes	Overall acceptability (SD)	Colour (SD)	Texture (SD)	Flavour (SD)	Aroma (SD)
Control	6.37(0.29)	6.60(0.51)	6.50(0.5)	6.5(0.71)	5.8(0.78)
F1	6.85(0.27)	6.7(0.48)	7.0 (0.4)	7.1(0.32)	6.6(0.52)
F2	7.15(0.47)	7.4(0.69)	7.2(0.63)	6.7(0.83)	7.3(0.82)

(F1, F2) Yogurts supplemented with 5 g 100 mL amaranth flour (non-roasted and roasted). p<0.05

Discussion

Analysis of non-roasted and roasted amaranth flour showed that the flour were rich in protein (6.5, 9.76% respectively), carbohydrates (60.0, 79.0% respectively) and fats (3.3, 1.6% respectively). The present study values for protein are comparable with the published data (Alekseeva, 2013; Derkanosova *et al.*, 2016).

Nutty flavour generated in the amaranth grains when subjected to the roasting process (Shinde *et al.*, 2020).

Yogurt samples analysed met the required standards for physicochemical composition and microbiological indicators. The determined moisture, carbohydrates, proteins, fats and ashes content is shown in Table 2 and showed slight differences between samples. The

determined fat content is shown in Table 2 and displays slight differences between samples. The control sample had the highest fat content, whereas F1, F2 had the lowest fat content among the samples ($P < 0.05$). There is possible explanation for this result.

As shown in Table 2 the protein and fat content of amaranth flour influenced the content of yogurts: An increase in yogurt samples fat content was associated with a decrease in moisture content.

The results of moisture content are presented in Table 2. The moisture content of the control sample was the lowest among the yogurt samples and the F2 content was the highest among all the samples ($P < 0.05$). The amaranth flour-supplemented yogurts were found to have higher moisture content than the control sample ($P < 0.05$). The result on pH and total acidity values of yogurts are summarized in Fig. 2. According to data research (Tamime and Deeth, 1980; Kim *et al.*, 2020) the most suitable pH of yogurt is in the range of 3.7 to 4.7. The yogurt samples' pH levels ranged from 4.65 to 4.36 and pH was decreased with the addition of amaranth flour. The pH of the amaranth flour - supplemented yogurts was slightly higher than that of control groups ($P < 0.05$). The pH of F1 and F2 were slightly decreased after 15 days storage.

From the results, sensory characteristics of yogurts with non-roasted and roasted amaranth flour has slight differences. It has been suggested that the sensory properties of food are strongly related to consumer preferences and determine product acceptability; this phenomenon can help optimize the recipe (Kim *et al.*, 2020). The results of the sensory evaluation of yogurt samples are shown in Table 3. The sensory attributes of yogurt were divided into the following categories: Appearance and color, taste, texture, aroma and general acceptability. The appearance is perceived visually and the surface is evaluated by smoothness, shape and texture. The F2 received the best scores in all categories evaluated among the samples. Draws a distinction between flavor, which is strongly related to preferences regarding food and quality properties.

In the present study, adding roasted amaranth flour to yogurts showed increasing sensory properties: Improved aroma and a nutty taste to the finish \$ Ed product (F2).

Conclusion

It was possible to formulate yogurts with two different types amaranth flour. Although nutritional composition showed improvements, the addition of amaranth flour had an undesirable effect on consistency, increased syneresis and overall acidity were found during storage. The overall acceptability decreases when adding the non-roasted amaranth flour in a product. The main weakness of this study was the paucity of size of our panel (10 people). With a small sample size, caution must be applied, as the

findings might not be transferable to show objective data. In spite of its limitations, the study certainly adds to our understanding of the production of yogurts with roasted amaranth flour is preferable. Further research is needed to investigate the effects of amaranth flour and apply it to various foods as a supplement to enhance overall quality parameters of fermented foods.

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Author's Contributions

Alma Shunkeyeva: Contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

Mariam Alimardanova: Coordinated the mous work.

Alexandr Majorov: Gave valuable suggestions during this research work's planning and development.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that the author's had read and approved the manuscript and no ethical issues involved.

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