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The proximate composition of *Nappi* and its marketing methods in Bangladesh

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Abstract

Nappi, fermented shrimp, is a traditional diet that is widely consumed by the ethnic communities of Southeast Asian countries, especially in Bangladesh. The present study was carried out to determine the proximate composition of *Nappi* collected from two different places, i.e., the Moheshkhali and Chaufaldandi areas of Cox's Bazar district, Bangladesh. Traditional methods were used to prepare *Nappi*, and the standard procedure was followed to determine the proximate composition. The proximate composition of *Nappi* varied from place to place depending on the raw materials, preparation techniques, and surrounding conditions of the formulation places. Associated statistical analysis was conducted by r-programming (version 4.2.3). Proximate composition includes moisture, protein, ash, fat, and carbohydrate contents, amounting to $37.66 \pm 1.51\%$, $34.34 \pm 0.68\%$, $17.49 \pm 0.46\%$, $8.53 \pm 0.45\%$, and $1.39 \pm 0.10\%$, respectively, for the Moheshkhali sample and $35.44 \pm 1.37\%$, $37.23 \pm 1.78\%$, $18.46 \pm 0.59\%$, $6.00 \pm 0.40\%$, and $2.66 \pm 0.21\%$, respectively, for the Chaufaldandi sample. The study showed that moisture and fat content were significantly higher (ANOVA, $p < 0.05$) in the Moheshkhali sample. In contrast, protein, carbohydrate, and ash content were substantially higher (ANOVA, $p < 0.05$) in the Chaufaldandi sample. *Nappi*'s marketing strategy, supply channel, and value chain were also analyzed. The study's findings revealed that the quality of *Nappi* relied on fresh raw materials, the hygienic condition of the processing places, and suitable techniques. Moreover, good-quality *Nappi* has a significant market demand among the local ethnic communities in Bangladesh and the ethnic communities living abroad. So, it is recommended that interventions be provided on proper preparation techniques and marketing channels for *Nappi*.

Keywords *Nappi*, Ethnic community, Fermented shrimp, Indigenous food, Commercialization

Introduction

Bangladeshi cuisine is among the most singular and diverse in the world. Bangladesh possesses an extensive culinary heritage and historical background in the realm of cuisine. The cuisine of the nation has been influenced by its climate, geographical location, and cultural

diversity. Bangladeshi cuisine has been shaped by numerous cultures, such as that of the Portuguese, the Mughals, and the British. Traditional Bangladeshi cuisine consists of a combination of *charchari* (dry curry), *dal* (lentil soup), *vaji* (fried), *bhorta* (mashed), *torkari* (cooked), and *bhorta* (mashed) prepared with locally or seasonally available meat, fish, and vegetables. Potatoes (*Solanum tuberosum*), cauliflower (*Brassica oleracea* L. var. botrytis), cabbage (*Brassica oleracea*), tomatoes (*Solanum lycopersicum*), beans (*Phaseolus vulgaris*), peas (*Pisum sativum*), carrots (*Daucus carota*), radishes (*Raphanus sativus*), pumpkins (*Cucurbita pepo*), eggplants (*Solanum melongena*), bitter gourds (*Momordica charantia*), and various others are typical vegetables [1]. Numerous

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well-known fish species can be found in the area, such as the bombay duck (*Harpadon nehereus*), rui (*Labeo rohita*), catla (*Gibelion catla*), mola (*Amblypharyngodon mola*), tengra (*Mystus tengara*), kachki (*Corica soborna*), puti (*Puntius sophore*), taki (*Channa punctata*), and a host of others [1].

Ethnic communities vary in identity, culture, organization, way of life, language, culture, food and dress patterns, housing arrangements, leadership structures, social and village organization, ceremonial ceremonies involving children and the deceased, and religious and social celebrations. There are various ethnic food stuffs in Bangladesh such as *Mundi* (a traditional *Marma* food), *palka* (popular in Northern Bangladesh), and ritual dishes in *Monipuri* community (*enorba*, *amperi*, *shinjhu*, *Oshoi*, *voutong*, *chamdhong*, *champhudh*, *bamboo chicken*, *mangso Morich godiye*, etc.). Religions often relate to dietary practices. Muslims are often avoiding ethnic food stuffs (*Nappi*) due to the religious matters in this region. They thought this is haram (prohibited) for them. Another reason is there is a lack of awareness building and poorly unknown the health benefit of *Nappi* to the other religious people (Hindu, Christian) in this country. This is something like late 1985, Bangladeshi Muslim thought shrimp is *makruh* (hateful). At the present time, this food item is one of a main cuisine in the country. It was made possible due to the awareness building of shrimp consumption and its importance to the people. The consumption of *Nappi* may one day be available to people from all classes of society in Bangladesh, much like shrimp.

There are typically two distinct ethnic groups residing in Bangladesh, categorized by geography. There are those who inhabit steep terrain and those who reside in plains. A segment of this population resides in the Chattogram Hill Tracts, specifically in the southeastern regions, namely Rangamati, Bandarban, and Khagrachhari [2]. These districts are inhabited by the *Chakma*, *Marma*, *Tripura*, *Mru*, *Tanjanga*, *Bawm*, *Pangkhuia*, *Chak*, *Khang*, *Khumi*, and *Lusai* minority ethnic groups. Both biologically and structurally, they closely resemble the Mongolian people. These individuals are also referred to as “Hill people.” Anthropologically speaking, Mongolians also inhabit the northeastern region of Bangladesh. The *Garo*, *Hajang*, and *Coach* are notable ethnic minority groups who reside in the vicinity of Mymensingh. Greater Sylhet is home to the *Khasi* or *Khasia* and *Monipuri* minority ethnic groups [3]. Additionally, *Rakhain*, an ethnic group associated with the Morgue people, inhabit the districts of Cox’s Bazar, Patuakhali, and Barguna. Small ethnic groups include *Saontal*, *Orao*, *Mahali*, *Monda*, *Malpahary*, and *Malo* inhabit the northwestern regions of Bangladesh, including Dinajpur, Rangpur, Rajshahi, Bogura,

and Pabna, among others. They are referred to as dwellers of plain land. They also live in greater Sylhet. Some more minority ethnic groups of people live in Bangladesh [2]. *Dalu*, *Hodi*, *Rajbangshi*, *Patro*, *Barman*, *Banai*, *Pahan*, *Mahato*, and *Kol* are a few examples. Additionally, they inhabit several regions of Gazipur, Mymensingh, larger Sylhet, and Tangail [4]. It is crucial to keep in mind that the Statistics Bureau classifies Bangladesh into 27 distinct tribal groups [5]. They currently reside in the Sylhet Division, Rajshahi Division, Chittagong Hill Tracts, and Mymensingh District. In Bangladesh, the *Chakma* constitute the largest ethnic group, while the *Marma* rank second in size. There are approximately two million people officially recognized ethnic minority groups in Bangladesh [5]. They constitute roughly 1.25 percent of Bangladesh’s population. There are two broad categories of ethnic minorities in Bangladesh: groups that reside in the Chittagong Hill Tracts (CHT) in the southeastern Chattogram Division, and groups that reside in the northern divisions, often referred to as plainland ethnic groups [5]. For them, fish and fishery-related activities are one of the primary sources of income contributing to their daily needs and survival. The indigenous population resides primarily in the hilly regions of Chittagong. Although most of them reside in hilly areas, they have recently tried to adapt to globalization, mainstream commerce, and language, among other things [6].

The indigenous people’s way of life and culture are extraordinarily intriguing. They are Buddhist in origin. Additionally, there are Christian, Hindu, and animist communities. Primitive ways of life are also prevalent within the majority of the ethnic group. Overall, women engage in more labor-intensive endeavors than men [7].

The indigenous people are exceptionally self-reliant. They choose to live an extremely basic existence. Conversely, they manufacture the vast majority of daily necessities, such as clothing and food. The majority of tribal people are bilingual in their native tongue and the state language (dialect). As to the communities’ assertions, they observe unique ceremonies and rituals. They, too, wear unique attire. The ladies possess a variety of unique abilities, such as weaving fabrics, preparing community-specific traditional dishes, and observing their own culture. Overall, they live a modest existence and are benevolent and welcoming. Under every critical circumstance, they proceed in unison.

The bulk of indigenous inhabitants in Bangladesh, nevertheless, do not have access to refrigerated facilities. Consequently, preservation techniques are implemented, including temperature reduction (e.g., boiling or frying), moisture dehydration (e.g., smoking, drying, and salting), and pH reduction (via fermentation). These procedures can potentially induce modifications in the flavor and

consistency of the fish, in addition to yielding distinctive fishery products. Note that fish and fishery products are consumed on a global scale for their nutritional value. The freshness of fish is the primary determinant of its nutritional value. The commencement of decomposition results in a reduction in the nutritional value of fish. Fish should therefore be handled without interruption.

In Bangladesh, locally processed fermented fish-derived, so-called *Nappi*, is a daily essential ingredient in cooking many dishes of the tribal people who lives in the southeast and west parts of this country and also the tribe in the neighboring country in Myanmar. The indigenous salty food ‘*Nappi*’ is specially made by *Rakhine*, an ethnic tribal community of hill track districts in Bangladesh includes coastal areas such as—Cox’s Bazar, Teknaf, Chaufaldandi, Moheshkhali, and Patuakhali. Among the ethnic community, *Rakhine* are the most well-known producers and vendors of *Nappi*. *Nappi*, a fermented semi-solid fish paste characterized by its robust flavor, serves as an affordable protein source for an economically disadvantaged and underprivileged ethnic population in Bangladesh. This popular indigenous cuisine is also known with diverse names in different countries, i.e., *Nappi* in Bangladesh, *Terasi* in Indonesia, *Ngapi* in Myanmar, *Kapi* in Thailand, *Ki* in Cambodia, *Blacan* in Malaysia, and *Bagoong* in Philippines [8–12]. It is thought that this shrimp paste was first made in the Southeast Asia, probably by the *Cham* and *Mon* peoples of the Indo-China region [12, 13]. It is important to note that the name of the fermented food staffs varies according to the country [14]), and the information is framed in Table 1.

Generally, shrimps are used to produce fermented paste named *Nappi*. Shrimps of the genera *Acetes*, (small krill like prawns), *Mesopodopsis*, *Lucifer*, and *Mysids* are usually use to make this product (Table 1). The genus *Acetes* is the most common raw materials to produce shrimp paste and other fermented products. Typically, small shrimps such as *Acetes sp* and *Mysid sp* are mainly used to make *Nappi* in Moheshkhali and Chaufaldandi of Cox’s Bazar district, Bangladesh.

Sometimes a small amount of fish fry, fingerling and small fish are also mixed with raw material which is locally known as “*Meng*” in Moheshkhali. Shrimp species used to produce this food varies country to country, depending on the types of shrimp availability in that specific country. In Southeast and East Asian countries, *Acetes* shrimp species are the most abundant and commonly used to produce fermented shrimp products, in which *A. indicus*, *A. erythraeus*, *A. vulgaris* and *A. japonicus* are the most common. *Nappi* is highly regarded by the inhabitants of the hill regions. *Nappi* is utilized by individuals to enhance the flavor of their dishes. This is also known as *chepa shutki* in another form. *Nappi*, which is used to dishes, is encased in banana tree leaves and torched until it becomes rigid. It may also be utilized in cooking directly after being combined with water. With the exception of the three hill tract districts, Chattogram, Barisal, Barguna, and Patuakhali all place significant significance on *Nappi*. Through Teknaf and the Chittagong Hill Tracts, *Nappi* is exported monthly to Myanmar and India. Numerous restaurants in Thailand, Indonesia, and Sri Lanka have begun to offer *shutki* staples such as *Nappi*. *Nappi* food products are becoming more popular and their market demand is growing day by day. Therefore, it is imperative to examine the preparation procedure for *Nappi* and its proximate composition to gain insights into its health benefits. Further, a comprehensive marketing channel analysis should be conducted through discussions with producers, sellers, and buyers, as well as with other relevant stakeholders (such as fishermen). It is necessary to examine the strength and gaps of the marketing channel of *Nappi*, in light of its potential financial contribution to the national economy. This study, however, focuses on the proximate composition of the *Nappi* from Moheshkhali and Chaufaldandi areas of Cox’s Bazar, Bangladesh. Furthermore, the study aimed to conduct a thorough analysis of the marketing, supply chain, and value chain of *Nappi* in Bangladesh. As such, outcomes from the study in terms of proximate analysis of *Nappi* and insight into the value chain information

Table 1 Shrimp species and fermented shrimp paste that are available in South and Southeast Asia. Source: [14]

| Country | Shrimp Paste Name | Shrimp Species |
|-------------|---|---|
| Bangladesh | <i>Nappi</i> | <i>A. indicus</i> , <i>A. vulgaris</i> |
| Myanmar | <i>Ngapi</i> , <i>Seinsa</i> | <i>A. indicus</i> , <i>A. vulgaris</i> , <i>A. intermedius</i> |
| Thailand | <i>Kapi</i> | <i>A. japonicus</i> |
| Indonesia | <i>Terasi</i> , <i>Udang</i> | <i>A. japonicus</i> , <i>A. sibogaesibagae</i> |
| Malaysia | <i>Belacan</i> | <i>A. japonicus</i> , <i>A. erythraeus</i> , <i>A. sibogaesibagae</i> |
| Philippines | <i>Bagoong</i> , <i>Alamang</i> , <i>Dinailan</i> | <i>A. erythraeus</i> , <i>A. intermedius</i> , <i>A. vulgaris</i> |

will help to provide better insight into the appropriate authority for scaling up this resource.

Methods

Sample collection

Nappi samples were collected from Moheshkhali and Chaufaldandi areas of Cox’s Bazar, Bangladesh (Fig. 1). In order to examine the origin of *Nappi*, two study areas were selected based on the fact that ethnic communities from these two sites were involved in the process.

The samples were collected from the villagers in those areas involved in the preparation of *Nappi*. It is during the winter season when the local indigenous community prepares the *Nappi*. December 2022 was the date when the study sample was collected. Collected samples were packed into an airtight container and brought immediately to the laboratory of the Institute of Marine Sciences (IMS), University of Chittagong, Bangladesh. A total of 100 samples were macerated in a motor with a pestle separately and used to determine the proximate

composition of the sample. Ten replicates were used for each analysis.

Preparation of Nappi

Raw materials, include trash fishes, bycatch species as well as undesirable species with no commercial importance were collected from the fishermen (A representative example of raw materials is shown in Fig. 2A and B). Those were regularly gathered from the nearby canals, creeks, tidal pond as well as from the shallow continental shelf close to the shore. Particularly, shrimp of the genera *Acetes* sp. and *Mysid* sp. was used for the preparation. However, fry and fingerlings, sea snails, other shrimps and small marine fishes as well as seashell, fish larvae and crab were also used in the combination.

Processing technology of Nappi

Collected raw materials were then graded on the basis of their sizes. Then, they were placed (thin layer of shrimp) over the mat (locally called Bamboo *Chatai*) was covered with a slight layer of salt. They were kept into the mat for 3–5 days for initial sun drying. Salt (amount of salt depends on the quality and quantity of raw materials;

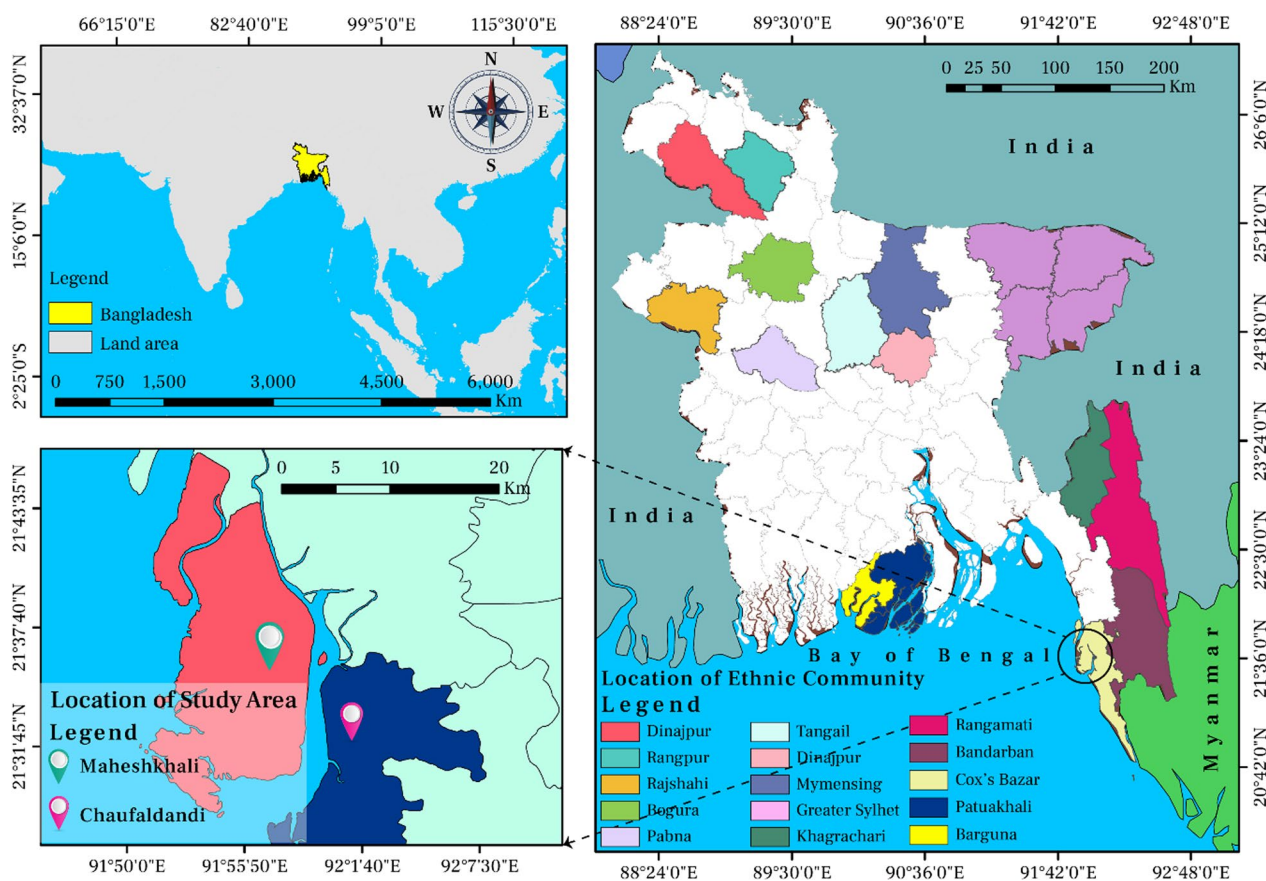


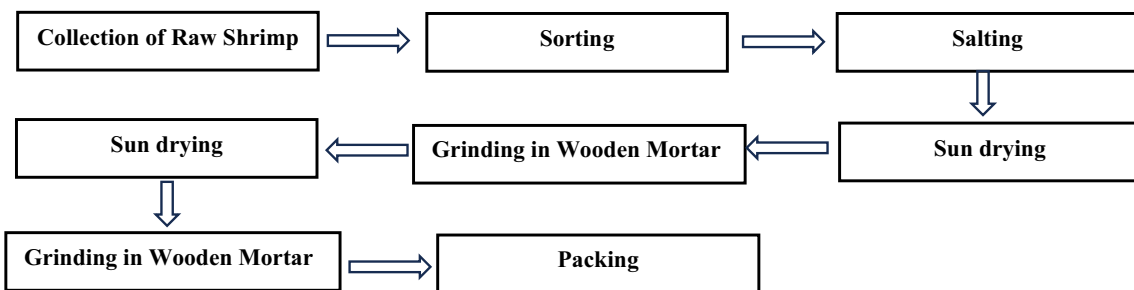
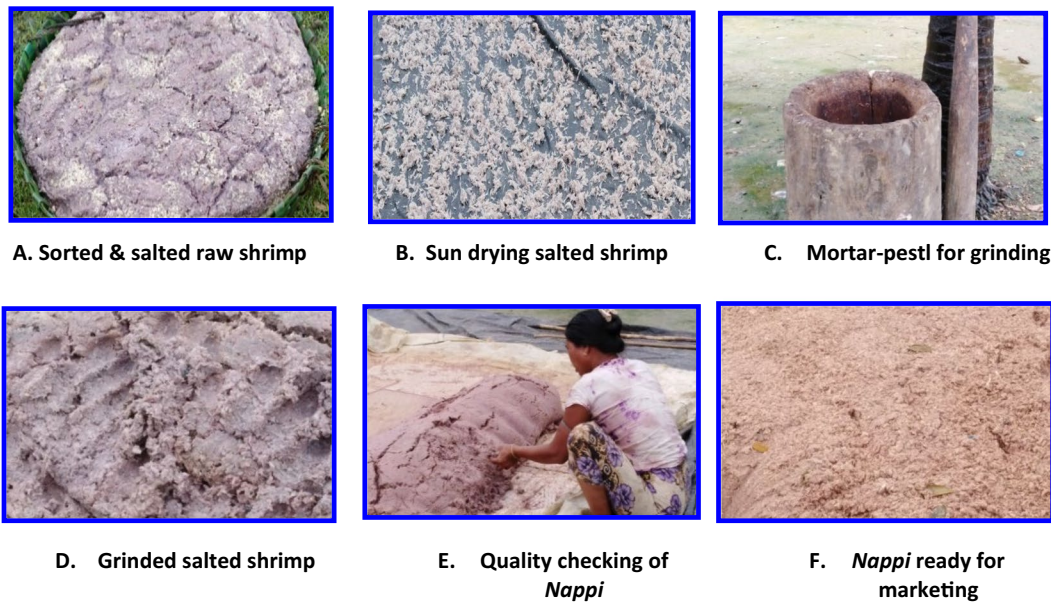
Fig. 1 Study area and the location of settlement of Ethnic communities in different districts of Bangladesh



A. Specimen used for *Nappi* preparation (*Acetes* sp)

B. Specimen used for *Nappi* preparation (*Mysid* sp)

Fig. 2 **A** Specimen used for *Nappi* preparation (*Acetes* sp). **B** Specimen used for *Nappi* preparation (*Mysid* sp)



F. Flow Chart

Fig. 3 **A–G** Traditional methods of *Nappi* preparation. **A** Raw materials sorted and salt added, **B** Sun drying to the salted raw materials; **C** Used mortar pestle for raw materials grinding; **D** Grinded raw materials by mortar; **E** Checking the quality of *Nappi*; **F**, *Nappi* ready for further applications, **G** Flow Chart of *Nappi* preparation

35–40 kg raw materials and 3–5 kg salt were used) was added with semi-dried raw materials (Fig. 3A). Then these were dried in the sun for 1–2 day (Fig. 3B). After sun drying, salted raw materials were grinded in wooden mortar (Fig. 3C). The grinding raw materials dried again in the sun and then grinded in wooden mortar without adding additional salt (Fig. 3D). Finally, the paste product was ready for packaging and selling (Fig. 3E, F). The finished paste looked like black to deep gray. The paste formed into blocks or balls. Wild hill tree leaves locally called ‘*Mos-pata*’ were used to wrap the blocks or balls. Initially, the wrapped *Nappi* can kept for 7–10 days while it has shelf life of six to seven months. *Nappi* preparation is clearly depicted in Fig. 3. *Nappi* is exclusively prepared by indigenous communities in Bangladesh in accordance with their traditional methods and within their local environment.

Proximate analysis

A standard procedure of AOAC was followed to determine moisture content using a hot air oven at 105 °C until a constant weight (g) was obtained [15–17], protein was analyzed by using the Kjeldahl apparatus [16, 18, 19], ash was determined by muffle furnace at 550 °C for 6 h [20], and fat content was measured by using the Soxhlet apparatus [19, 20] and carbohydrate [20] of *Nappi*.

Marketing, supply chain and value chain analysis of *Nappi*

The information related to marketing channel of *Nappi* and value chain considerations of its were executed by following the PRA (Participatory Rural Appraisal) tools such as FGD (Focus Group Discussion) and KII (Key Informant Interview). Due to data gathering, relevant stakeholders such as fishermen, fish trader, producer, intermediary, consumer, whole seller, and local fisheries offices were consulted.

Statistical analysis

For all proximate compositions (moisture, protein, ash, fat, and carbohydrate), ten replicates were done ($n=10$) in the laboratory and the obtained data are expressed as mean \pm standard deviation (mean \pm SD). All the statistical analysis was conducted by r-programming (version 4.2.3). Graphs were produced by using r packages named

as ggplot2 (version 3.4.4) and Performance Analytics (version 2.0.4). Data of two different sampling stations were analyzed by one-way analysis of variance (ANOVA) and Tukey as post hoc test, i.e., difference between the same proximate composition (i.e., protein) of two different sampling stations (Moheshkhali and Chaufaldandi) with the significance difference level of $p < 0.05$.

Results and Discussion

Proximate composition of *Nappi*

The percentage of moisture, protein, ash, fat, and carbohydrate of *Nappi* from Moheshkhali and Chaufaldandi were $37.66 \pm 1.51\%$, $34.34 \pm 0.68\%$, 17.49 ± 0.46 , $8.53 \pm 0.45\%$, and $1.39 \pm 0.10\%$, respectively, and $35.44 \pm 1.37\%$, $37.23 \pm 1.78\%$, $18.46 \pm 0.59\%$, $6.00 \pm 0.40\%$, and $2.66 \pm 0.21\%$, respectively (Table 2).

Furthermore, a comparative study of proximate value was conducted between the two sites (Table 2). The study revealed the average crude protein content from both areas. Despite the low moisture content in the samples, Chaufaldandi had a higher crude protein concentration than Moheshkhali.

There is a slight positive correlation of protein in the sample of Moheshkhali sample with ash and carbohydrate ($r=0.48$ and 0.31) and negatively altered with moisture and fat content ($r=-0.44$ and -0.33) in a similar way (Fig. 4). On the contrary, the protein in Chaufaldandi sample showed a less positive relationship with ash and carbohydrate ($r=0.36$ and 0.16) than that of Moheshkhali (Fig. 4). However, a higher negative relation than all is observed in the ash and fat content of Chaufaldandi sample.

Protein, carbohydrate, and ash percentage in Chaufaldandi sample were found to be significantly higher $F(1)=22.97$, 295.7 , and 16.95 ; $p=0.0001$, 0.0000 , and 0.0006) compared to the Moheshkhali sample, whereas moisture and fat content were statistically higher ($F(1)=11.73$, and 178.9 ; $p=0.0030$ and 0.0000) in the sample of Moheshkhali (Fig. 5, Table 3).

It is noteworthy that these protein content values are similar to those reported by relevant studies such as those conducted by Clucas and Ward in 1996, who reported that *Nappi* contains a crude protein content of 30–40% [21]. Study reported that the crude protein

Table 2 Proximate composition of *Nappi* collected from two sites (Moheshkhali and Chaufaldandi)*

| Proximate composition Station | Moisture (%) (Mean \pm SD) | Protein (%) (Mean \pm SD) | Ash (%) (Mean \pm SD) | Carbohydrate (%) (Mean \pm SD) | Fat (%) (Mean \pm SD) |
|-------------------------------|------------------------------|-----------------------------|-------------------------|----------------------------------|-------------------------|
| Moheshkhali | 37.66 ± 1.51 | 34.34 ± 0.68 | 17.49 ± 0.46 | 1.39 ± 0.10 | 8.53 ± 0.45 |
| Chaufaldandi | 35.44 ± 1.37 | 37.23 ± 1.78 | 18.46 ± 0.59 | 2.66 ± 0.21 | 6.00 ± 0.40 |

*Data shown are the mean \pm SD ($n=10$)

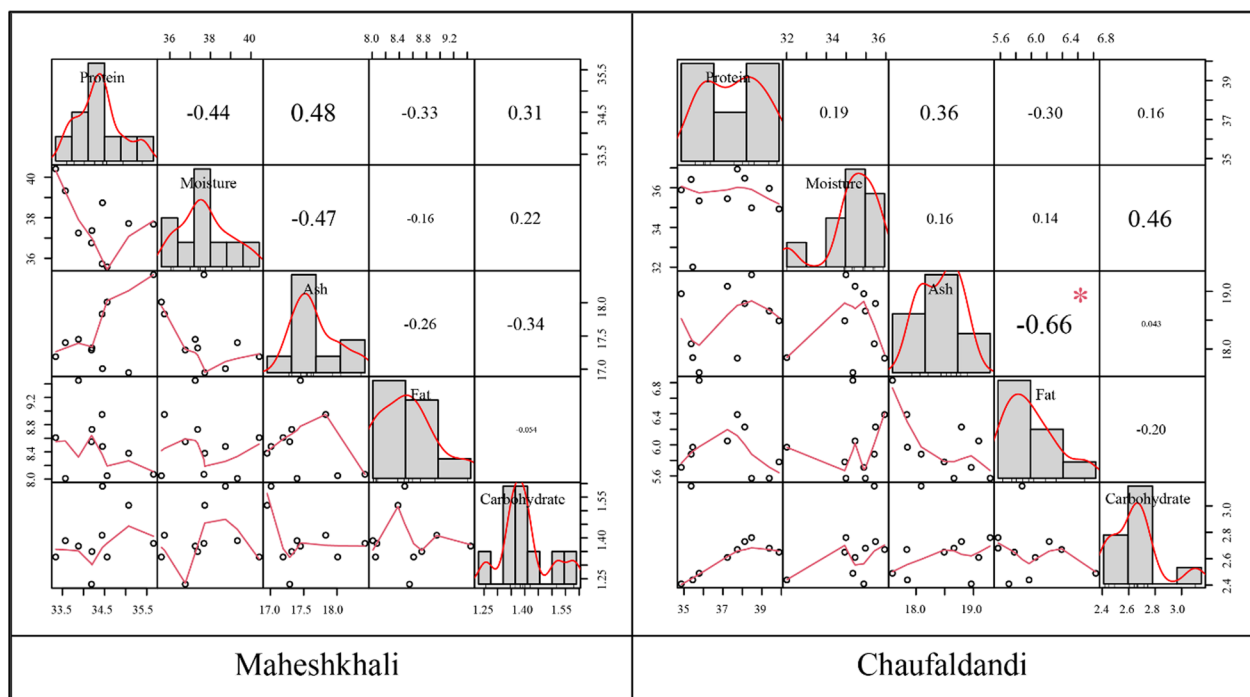


Fig. 4 Correlation plot of proximate composition of two different location showing the relationship among the proximate composition

content of *Nappi* ranged between 22.62 and 33.46% [22]. Research revealed that the protein content of Bruneian and Korean shrimp paste ranges from 21.70 to 30.38% [9]. In the samples collected from Moheshkhali and Chaufaldandi, the fat content was 8.53% and 6%, respectively. According to the study, the fat content is similar to that of Mau, conducted in 2012 [22]. Depending on the source, the fat content ranged from 5.58 to 12.53% [22]. A study reported a fat content of 0.91 percent in *Acetes sp* from Philippines [23]. It is important to note that the fat content of *Nappi* is dependent on the raw materials, and low values may be observed because the main components were *Acetes* and *Mysids* shrimp, both of which are low in fat. A percentage of 37.66% and 35.44% of moisture was recorded in Moheshkhali and Chaufaldandi, respectively. A study reported that the *Nappi* has a moisture content between 27 and 40% [24]. In traditional *Belacan* and *Cincalok* shrimp paste from Malaysia found moisture contents ranging from 32.16 to 67.44% [25]. Proximate composition of fermented paste for different countries is mentioned in Table 4. As observed in Chaufaldandi, the amount of ash in the *Nappi* was higher (18.47%) than that observed in Moheshkhali (17.49%), which agreed with the study from Clucas and Ward in 1996 and Huda-Faujan et al. in 2020, who reported higher levels of ash 20–24% and 43.97–56.15%, respectively [24, 25].

Study revealed that fermented fish contains moisture: 35.40%, protein: 32.0%, fat: 12.0%, ash: 18.9%, and pH:

6.2 [25]. Another study reported about the percentages of protein (38.35%) and fat (20.31%) with antioxidant activity along with their health beneficial bioactive compounds [34]. Fish fermentation increases the bioavailability of minerals and provides excellent organoleptic qualities to the product [35]. Fatty acid content is considerably lower in fermented fish as opposed to fresh fish [36]. It has been discovered that fermented fish oil is exceptionally rich in EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) [37]. Fermented fish oil contains DHA which can help alleviate the symptoms of atopic dermatitis [37]. Fermented fish also contains natural antioxidants and essential nutrients. It has been reported that bioactive peptides derived from fermented fish products act as antioxidants [38]. A research emphasized that, depending on their amino acid sequences, bioactive peptides may exert a variety of biological effects, including antioxidant, antagonist, antihypertensive, immunomodulatory, and anticancer action [39]. Fermented shrimp paste contains fatty acids, amino acids including aspartate, glutamate, alanine, leucine, lysine, arginine, and proline [40]. Like as, *Nappi* also contains high amino acids, protein, minerals and polypeptides [9, 41]. The nutritional value of fermented shrimp or *Nappi* basically depends on manufacturing procedures or processing techniques, handling, the quality of raw material, and processing place [9]. It has a chance of contamination with some

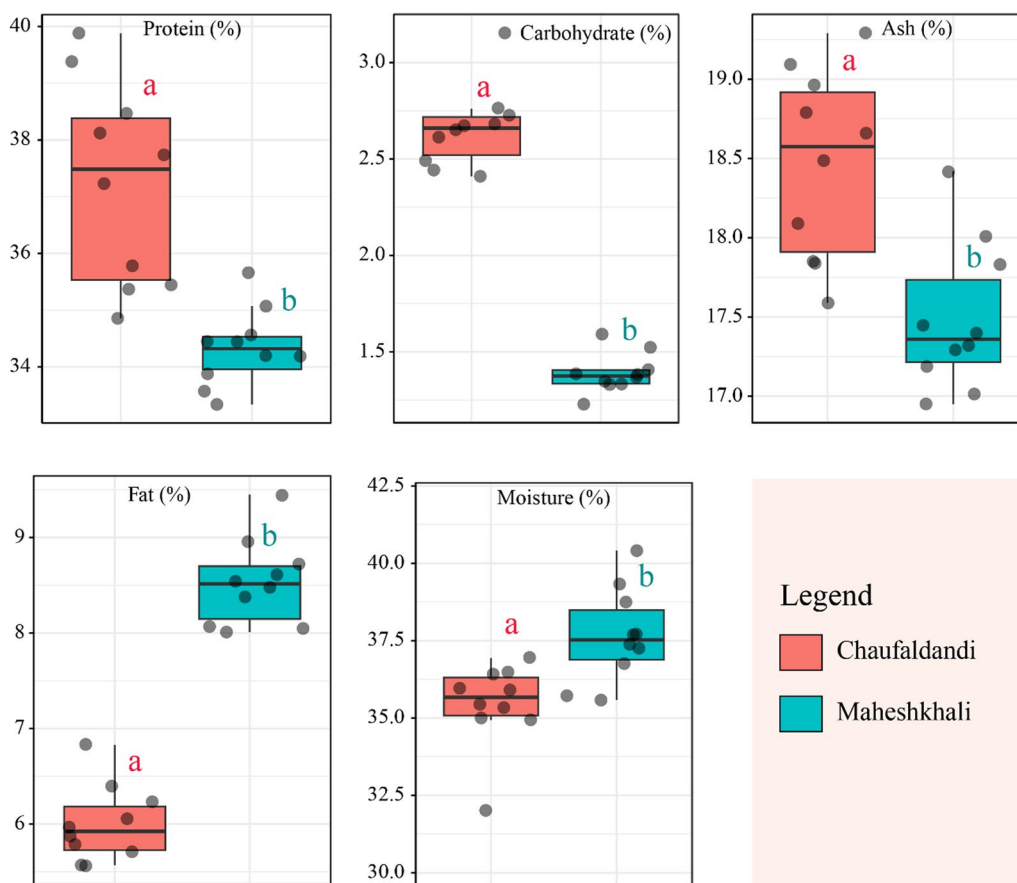


Fig. 5 Percentage of proximate composition from two different locations (Moheshkhali and Chaufaldandi). Different letters above the boxplot depict significant difference (ANOVA, $p < 0.05$) between same proximate composition of two different locations with ten observations each ($n = 10$)

Table 3 Statistical summary of Tukey SHD and ANOVA for same proximate composition of two different locations (Moheshkhali and Chaufaldandi)

| Statistical test | Tukey SHD result | | | | ANOVA result | | |
|------------------|------------------|-------------|-------------|---------|--------------|---------|---------|
| | Diff | Diff. Lower | Diff. Upper | p value | df | F value | p value |
| Protein | -2.892 | -4.160 | -1.624 | 0.0001 | 1 | 22.97 | 0.0001 |
| Carbohydrates | -1.269 | -1.424 | -1.114 | 0.0000 | 1 | 295.7 | 0.0000 |
| Ash | -0.978 | -1.477 | -0.479 | 0.0006 | 1 | 16.95 | 0.0006 |
| Fat | 2.530 | 2.133 | 2.927 | 0.0000 | 1 | 178.9 | 0.0000 |
| Moisture | 2.215 | 0.856 | 3.574 | 0.0030 | 1 | 11.73 | 0.0030 |

Diff, Difference; p value, Probability value; df, Degrees of freedom; F value, F statistics

bacteria, fungi, viruses, and parasites if there are unhygienic conditions, poor preparation techniques, and spoiled raw shrimps [7, 13]. As it has a higher nutrient contents and high demand to the ethnic community, this food product can be taken to the potential international market in Myanmar, Indonesia, Thailand, China, Hong Kong, and Malaysia, if quality is ensured. The

ethnic people specifically regulate the methods used in the making of *Nappies*. They lack the necessary skills to maintain a regulated atmosphere, practise good sanitation and hygiene, and have enough storage facilities. In that regard, microbes may cause contamination and spoiling. According to a study, keeping the sample outside increased the likelihood of massive bacterial

Table 4 Proximate composition of fermented paste in different countries

| Ethnic food items | Proximate composition | | | | | | References |
|--|---------------------------|--------------|-------------|------------|-------------|------------------|---------------|
| | Country | Moisture (%) | Protein (%) | Fat (%) | Ash (%) | Carbohydrate (%) | |
| Korean fermented shrimp paste | Korea | 26.96 | 21.70 | 4.89 | 45.83 | | [26] |
| Traditional Bruneian <i>Belacan</i> shrimp paste | Brunai | 47.92 | 30.38 | 0.63 | 19.15 | | [26] |
| Filipino shrimp paste, <i>Alamang</i> | Philippines | 33.2 | 30.38 | 0.91 | 19.15 | | [27] |
| Shrimp paste, <i>Belacan</i> | Singapore | 27 | 36 | – | – | | [28] |
| <i>Ngari</i> | India | 33.5 | 34.1 | 13.2 | 21.1 | 31.6 | [29] |
| <i>Hentak</i> | India | 40 | 32.7 | 13.6 | 15 | 38.7 | [29] |
| <i>Tungtap</i> | India | 35.4 | 32 | 12 | 18.9 | 37.1 | [29] |
| <i>Belacan</i> | Malay Archipelago | >40 | Not ≤25 | ~1 | >35 | 11 | [30] |
| <i>Pekasam</i> | Malay Archipelago | 57–73 | 15–25 | 3–8 | 6–14 | | [30] |
| <i>Ka-pi-plaa</i> | Thailand | 44.22–52.57 | 35.07–44.97 | 1.41–3.67 | 37.04–52.88 | 1.10–24.19 | [31] |
| <i>Peda</i> | Indonesia | 46 | 28 | 4 | – | – | [32] |
| <i>Suan yu</i> | China | 52.9–58.1 | 17.2–22.9 | | | | [33] |
| <i>Nappi</i> | Moheshkhali (Bangladesh) | 37.66±1.51 | 34.34±0.68 | 17.49±0.46 | 8.53±0.45 | 1.39±0.10 | Present study |
| | Chaufaldandi (Bangladesh) | 35.44±1.37 | 37.23±1.78 | 18.46±0.59 | 6.00±0.40 | 2.66±0.21 | Present study |

growth, which is why salmonella, vibrio, yeasts, and molds spp. were discovered in the stored *Nappies* [5].

However, studies have shown that copepods and other zooplankton, as well as other aquatic crustaceans, such as crabs, prawns, lobsters, and blue green algae, are important reservoirs of *V. cholerae*. These findings are related to the contamination of raw product prawns, which is the primary source of *Vibrio* and *Salmonella* in aquaculture products [42–45]. The study also revealed that the inadequate *Nappi* storage facilities in Chaufaldandi may be the cause of the increased densities of TC (total coliform) and FC (fecal coliform) that were seen in the stored category [5].

A significant factor in the prevention or limitation of microbial growth in *Nappi* is water activity (aw). Following the grinding process, the *Nappi* paste is subjected to a series of alternate fermentation and sun-drying processes before maturing in an airtight container or freezing. The process involved in salt treatment also involves the microorganisms present in the salt used to salt the composition that may contribute to its degradation. It is believed that salt has been used in *Nappi* preparation to reduce the water activity of the compositions that have been exposed to fermentation and protect them from spoilage. Finding the optimum salt concentration in order to maintain the water activity in terms of bacterial growth, product flavor, and texture is necessary. In this study, the water activity (wa) of *Nappi* was not thoroughly examined. It is necessary to conduct a further study in order to obtain more

detailed information regarding the water activity of *Nappi* from the study samples.

Marketing, supply channel and value chain of *Nappi*

Market channels are the routes along which products flow from producers to consumers [46]. However, value chains describe the activities that lead from raw materials to the final consumer [47]. Processes and activities related to producing a product and delivering it to a target market are considered to be part of the supply chain. Several market intermediaries were involved in the supply chain of *Nappi* between producers and the final consumers, including local traders, traders, commission agents, wholesalers, and retailers. A diagram illustrating *Nappi*'s distribution and supply chain with two flows: major and minor flows, is depicted in Fig. 6. The supply of *Nappi* is distributed through a number of different marketing channels in both study areas, whereas only a few marketing channels account for a significant portion of the supply. Distribution and supply chain of *Nappi* are divided among three market categories: primary, secondary, and retail. Market categories of all types have a significant effect on the production of *Nappi* as well as earning from *Nappi*.

The primary market is comprised of *Nappi* producers and local traders. In this type of market, local traders directly purchase *Nappi* from the producer, maintain the local market, and are responsible for managing both the market size as well as the price. It does not matter what the initial purchase price is from the producer. The

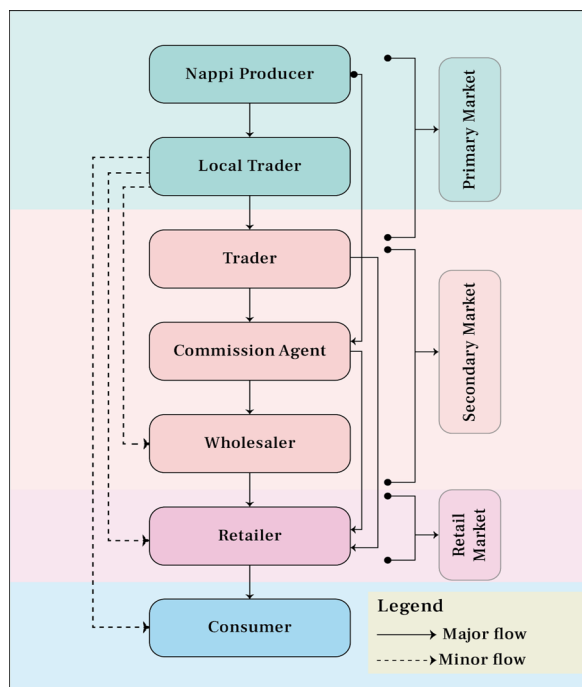


Fig. 6 Distribution and supply chain of Nappi in Bangladesh

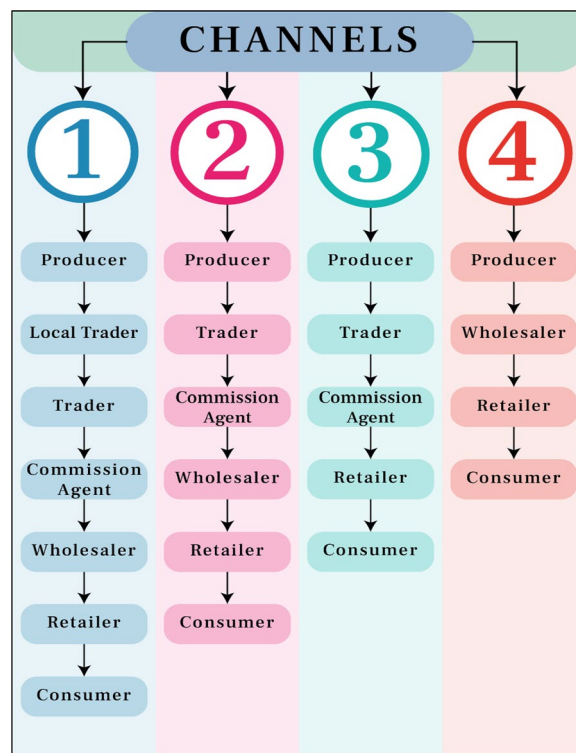


Fig. 7 Marketing Channel of Nappi in Bangladesh

secondary market, on the other hand, consists of traders, commission agents, and whole sellers. It is important to emphasize that each and every stakeholder in this market size has a significant impact on the production of Nappi. Among the three stakeholders of this market size, the commission agent is the most influential. The fact that he acts as a broker is the primary reason for Nappi's significant price variation. Due to his role in shaping and reshaping the Nappi marketing strategy, whole sellers and retailers are influenced by him. Historically, it has been the case that the producer receives the lump sum at any given time, and that secondary market stakeholders are the sole ones responsible for scaling up and down the market. For the retail market, the strategies employed by retailers depend on the local traders of the primary market and the whole sellers of the secondary market, due to the fact that he has to manage them as well as he has only a very small influence over market size. In case of negative market strategy, consumer and producer suffers due to the negative role playing by trader, whole seller, and of course unavoidable and unnecessary stakeholder, commissioning agent. In the field study, it was identified that four channels would be considered for the marketing of Nappi in Bangladesh (Fig. 7).

It involves activities such as production, marketing, distribution, competitive analysis, flexibility, quality maintenance, and identifying unique opportunities and solutions. Traditionally, the value chain includes the

producer, the processor, the wholesaler, the exporter, the importer, the retailer, and the consumer. This helps to understand the flow of goods and services up and down the chain, as well as between different chains.

In summary, the value chain is the sequence of activities, the key participants, and the relationship between them. In Fig. 8, the top row indicates the various functions of the actors involved in the production, collection, wholesale, retail, and consumption of Nappi. Similarly, on the right side of Fig. 8, it is shown that the stakeholders are involved and how the products are flowed between them.

Conclusion

Nappi is a seasonal product, in light of the fact that the products are produced very locally. Due to the availability of raw materials in the coastal area of Bangladesh, Nappi is traditionally produced, but has a great deal of demand among indigenous peoples of the districts, such as Cox's Bazar, Rangamati, Khagrachari, Bandarban, Patuakhali, etc.

As a result of a proximate composition analysis, this study concludes that the highest percentage of protein contained in the Chaufaldandi sample is due to the presence of good quality raw materials with low moisture content. It may be possible to enhance the quality of the

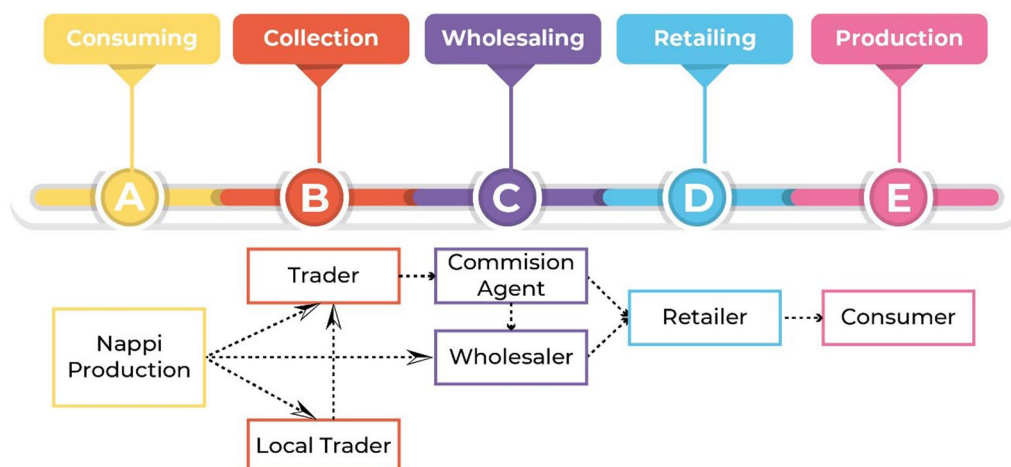


Fig. 8 Value Chain of *Nappi* in Domestic Market of Bangladesh

Nappi produced on Moheshkhali Island by decreasing its moisture content. The addition of improved processing facilities can increase the greater market demand as well as enhance its shelf life. In order to ensure best quality and value of *Nappi*, proper sanitary and hygiene maintenance must need to be followed during the production process. In addition, it is important to develop and distribute low-cost storage technologies to the producers.

In the study, the marketing, distribution, and value chain of *Nappi* are examined in the context of Bangladesh. However, establishing good marketing strategy, value chain and to open up a proper distribution channel will create a new startup up for these foodstuffs. For doing so, proper authorities should come forward to make an intervention on proper preparation techniques, storage facilities and to develop marketing channel for *Nappi* in Bangladesh to get national and international attention to highlight this ethnic food item. Incorporating and enforcing proper sanitary and hygiene practices in *Nappi* production not only enhances product quality but also ensures consumer safety, contributing to the overall success of the product, especially in view of export potential. Currently, this product is exported to our neighboring country Myanmar via the internal trade route. However, improved *Nappi* can take the potential international market to other southeast Asian countries.

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Author contributions

MMM contributed to conceptualization, methodology, writing, editing, reviewing, and supervision; MRI performed writing, reviewing, and editing; SDN performed data collection, data analysis, and writing; MAAK performed editing, reviewing, and supervision; MSA performed editing and reviewing; AA contributed to data analysis and visualization; IA performed data analysis, visualization, and reviewing.

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Availability of data and materials

The datasets during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

The published version of the article has been reviewed and approved by all authors.

Competing interests

The authors declare that they have no competing interests.

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