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Dietotherapeutic potency of ornamental lentil dumpling, a traditional food preparation from South West Bengal, India

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Gahana bori (in Bengali) or ornamental lentil dumpling is a state-of-art preparation designed in the form of paisleys, ornaments or flowers, used as a decorative adjunct with the main dish.. Here, we have made an attempt to evaluate the dirtotherapeutic potency of this traditional preparation. The principal ingredient is the *Vigna mungo* (blackgram/ urad bean). In its preparation, the soaked bean is pasted and placed on a cloth piece having a central small pore. The fermented paste is squeezed onto the poppy seeds containing plate in such a way that it looks like an ornament. The sundried preparation is generally fried in oil and served along with the meal. For the first time, we have scientifically explored *Gahana bori*. The number of total aerobes, total anaerobes, yeast, mould, and LAB were increased during soaking. The contents of free phenolics and flavonoids were increased in the fermented paste and that also reflected by the higher *in vitro* DPPH antioxidant activity. The levels of B-group of vitamins particularly the quantity of riboflavin, thiamin, folic acid, vitamin B_{12}, and vitamin C were also enriched in the products. The water extract of this product exhibited a notable antibacterial activity against enteropathogens. Thus, the lentil-based *Gahana bori* is not only improved the appearance or presentation of food product but also the same have a good health beneficial potentiality.

Keywords: Antioxidants, Black gram, Urad bean, *Vigna mungo*

The recent global trend is towards indigenous food and the conservation of traditional knowledge and local heritage, including traditional food cultures. The culinary culture of colonial India is intimately linked with the abundant traditional and indigenous food grains. Purba Medinipur district is a province of South West Bengal, India (Fig. 1) that has tremendous food diversity. Cereal, pluses, and other plant foods achieve a very important place in the nutrition of this region's people. A group of pulse crops, namely chickpea, black gram, green gram and lentils are extensively cultivated all around India to meet the protein demand of the native people[1]. To boost up their productivity, Government initiated a special program 'Accelerated Pulses Production Programme (A3P)' which was launched in the year 2010-11. Many shreds of evidence suggested that pulses are very effective in cardiovascular diseases, cancer, hypertension, and gastrointestinal disorders[2-4]. *Vigna mungo*, commonly known as black gram is the highly cultivated crop in the Indian subcontinent as summer food legumes. Its seeds are used for the preparation of many culinary dishes since primeval. Several delicious traditional fermented foods, such as *Dosa*, *Idli*, *Papad*, *Wari*, *Imrati*, and *Halwa* are prepared from black gram[5].

Likewise graphic or interior design in any other product, food design is also very important for

Fig. 1 —The black coloured region is Purba Medinipur, a district in the south of West Bengal state, India. The latitude and longitude coordinates are 21.9373° N, 87.7763° E, respectively. [*Disclaimer: only for education purpose*].

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Fig. 2 — Sun-dried ornament shaped product, *Gahana bori*

exploring or attracting the consumer. Ethnic food design depends upon personal art based on deliberate and reasoned shaping and making of food in ways that satisfy our needs and give meaning to our lives. In the present treaties, rural women prepared a lentil dumpling, shaped like their occasional festive ornaments. This fermented food, locally called *Gahana* (ornament) *bori* (Fig. 2), has a significant impact on local food culture as it can protect their food heritage and pass on traditional and local wisdom on how to prepare and cook such products.

While the other pulse-based fermented foods have been studied extensively, the *Gahana bori* has not been explored scientifically so far. In this study, we documented the traditional preparation process of *Gahana bori* or ornamental lentil dumpling and also evaluated its dietotherapeutic importance.

Materials and Methods

Chemicals

All the chemicals used in the study were procured from Sigma-Aldrich, St. Louis, MO, USA and Himedia Laboratories, Mumbai, India.

Data collection about the preparation process of *Gahana bori*

A household survey and focused group discussion were employed to document the preparation process of *Gahana bori*[6]. The survey was conducted in the Purba Medinipur district of West Bengal state in India. A total of 20 women were involved in the interviews and discussions. Face-to-face interaction with knowledgeable adults was conducted to get an idea of the *Gahana bori* preparation. After discussion and field observation, *Gahana bori* preparation can be divided into following steps: soaking of the pulses, preparation of the batter, handshaking of fermented batter, making of unique ornaments like structure, sun-drying and storage.

Sample collection

Raw substrate and *Gahana bori* samples were collected from 10 different houses of Purba Medinipur district. The sterile gloves and spatulas were used. Samples were kept in the sterilized containers and immediately transferred to the laboratory in an icebox. The samples were stored in the laboratory at −20°C for further analysis.

Microbiological analysis

One gram of each sample was mixed with 9 mL of phosphate buffer saline (pH 7.2) and homogenized. The appropriate dilution was spread on different media and the dominant culturable microflora was enumerated based on colony-forming units (CFU)[7]. Total aerobic bacteria were enumerated using plate count agar and the plates were incubated at 37°C for 24 h. Enumeration of total anaerobic bacteria was done using reduced Wilkins Chalgren agar and the plates were incubated at 37°C in a CO_2 incubator (5% CO_2). Lactic acid bacteria (LAB) were counted using selective media such as Rogosa SL agar (supplemented with 0.132% acetic acid) and plates were incubated in a CO_2 incubator (5% CO_2), at 37°C for 48 h. Yeast and mould were enumerated using yeast and mold agar and potato dextrose agar, respectively, and plates were incubated at 28°C for 72 h.

Proximate analysis

The amounts of moisture, carbohydrate, protein, and fat, in *Gahana bori* samples were estimated according to the method of the Association of Official Analytical Chemists[8]. The carbohydrate, protein, and fat were expressed as % DM (g/100 g dry matter).

Determination of hydrosoluble vitamins

Hydrosoluble vitamins in *Gahana bori* were analyzed using reverse phase-HPLC (Agilent HPLC system, Agilent Technology) equipped with a Zorbax SB-C18 column[9]. The mobile phase was acetonitrile (A) and 0.05M KH_2PO4 (pH 2.5). The solvent gradient was as follows: at 0 minutes 0.6% A, at 0.5 min 0.6% A, at 4 min 6% A, at 12 min 0.6% A, at 17 min 0.6% A, and the stop time was 20 min. The temperature was kept at 15°C and a constant flow rate of 1.0 mL/min was maintained. The effluent from the

column was monitored by a variable wavelength UV detector (204 nm).

Estimation of total phenolics and flavonoids

Ten grams of each sample were extracted separately with 300 mL mixture of methanol: acetone: water (4:3:3 v/v/v) mixture at room temperature (~30°C) for 24 h followed by centrifugation at 10000 rpm for 20 min. The supernatant was collected and concentrated by a rotary evaporator at 60°C. The resulting solutions were lyophilized for 48 h at –42°C and dissolved in ethanol at a concentration of 1.0 mg/mL.

The amounts of total phenolics in extracts were determined using the Folin-Ciocalteu method as described by Singleton & Rossi [10]. Briefly, 500 µL of the extracted sample was mixed with 2.5 mL of 0.2 mol/L Folin-Ciocalteu reagent and incubated for 4 min followed by the addition of 2 mL saturated sodium carbonate solution (75 g/L). The mixture was allowed to incubate at room temperature for 2 h and the absorbance was taken at 760 nm. Gallic acid was used as a reference standard, and the results were expressed as mg gallic acid equivalent (mg GAE)/g.

Total flavonoids content was determined following the method of Zhishen, Mengcheng[11]. Briefly, 500 µL of the extracted samples were mixed with 2 mL of distilled water and 150 µL of 5% sodium nitrate. After 6 min of incubation at room temperature, 150 µL of 10% aluminum chloride and 2 mL of 1M sodium hydroxide was added and kept at room temperature for 15 min. The absorbance of the mixtures was measured at 510 nm and total flavonoid contents were calculated as quercetin equivalent (mg QUE)/g.

DPPH free radical scavenging activity

The extracts were mixed with 1.9 mL of 0.1 mM DPPH and incubated for 10 min. The absorbance was taken at 515 nm and scavenging activity was determined against DPPH radicals[12]. The radical scavenging activity was expressed using the following equation:

$$\text{Scavenging activity (\%)}: (1 - A_{sample} / A_{control}) \times 100$$

Antimicrobial activity

The antibacterial activity was evaluated by agar well diffusion method[13]. The samples (1 g) were mixed sterilized distilled water (9 mL) followed by centrifugation at 10000 rpm for 10 min. The collected supernatant was filtered by 0.2 µm filter and used to determine the antimicrobial activity against the enteric pathogens such as *Shigella sonnei* MB 17 and *Escherichia coli* ATCC 25938. Samples (50 µL) were then transferred into the wells in the agar plates previously inoculated with the target microorganisms. Antibiotic (ciprofloxacin) was used as a positive control. The diameter of the inhibition zone was measured after 24 h incubation at 37°C.

Results and Discussion

***Gahana bori* preparation**

A survey was conducted among the local people of the Purba Medinipur district to gather knowledge about the traditional preparation process of *Gahana bori*, which is schematically represented in Fig. 3.

A step-wise traditional method of *Gahana bori* preparation is as follows:

Soaking of the pulses

Black gram seeds or Urad beans are mainly used for the preparation of *Gahana bori*. Good varieties of beans are kept in a container and soaked with an excess amount of water at room temperature.

Preparation of the batter

The soaked pulses are ground using a traditional grinder to prepare the paste. Then the paste is allowed to ferment in the room temperature overnight (~12 h). This is called the batter. The salt is added to this batter.

Handshaking of fermented batter

The fermented batter is shaken by hand to get stickiness and it also aerates the batter.

Making of unique ornaments like structure

The fermented batter is kept in the fine cloth where a tiny hole is made. The batter is squeezed through the

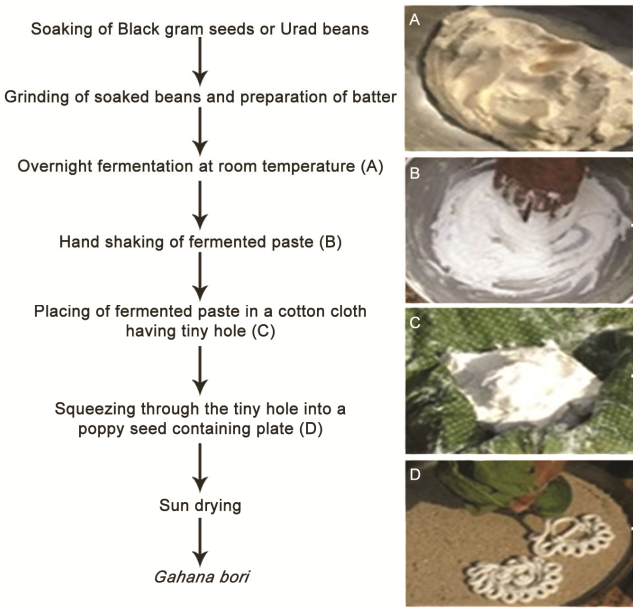

Fig. 3 — Schematic diagram of *Gahana bori* preparation

tiny hole into a poppy seed containing plate to make the unique ornament (in *Bengali* language, it is called *Gahana*) like structure.

Sun-drying and storage

The prepared *Gahana bori* is sun-dried for 5-10 days and kept in the airtight container. It is generally fried in oil and served along with the meal.

Microbiological analysis

In the microbiological analysis, we checked loads of total aerobes, total anaerobes, yeast, mould and LAB in dried beans, water-soaked beans, fermented pastes, sun-dried *Gahana bori*, and fried *Gahana bori.* It is evident from the result that yeast, mould, and LAB were the predominant *Gahana bori*. The dried black gram beans contained 4.62±0.65, 6.51±0.98, 5.24±0.74, 4.58±0.39, and 3.58±0.58 $\log_{10}$ CFU/g of the total aerobes, total anaerobes, yeast, mould, and LAB, respectively (Table 1). The microbial loads were slightly increased during the water-soaked condition and their numbers were found highest in fermented paste (except total aerobes). The counts were 5.13±0.71, 7.28±1.17, 6.89±0.73, 5.12±0.47, 5.82±0.78 $\log_{10}$ CFU/g of the total aerobes, total anaerobes, yeast, mould, and LAB, respectively (Table 1). However, the microbial counts were drastically reduced during sun drying and frying. The numbers were 4.12±0.62, 5.30±0.92, 4.18±0.59, 2.18±0.43, 3.21±0.62 $\log_{10}$ CFU/g of the total aerobes, total anaerobes, yeast, mould, and LAB, respectively in the consumable form (fried *Gahana bori*). Due to the low moisture content and the high temperature might reduce the microbial count during sun drying and frying. Till now, there are no such reports on the microbial load in *Gahana bori*, but our findings are in good agreement with the previous report of Chettri & Tamang[14] on *Maseura*, an ethnic fermented legume-based condiment of Sikkim. Moreover, Rahi & Soni[15] also observed that fermented black gram contained yeast, mould, and LAB. Clearly, the major source of the microbes in *Gahana bori* was the dried bean (Table 1). In addition, the microbes might come from the ingredients, utensils, environment as previously suggested by Tamang[16].

Proximate analysis

Gahana bori contained 8-10% moisture, 55.2±5.5% DM of carbohydrate, 23.6±3.8% DM of protein, and 1.1±0.7% DM of fat. A similar type of proximate composition was also reported in *Maseura*[14, 17].

Hydrosoluble vitamins content

The hydrosoluble vitamins content of *Gahana bori* is shown in Table 2. Riboflavin (0.68±0.12 mg/g), thiamine (0.55±0.03 mg/g), and folic acid (0.21±0.07 mg/g) contents were found highest in the fermented bean. The fortification of the vitamins was probably due to the production of vitamins by the participating microbes or microbes producing enzymes dislodge these vitamins from the bean as it is evident from the result that the bean contained a significant amount of vitamins (riboflavin [0.65±0.05 mg/g], thiamine [0.58±0.08 mg/g], folic acid [0.19±0.03 mg/g], vitamin B_{12} [0.21±0.08 mg/g], vitamin C [0.52±0.04 mg/g]). However, vitamin B_{12} and vitamin C content were either unchanged or drastically decreased during the fermentation. The presence of different types of vitamins was also reported by Nawaraj, Rati [17] in *Masyaura*, a similar kind of fermented black gram product in North East India and Nepal [18]. Nevertheless, all of the tested vitamin contents were decreased during oil frying (riboflavin [0.35±0.02 mg/g], thiamine [0.50±0.15 mg/g], folic acid [0.18±0.03 mg/g], vitamin B_{12} [0.15±0.02 mg/g], and vitamin C [0.11±0.06 mg/g]). It has been already established that heat can degrade the vitamins. Therefore, it can be articulated that the

Table 1 — Microbiological analysis of different stages of *Gahana bori* preparation

Samples	Total aerobes ($\log_{10}$ CFU/g)	Total anaerobes ($\log_{10}$ CFU/g)	Yeast ($\log_{10}$ CFU/g)	Mould ($\log_{10}$ CFU/g)	Lactic acid bacteria ($\log_{10}$ CFU/g)
Dried bean	4.62±0.65	6.51±0.98	5.24±0.74	4.58±0.39	3.58±0.58
Soaked bean	5.38±0.58	6.78±0.94	6.12±0.69	4.71±0.58	4.78±0.62
Fermented paste	5.13±0.71	7.28±1.17	6.89±0.73	5.12±0.47	5.82±0.78
Sun-dried	5.85±0.85	6.85±0.81	5.36±0.82	4.72±0.61	3.58±0.71
Fried product	4.12±0.62	5.30±0.92	4.18±0.59	2.18±0.43	3.21±0.62

Table 2 — Changes of hydrosoluble vitamins in different stages of *Gahana bori* preparation

Samples	Riboflavin (mg/g)	Thiamine (mg/g)	Folic acid (mg/g)	Vit-B_{12} (mg/g)	Vitamin C (mg/g)
Dried bean	0.65±0.05	0.58±0.08	0.19±0.03	0.21±0.08	0.52±0.04
Soaked bean	0.58±0.08	0.47±0.04	0.13±0.08	0.20±0.02	0.18±0.09
Fermented paste	0.68±0.12	0.55±0.03	0.21±0.07	0.19±0.08	0.22±0.03
Sun-dried	0.58±0.05	0.51±0.01	0.17±0.01	0.16±0.01	0.23±0.02
Fried product	0.35±0.02	0.50±0.15	0.18±0.03	0.15±0.02	0.11±0.06

Table 3 — Total phenolics and flavonoids content and DPPH free radical scavenging activity

Samples	Total Phenolic (mg of GAE/g extract)	Total Flavonoids (mg of QUE/g extract)	DPPH free radical scavenging activity (%)
Dried bean	1.14±0.73	1.25±0.87	11.71±1.20
Soaked bean	1.78±0.22	1.31±0.32	15.68±1.32
Fermented paste	1.91±0.64	1.59±0.53	20.01±1.30
Sun-dried	1.9±0.41	1.63±0.54	16.38±2.30
Fried product	1.65±0.41	1.51±0.44	15.39±2.19

fermentation might increase the quantity of vitamins, but their amounts were significantly lost during oil frying.

Total phenolic and flavonoids content

Gahana bori contained a notable amount of phenolic and flavonoids. The dried bean contained 1.14±0.73 mg of GAE/g extracts of phenolics and 1.25±0.87 mg of QUE/g extracts of flavonoids which were slightly increased during soaking (1.78±0.22 mg of GAE/g extracts of phenolics and 1.31±0.32 mg of QUE/g extracts of flavonoids) (Table 3). The findings were contrary to the previous report of Pratape & Rao[19]. The differences in phenolic and flavonoids content in different studies might be due to different extraction processes followed and the variant in the cultivars[19]. During fermentation, the amount of phenolics and flavonoids were drastically increased in the fermented paste and reached 1.91±0.64 mg of GAE/g extracts of phenolics and 1.59±0.53 mg of QUE/g extracts of flavonoids which were then decreased during sun drying and oil frying. It could be explicated that the action of microbial enzymes during fermentation might facilitate the release of phenolics and flavonoids which were associated in complex form with dietary fibre. Clearly, a detailed profiling of phenolics and flavonoids are very essential.

DPPH free radical scavenging activity

Gahana bori showed a significant level of DPPH free radical scavenging activity. Resembling the findings of phenolics and flavonoids (Table 3), the DPPH free radical scavenging activity was found highest in the fermented paste which was drastically reduced during sun drying and oil frying (Table 3). It can be correlated with the presence of a higher amount of free phenolics and flavonoids (Table 3) in the extract and its hydrogen donating ability helped out to scavenge and decolourized the violet colour DPPH into colourless product. Hence, *Gahana bori* might be used as nutraceuticals and functional food ingredients as well as it might exhibit different health benefits as suggested earlier[19,20].

Table 4 — Antimicrobial activity of *Gahana bori* against the pathogenic bacteria

Samples	Zone of inhibition (mm)	
	Shigella sonnei MB 17	*E. coli* ATCC 25938
Dried bean	3.3 ± 0.5	2.8 ± 0.7
Soaked bean	7.1 ± 1.5	6.4 ± 1.2
Fermented paste	9.2 ± 1.8	7.2 ± 1.5
Sun-dried	8.8 ± 1.2	6.8 ± 1.5
Oil fried product	7.5 ± 1.5	6.5 ± 1.7

Antimicrobial activity

Antimicrobial efficiency of *Gahana bori* was examined against two common human enteric pathogens and it showed strong antimicrobial activity against *Shigella sonnei* MB 17 and *Escherichia coli* ATCC 25938 (Table 4). The antimicrobial activities were highest in the fermented bean for both of the pathogens. This antimicrobial activity might be due to the production of bioactive metabolites, such as lactic acid, phenolics, flavonoids, and antimicrobial peptides by the participating microbes specifically LAB. The antimicrobial activity of foodborne LAB had been well documented by Tamang *et al*.[21]. Moreover, the antimicrobial activity of fermented black gram seed was reported by Ray *et al*.[5]. Hence, the *Gahana bori* might be used in the treatment of gastrointestinal disorders related to *Shigella sonnei* MB 17 and *E. coli* ATCC 25938.

Conclusion

The results above have demonstrated that traditional preparation process of the *Gahana bori*, particularly the fermentation, increases its total number of microbes, and the vitamins, phenolics and flavonoids contents. However, their amount decreased during sun drying and frying. Moreover, *Gahana bori* exhibited antioxidant and antimicrobial activities against human pathogens. A detailed study is needed to scientifically explore this traditional food.

Conflicts of interest

Authors declare no competing interests.

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