Bangladesh Journal of Animal Science
Journal homepage: http://www.banglajol.info/index.php/BJAS

Sensorial, chemical and microbial quality of spongy *rosogolla*

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ARTICLE INFO

Article history:
Received: 26 November 2021
Revised: 12 January 2022
Accepted: 09 March 2022
Published: 31 March 2022

Keywords:
Spongy Rosogolla, Cow milk, Buffalo milk

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ISSN: 0003-3588

OPEN ACCESS

ABSTRACT

The goal of this investigation was to compare the physical, chemical and microbial qualities of laboratory made and market spongy *rosogolla*. Two types of spongy *rosogolla* were made in laboratory from the cow and buffalo milk chhana to reveal the quality in regards of the species and three types of market spongy *rosogolla* were collected from three different shops. With regard to the physical attributes, laboratory made spongy *rosogolla* were found better than the market spongy *rosogolla* and cow milk spongy *rosogolla* was the best. In chemical aspects, laboratory made spongy *rosogolla* had greater pH, fat, protein, and ash content, whereas, market spongy *rosogolla* showed higher acidity and carbohydrate content. The moisture content of cow milk spongy *rosogolla* was highest. The mineral contents (Ca, P, and Mg) were also differed significantly ($p<0.01$) among the samples except for Na content. Highest Ca, P and Mg contents were found in market spongy *rosogolla*. The total viable count (TVC) was significantly ($p<0.01$) lower in laboratory made spongy *rosogolla*. However, the *Escherichia coli* count was found similar ($p>0.05$) in both cow and buffalo milk spongy *rosogolla* but lower ($p>0.05$) than other market spongy *rosogolla* samples. Considering all the findings, it may be concluded that the quality of market spongy *rosogolla* needs improvement and responsible authorities might take necessary initiatives for monitoring.

Introduction

Milk and milk products are important human foods that are well recognized since the ancient period, and *rosogolla* is one of the most popular, tasty, and healthy sweetmeats in Bangladesh (Mannan *et al*., 1995). *Rosogolla* is a popular syrupy dessert made by cooking and soaking of chhana balls (a milk protein and whey protein co-precipitate produced by heat and acid precipitation) in sugar syrup, which is generally soft and spongy in texture (David, 2016; Gurveer and Goswami, 2017). *Rosogolla* is most popular sweetmeat which is highly acceptable to the people for its characteristics texture and a pleasant sweetness (Desai *et al*., 1993). It has high nutritional value because of its digestibility and high protein, fat, mineral content, particularly Ca and P, as well as fat-soluble vitamins A and D. (Kumar and Prasad, 2010; Prajapati *et al*., 2011). *Rosogolla* has 186 calories per 100g, with 153, 16, and 17 calories coming from carbohydrate, protein, and fat, respectively (Gurveer and Goswami, 2017). It is widely consumed because of its nutritional and physiological benefits for humans (Chavan *et al*., 2009; Sahu and Das, 2009) and its consumption has surged in India at a pace of more than 20% per year because to its health benefits (Singh *et al*., 2007). Aside from acceptable shelf life and public health safety, *rosogolla* has been regarded a vital meal item in numerous festivals of life in our country, such as Eid, Puja, birthdays, and marriage ceremonies, and it would be meaningless without offering this sweetmeat to people of all ages during these occasions (Islam *et al*., 2003). Spongy *rosogolla* is one kind of *rosogolla* which is more resilient in texture than

How to Cite
MS Hossain, MMH Khandakar, MN Islam, MA Islam (2022). Sensorial, chemical and microbial quality of spongy rosogolla. *Bangladesh Journal of Animal Science*, 51 (2): 81-84. https://doi.org/10.3329/bjas.v51i2.60499.

the conventional type and very popular in Bangladesh. In majority of the sweetmeat shops, spongy *rosogolla* is a common item. The quality of such sweetmeats varies from place to place, market to market, and shop to shop (Prodhan *et al*., 2017). The manner of chhana production, the standard of chhana, the use of an appropriate proportion and kind of binding material, and other process factors all affect the quality of this type of sweetmeat, and the quality of raw materials plays an essential part in the body and texture subsequently the overall quality of it (Gurveer and Goswami, 2017). To get a hefty profit, some manufacturers use low quality ingredients for *rosogolla* preparation that leads to deterioration of spongy *rosogolla*'s quality. *Rosogolla* is typically produced using cow milk (Rao *et al*., 1989), and there are just a few accounts of *rosogolla* made with buffalo milk (Kanwal *et al*., 1980). As per authors' knowledge, very few or no research works have been done to improve the quality of spongy *rosogolla* available in market. Therefore, we prepared the spongy *rosogolla* in the laboratory from both cow and buffalo milk to reveal the best quality in regards of species variation as well as to assess the quality of market spongy *rosogolla* against same product manufactured in laboratory from cow milk and buffalo milk chhana.

Materials and Methods

Raw milk collection

Cow milk and buffalo milk was collected in the morning from Bangladesh Agricultural University (BAU) Dairy Farm (24°43'46.5"N, 90°25'22.8"E), Mymensingh-2202, Bangladesh. Following that, the milk samples were transferred to the laboratory for spongy *Rosogolla* manufacture and further analysis. An automated milk analyzer (Lactoscan, SLP, MILKOTONIC Ltd., Nova Zagora-8900, Bulgaria) was used to examine gross milk compositions at the Dairy Chemistry and Technology Laboratory, Department of Dairy Science, BAU, Mymensingh-2202. Calcium (Ca), and magnesium (Mg) contents of milk were determined by EDTA trimetric method using Na_2-EDTA solution (Page *et al*., 1982; Singh *et al*., 1999). Phosphorus was measured colorimetrically using the stannous chloride ($SnCl_2$) technique, as described by Jackson (1973) and Tandon (1995) whereas, the sodium (Na) content was determined by using a Jenway flame photometer (Indonetwork, model PFP7, United Kingdom) according to the methods of Kibria *et al*. (2017) and Ghosh *et al*. (1983). In addition, total viable count (TVC) and coliform count was carried out at Dairy Microbiology and Biotechnology Laboratory, Department of Dairy science, BAU. Table 1 shows the chemical composition and microbial quality of raw cow milk and buffalo milk.

Table 1. Chemical composition (%) and microbial quality (Log cfu/ml) of raw cow and buffalo milk

Parameters	Buffalo Raw Milk	Cow Raw milk
pH	6.88	6.87
Acidity	0.16	0.15
TS	15.64	12.38
Moisture	84.36	87.58
Fat	6.60	4.23
Protein	3.45	3.20
CHO	37.77	36.37
Ash	0.71	0.68
Calcium*	0.184	0.122
Phosphorus*	0.105	0.074
Sodium*	0.052	0.052
Magnesium*	0.076	0.048
TVC	29.67	36.67
E. coli	13.33	13.33

*cfu, colony forming unit; *, in mg/kg; TS, total solids; CHO, carbohydrate; TVC, total viable count; E. coli, Escherichia coli*

Preparation of spongy Rosogolla

Chhana from cow milk and buffalo milk was prepared by using whey water (with acidity ≈1.1% lactic acid). First, the temperature of the milk was increased to 90 - 92°C by heating followed by cooling to 85°C. Following that, sour whey was progressively mixed together with the milk as a coagulant, with constant gentle stirring. The coagulant was added until the pH reached 5.2 and the milk coagulated, resulting in a greenish-yellow hue in the whey. When precipitation of milk protein was completed, the chhana was gathered in a muslin cloth, and the whey was drained out for 3 hours. Messing of chhana was done to soften the coagulum uniformly. To make the dough, 5% of flour was added to the chhana and thoroughly kneaded until visible fat separation occurred on the palms. This dough was made into chhana balls by rolling

them between palms for 1 minute without cracking the surface (Sengupta *et al*., 2017) otherwise these balls would lose their integrity when cooking. After making all chhana balls, they were cooked in the syrup of sugar (Sugar: water = 2:1) for 40 to 60 minutes. During the continuous boiling of sugar syrup, hot water was sprinkled to maintain syrup concentration. After boiling, the chhana balls were kept in hot water of above 80 - 90 °C for 1 hour. Next, the balls were kept into another sugar syrup (Sugar: water = 1:1) for 3 hours at above 80 °C. Finally, the spongy *rosogolla* were allowed to stay for sometimes to cool. The spongy *rosogolla* manufactured from cow milk chhana was coded as R_1 and from buffalo milk chhana was codded as R_2.

Collection of spongy Rosogolla from market

Market spongy *rosogolla* samples were collected from three different shops namely Adorsho Mistanno vander, Kalibari Road, Mymensingh Sadar, Mymensingh (R_3), Cantonment Mistanno vander, Shankipara, Mymensingh Sadar, Mymensingh (R_4), and Abdus Salam Mistanno vander,Haluaghat bazar, Haluaghat, Mymensingh (R_5). After collection, the samples were transferred to the Laboratory of Dairy Chemistry & Technology, and Laboratory of Dairy Microbiology, Department of Dairy Science, Bangladesh Agricultural University for further analyses.

Sensory evaluation

A panel of five judges from Department of Dairy Science, Bangladesh Agricultural University, Mymensingh, Bangladesh, evaluated spongy *rosogolla* samples using a score card containing 45 marks for flavour, 30 marks for body and texture, 15 marks for colour and appearance and 35 marks for taste.

Chemical and microbial analysis

The proximate components (moisture, total solids, fat, protein, and ash) of the spongy *rosogolla* samples were determined using the standard methods of AOAC (2003). The aggregated value of protein, fat, and ash contents was subtracted from total solids content to calculate the carbohydrate content. Mineral elements (Ca, P, Na and Mg) were determined similarly as described for the raw milk minerals determination. Acidity was determined by titrating with N/10 sodium hydroxide solution according to the method of Agarwala and Sharma (1961) and pH was measured with help of pH meter-215 (Ciba Corning Diagnostic Ltd. Sudbury, Suffolk, England Co. 106*D). The microbial quality (total viable count and coliform count) of the samples were evaluated according to the methods described by Marshall (1993).

Statistical analysis

Statistical analysis of data obtained on various parameters was accomplished by One Way ANOVA using MSTAT 6.1.4 program and the means were compared by the least significant difference (LSD) test.

Results and Discussion

Sensory characteristics of Rosogolla

The results of sensory evaluation of spongy *rosogolla* were described in Table 2.

Flavour

The average flavour score of *rosogolla* samples from different sources showed significant differences ($p<0.01$). R_1, R_2, and R_3 spongy *rosogolla* samples were significantly ($p<0.01$) higher than R_4 and R_5 samples for flavour score. However, the highest score was found in R_1 samples and the lowest in R_5 *rosogolla* samples. Begum *et al*. (2020) and Acharya and Kanth (2005) indicated that flavour of *rosogolla* was enhanced by cooking. Joshi *et al*. (1991) revealed that, chhana from cow and buffalo milk had acceptable flavour whereas that from goat milk had an acidic flavour.

Body and texture

The R_1 spongy *rosogolla* samples obtained the highest ($p<0.01$) score than other samples. R_2 and R_3 samples were statistically similar ($p>0.05$) but they were significantly better ($p<0.01$) than R_4 followed by R_5 samples. Body and texture of *rosogolla* may vary with various factors such as quality of raw ingredients, type of coagulant, proportion of chhana binding agent, sugar syrup concentration, etc. Joshi *et al*. (1991) observed that chhana prepared from buffalo milk had a hard body and coarse texture. Cow and goat milk produced chhana with soft body and smooth texture. This might be the reason behind the highest score or R_1 spongy *rosogolla* samples because these samples were prepared from the chhana of cow milk. The texture of *rosogolla* might also be decreased with increased temperature and length of storage time

(Arora *et al.*, 1996; Dongare *et al*. (2019); Kaur and Goswami (2019); Sarkar *et al*., 2021b) which might decrease the body and texture score of R_3, R_4, and R_5 samples.

Table 2. Comparison of average score of organoleptic characteristics of spongy *Rosogolla*

Parameters	Sources of Spongy *Rosogolla*					
	R_1	R_2	R_3	R_4	R_5	P Value
Flavour()	40.00^{a}±3.00	39.67^{a}±1.53	39.00^{a}±1.73	36.33^{b}±1.53	35.00^{b}±1.00	0.0001
Body and Texture()	28.00^{a}±2.00	26.67^{b}±1.53	25.00^{b}±2.65	23.33^{c}±1.53	21.33^{d}±1.53	0.0020
Colour and Appearance()	13.00^{a}±2.00	12.00^{b}±1.00	12.09^{b}±1.73	12.04^{b}±1.00	11.67^{b}±1.53	0.0071
Taste()	8.00^{a}±1.00	7.67^{b}±0.58	7.65^{b}±0.51	6.33^{c}±1.15	5.33^{d}±1.15	0.0041
Total()	89.00^{a}±2.00	86.01^{b}±3.61	83.74^{c}±6.11	78.03^{d}±4.00	73.33^{e}±2.52	0.0021

Mean with different superscripts in a row vary significantly; R1, Laboratory made spongy rosogolla from cow milk; R2, Laboratory made spongy rosogolla from buffalo milk; R3, Spongy rosogolla from Adorsha Mistanno Vander; R4, Spongy rosogolla from A. Salam Mistanno Vander; R5, Spongy rosogolla from Cantonment Mistanno Vander

Colour and appearance

The highest mean value ($p<0.01$) of colour and appearance was recorded in laboratory made spongy *rosogolla* made from cow milk chhana (R_1) than other spongy *rosogolla* samples. R_2, R_3, R_4 and R_5 samples were statistically similar ($p>0.05$) although the lowest score was observed for R_5 *rosogolla*. The variation of colour and appearance was probably due to fat % in milk and high fat percentage is positively correlated with the colour of *rosogolla* (Chavan *et al*., 2011). According to Mini *et al.* (1995) *rosogolla* prepared from whole milk scored higher than that of skim milk for colour and appearance. R_3, R_4, and R_5 samples might be prepared from low fat milk chhana. Though buffalo milk contains higher fat content than cow milk, the colour of milk fat of buffalo milk is creamy white because of the conversion of beta-carotene pigment into colourless vitamin-A. Therefore, *rosogolla* prepared from buffalo milk chhana (R_2) scored lower than that of from cow milk chhana (R_1). The addition of flour level also has effect on the colour and appearance of *rosogolla* (Tambat *et al*., 1992; Begum *et al*., 2022). Sometimes cooking time might enhance the colour of *rosogolla* (Bhattacharya and Raj, 1980) but overcooking and prolonged boiling should be avoided as it can lead to brown color formation in *rosogolla* due to Maillard reaction (Sarkar *et al.*, 2021a).

Taste

The difference between R_2 and R_3 spongy *rosogolla* was not significant ($p>0.05$) for their taste score. However, the maximum score was reported for R_1 samples which was significantly higher ($p<0.01$) than R_2 and R_3 samples followed by R_4, and R_5 samples. The taste of *rosogolla* actually depends on the raw ingredients used for the manufacture of *rosogolla*. Begum *et al*. (2022) reported that the *rosogolla* contained 53.43% moisture, 33.83% carbohydrate, 6.65% proteins and 5.58% fat had better taste. Basak *et al*. (2007) found that *rosogolla* with 5% added flour received the highest flavour rating. During preparation of *rosogolla* in the laboratory, all the ingredients used as standard levels tended better taste in laboratory made spongy *rosogolla* than in market spongy *rosogolla*.

Total sensory score

From table 2, it was revealed that the highest overall score for sensory evaluation was recorded for R_1 spongy *rosogolla* followed by R_2, R_3, R_4, and R_5. All the samples from different sources differed significantly ($p<0.01$) from each other. As all physical parameters for laboratory made spongy *rosogolla* from cow milk and buffalo milk chhana were greater than the market spongy *rosogolla* that is why total physical score went highest for R_1 spongy *rosogolla*. And this higher value indicated that the laboratory made spongy *rosogolla* was superior to the market sources. Our findings are supported by Tarafder *et al*. (2002), who observed superior quality of

rosogolla over market *rosogolla*. The total physical score of spongy *rosogolla* may vary with different factors. According to Puranik *et al*. (1997) pure recombined milk chhana was not acceptable and according to Mini *et al*. (1995) the overall quality of *rosogolla* depends on the sources of milk (such as whole milk, coconut milk, or skim milk), and in these cases, laboratory-made (control) *rosogolla* scored higher than other samples.

Chemical composition and microbial quality

The chemical composition and microbiological quality of spongy *rosogolla* from various sources are presented in Table 3. It has been noted that all the chemical and microbial parameters differed significantly for different samples except sodium content (mg/kg) and *E. coli* count (cfu/g).

The pH of the sample R_2 was found significantly ($p<0.05$) higher followed by sample R_1. Sample R_3 was found similar ($p>0.05$) to samples R_1 and R_4. Sample R_5 has the lowest value but differed non-significantly ($p>0.05$) from sample R_4. Haque (2000) reported pH of *rosogolla* prepared from cow milk and buffalo milk chhana was 6.60 and 6.73, respectively while Chanda (1999) stated that the pH of *rosogolla* ranges within 5.92 and 6.36. All the samples were similar or slightly higher to these findings in their pH value.

Table 3. Average chemical composition (%) and microbial quality (log cfu/g) of various sources of spongy *rosogolla*

Parameters	Spongy *Rosogolla*					
	R_1	R_2	R_3	R_4	R_5	P-value
pH	6.87^{ab}±0.029	6.88^{a}±0.029	6.77^{bc}±0.076	6.70^{cd}±0.087	6.68^{d}±0.029	0.002
Acidity	0.072^{c}±0.003	0.071^{c}±0.002	0.076^{b} ±0.002	0.08^{a}±0.002	0.08^{a}±0.004	0.004
TS	46.33^{b}±1.06	50.23^{a}±0.90	49.91^{a}±0.63	51.58^{a}±1.14	49.73^{a}±1.39	0.000
Moisture	53.67^{a}±1.06	49.77^{b}±0.90	50.09^{b}±0.63	48.43^{b}±1.14	50.28^{b}±1.39	0.000
Fat	5.40^{b}±0.36	7.77^{a}±0.15	4.75^{c}±0.05	4.57^{d}±0.06	4.70^{c}±0.10	0.000
Protein	3.82^{a}±0.025	3.91^{a}±0.036	3.58^{c}±0.076	3.46^{c}±0.055	3.60^{b}±0.050	0.000
CHO	36.37^{c}±0.71	37.77^{c}±0.71	40.87^{b}±0.61	42.83^{a}±1.04	40.70^{b}±1.45	0.000
Ash	0.74^{b}±0.012	0.78^{a}±0.015	0.71^{c}±0.010	0.71^{c}±0.014	0.72^{c}±0.008	0.000
Calcium*	1.443^{c}±0.001	1.603^{b}±0.001	2.405^{a}±0.001	1.283^{d}±0.001	0.481^{e}±0.001	0.000
Phosphorus*	0.009^{a}±0.001	0.008^{b}±0.001	0.009^{a}±0.001	0.008^{b}±0.001	0.010^{a}±0.001	0.000
Sodium*	0.038±0.00	0.132±0.17	0.042±0.00	0.041±0.001	0.013±0.00	0.151
Magnesium*	0.097^{d}±0.00	0.049^{e}±0.001	0.972^{a}±0.001	0.194^{c}±0.001	0.486^{b}±0.00	0.001
TVC	49.00^{b}±3.06	44.67^{b}±6.24	92.00^{a}±7.09	88.67^{a}±6.66	84.33^{a}±4.16	0.000
E. Coli	10.00±3.61	10.00±5.77	16.67±5.75	13.33±11.55	16.67±5.77	0.123

**, in* (mg/kg); cfu, *Colony forming unit; R1, Laboratory made spongy rosogolla from cow milk; R2, Laboratory made spongy rosogolla from buffalo milk; R3, Spongy rosogolla from Adorsha Mistanno Vander; R4, Spongy rosogolla from A. Salam Mistanno Vander; R5, Spongy rosogolla from Cantonment Mistanno Vander; Mean with different superscripts in a row vary significantly*

In contrast to the pH value, the highest acidity was observed in R_5 *rosogolla* whereas the lowest in R_2 samples. The acidity of laboratory spongy *rosogolla* was found lower than market spongy *rosogolla*. Haque (2000) revealed that the acidity of *rosogolla* were 0.75, 0.70 and 0.71%, respectively which are prepared from cow milk, buffalo milk and equal combination of cow milk and buffalo milk. Arora *et al*. (1996) stated that the acidity was increased during the storage of sample. Laboratory made spongy *rosogolla* was fresh whereas market spongy *rosogolla* probably stored, therefore, the acidity of laboratory made spongy *rosogolla* was relatively lower than collected market spongy *rosogolla.* The total solids (TS) content of laboratory manufactured spongy *rosogolla* from the chhana of cow milk was significantly ($p<0.01$) lower than other samples. R_2 spongy *rosogolla* contained highest TS content as it was prepared from buffalo milk chhana. The TS content of market *rosogolla* was also higher in our study which is close to the

results of Kanwal *et al*. (1980) who observed higher TS content of market *rosogolla* than laboratory made *rosogolla*. Higher moisture content was observed in laboratory spongy *rosogolla* whereas collected spongy *rosogolla* samples had a low amount of moisture. According to BSTI standard, spongy *rosogolla* could contain maximum 55% moisture. Therefore, sample R_1 was the best among the samples. However, acceptable quality *rosogolla* could contain 49.85 to 53.80% moisture (Bhattacharya and Raj, 1980). Higher moisture content is related to the good quality flavour and texture of spongy *rosogolla* (Prodhan *et al*., 2017). Tewari and Sachdeva (1991) observed good flavoured *rosogolla* contains 62.5 to 63.5% moisture.

Laboratory prepared spongy *rosogolla* samples (R_1 and R_2) had higher protein, fat, and ash contents whereas market spongy *rosogolla* samples (R_3, R_4, and R_5) contained lower protein, fat, and ash content. On the contrary, R_1 and R_2 samples showed lower carbohydrate content and R_3, R_4, and R_5 samples exhibited higher carbohydrate content. The maximum fat content was found in R_2 type made from buffalo milk chhana as because buffalo milk comprises higher fat content than cow milk. Consequently, buffalo milk chhana and finally spongy *rosogolla* manufactured from chhana of buffalo milk had the highest fat content. Similar to our findings, Bhattacharya and Raj (1980) and Sur *et al*. (2000) reported that high fat percentage in milk leads to a greater fat percentage in the spongy *rosogolla.* Lower fat content of market *rosogolla* may be due to the lower fat percentage of milk that was used for the chhana preparation. Kanwal *et al*. (1980) also found that market *rosogolla* contains lower fat content than laboratory made *rosogolla*. Again, laboratory mad spongy *rosogolla* contained significantly ($p<0.05$) higher protein content than that of market spongy *rosogolla*. The higher protein content of laboratory prepared *rosogolla* tends them toward higher quality. According to BSTI standard, spongy *rosogolla* should contain minimum 5% fat, 5% protein and maximum 0.9% ash. Only laboratory made spongy *rosogolla* conformed to the mentioned standards although the protein percentage was slightly lower but it was better than market spongy *rosogolla*. The greater carbohydrate percentage of spongy *rosogolla* collected from the market might be the result of higher level of added flour or higher sugar concentration of syrup. Tarafdar *et al*. (2002) indicated that *rosogolla* manufactured in laboratory had carbohydrate content of 357 (g/kg) whereas market *rosogolla* had 408-461 (g/kg) carbohydrate content that supported in favour of this study. Adhikari *et al*. (1992) found that chhana with a higher percentage of lactose contributed to the higher percentage of lactose in *rosogolla* (spongy).

There were significant differences ($p<0.01$) among the *rosogolla* samples for their mineral contents except for sodium content. However, there was no clear distinction between two types of laboratory made and market spongy *rosogolla*.

Microbiological quality

From Table 3 it is clear that the microbial quality of spongy *rosogolla* manufactured in laboratory was significantly superior over market spongy *rosogolla*. Total viable counts (TVC), and *E. coli* count were higher in market spongy *rosogolla* than laboratory made spongy *rosogolla*. Nonetheless, the differences in *E. coli* counts in different sample were not significant. Higher bacterial count of market spongy *rosogolla* indicates that strict hygienic conditions might not be maintained during the manufacturing time.

Conclusion

The spongy *rosogolla* manufactured and evaluated clearly indicates that the laboratory prepared product has better quality attributes in all three aspects of the quality *viz.* organoleptic, chemical and microbiological. This implies the importance of studying methodologies follow in the market level for spongy *rosogolla* production and standardizing them. This could lead to the better uniform quality products to the consumer. The variation between the cow milk and buffalo milk spongy *rosogolla* necessitates more studies to obtain comparable buffalo milk products.

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