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Research Article

UTILIZATION OF MANGO CO-PRODUCTS AS FUNCTIONAL INGREDIENT

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A B S T R A C T

Mango peel and seed are nutritionally dense co-products of mango but are commonly discarded as waste. This research work was carried out to determine the physico-chemical and sensory attributes of biscuits prepared by partial substitution of whole wheat flour separately with mango peel powder (MPP) and kernel powder (MKP) at different levels (0, 15, 25 and 50%). As compared to the whole wheat flour (WWF), powders prepared from mango peel (MPP) and mango kernel (MKP) were low ($p<0.05$) in moisture content and high in ash content and fiber. The moisture content was 13% in whole wheat flour, 10% in mango peel powder and 10% mango kernel powder. The MPP and MKP had dietary fiber ranging from 8%-10%. The total phenol content was higher in MPP (19.06mgGAE/g) and MKP (21mgGAE/g) as compared to WWF (3.4mgGAE/g). Biscuits prepared with 25% MPP and 50% MKP showed the greatest crude fiber content. Increase in the levels of MPP and MKP in biscuits had effect on the volume and color of the product. The biscuits formulated with 15% MPP and 15% MKP were most acceptable on sensory parameters. The result of the present work showed that both MPP and MKP can be utilized as value-added ingredients in the preparation of biscuits.

INTRODUCTION

Mango (*Mangifera indica)* is an important fruit with a large production and great consumer acceptance worldwide. It is a green colored fruit that turns yellow on ripening having a yellow flesh with soft fiber. It is rich in fiber, minerals, vitamins and antioxidants that can be processed as juice, pickle, canned products etc (Wasim *et al*., 2015). The fruit is seasonal and highly perishable. Due to poor post-harvest handling, around 60-80% of the produce goes waste during peak season (Djantou *et al*., 2007). To reduce wastage and ensure extended consumption, the surplus fruit can be processed into flour and can be used in the development of several food products as a functional ingredient (Jahurul *et al*., 2015).

Status

Around 50.6 million tonne mangoes were produced in the year 2017 worldwide. Of the total mango production, around 77% production was from Asia, 13% was from America and Africa accounted for around 9%. Some of the countries producing mangoes include India, Mexico, Nigeria, China and Egypt. According to Food and Agriculture Organization Corporate Statistical Database (2017), mango is the second most traded fruit globally and first in India. With a huge production of around 23 million tonne annually, major producer of mangoes is India, chased by China that produces 5 million tonne. In India, major states that produce mangoes are Uttar Pradesh, Maharashtra, Gujarat Tamil Nadu, Karnataka, Andhra Pradesh, Telangana and Bihar (FAO, 2016). Around 1500 varieties of mangoes are grown in India and each variety has a unique flavor and taste. Himsagar, Suvernarekha, Alphonso, Vanraj, Dashehari, Langra, Mulgoa and Chausa are example of some of the varities.

The maturity of mangoes at the time of harvest largely decides its color and appearance, taste, quality and shelf life. Harvesting mangoes before attaining full maturity results in improper ripening, excessive shrinkage and more sourness in the fruit (Jha *et al*., 2007). In contrast, harvesting fruits at maturity results in mangoes that have lower shelf life and are more susceptible to microbial infections (Kansci *et al*., 2003). The proper storage of the fruit is critical, as rapid degradation of the fruit occurs if stored at ambient temperature (25 to 35°C) and enzymatic browning occurs during freezing. The storage of whole mangoes at temperature of 13°C for several days has also shown symptoms of chill injury (Tovar *et al*., 2001). The poor post-harvest storage is therefore resulting into wastage of large quantities of this high value fruit.

Several efforts have been made in the past to utilize surplus of this fruit to avoid wastage. Traditionally, the unripe mangoes are used to prepare products like pickles, chutneys, raw mango powder, some beverages. Preservation and processing of ripe mangoes as puree helps in storage of large quantities of fruit

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that can be utilized to prepare products like fruit nectar, jams, candies, syrups etc. (Ajila *et al*., 2010). Even after processing, 35-60% of the fruit goes as waste and the major co-products of mango processing include peel and kernel. A huge quantity of mango seeds (around one million tonne) is generated as waste annually that is going commercially unutilized (O'Shea *et al*., 2012) and also causing serious environmental issues. Mango co-products, especially seeds and peels, are economical sources of valuable nutraceutical ingredients (Jahurul *et al*., 2015) with several health benefits.

Mango Peel, Mango Kernel and Powder

Mango peel contributes around 15-20% of the fruit and is mixture of pigments like chlorophyll, anthocyanin and carotenoid (Litz and Mukherjee, 2009). Studies have shown that mango peels contain phyto-chemicals, fiber and vitamin C in good amounts and has also shown antioxidant properties. The peel of the mango contain high levels of biologically active substances but is usually discarded and considered inedible.

Depending on the variety of mango, around 10-15% of the mango fruit is comprised by the seed and 40-45% of this seed is represented by kernel (Torres Leon *et al*., 2016). The phenolic components like tannins, Gallic acid, Ellagic acid, Vanillin and Mangiferin are present in high amount in mango seed kernel (Soong *et al*., 2004). It also contains good amount of potassium, magnesium, phosphorus, calcium and sodium. Some studies have shown that the commonly used synthetic antioxidants like Butylated Hydroxy Anisole and Butylated Hydroxyl Toluene are indicating some toxicity and carcinogenicity in processed food products (Butsat, 2009). Therefore, the demand for antioxidants from natural sources is continuously increasing to substitute these synthetic antioxidants and also to provide inexpensive alternates. The mango seed kernel with its high antioxidant properties can be utilized as one such inexpensive natural source of antioxidants.

With high moisture content (85%), mango is a perishable seasonal fruit having a short shelf life (Raj Kumar *et al*., 2007). The most common technique that can be used to prevent losses is dehydration. Out of different methods of dehydration practiced nowadays, hot air drying is a cost-effective method that gives high productivity, hygienic, uniform, high quality and attractively colored end product (Doymaz, 2004). The mango powder with high levels of dietary fiber and antioxidants is an excellent raw material that can be used for modification of texture and consistency of food products like bread, macaroni, etc. (Vergara-Valencia *et al*., 2007; Ajila *et al*., 2010)

Health Benefits of Mango

Nowadays, people have become more conscious about their health and prefer taking foods that have lower fat content, lesser calories and are high in antioxidant and dietary fiber. Mango fruit exhibits excellent antioxidant activity and contains bioactive compounds in good amounts. Health isssues such as hypertension, diabetes, constipation, etc. can be prevented by consuming diet higher in dietary fiber content (Champ *et al*., 2003). With the increased awareness about importance of dietary fiber in diet, the search for newer sources that can be utilized in food industry has increased substantially. The major source of dietary fiber products utilized currently is cereal (Bunzel *et al*., 2001). However, the dietary fiber obtained from fruit sources is considered better because of balanced composition, better nutritional quality and higher bioactive compounds (Aslam *et al*., 2014) with good functional properties and capacity to absorb oil. Several studies in the past have also mentioned that pulp and peel from mango are good source of dietary fiber (Ajila *et al*., 2008).

Biscuits with functional ingredients

As the consumers are becoming more health conscious, the demand for health-promoting fiber-enriched processed foods (biscuit, bread, sponge cake etc.) is increasing day by day. Several studies in the recent past have reported that wheat flour can be replaced by inexpensive natural source of fiber for preparing various bakery products. Generally, biscuits are liked by people of all ages but higher levels of fat and sugar and also lack of essential nutritional components like dietary fiber, antioxidants, vitamins, minerals (that are lost during refining process of wheat flour) limits their acceptance (Heiniö *et al*., 2003; Rodríguez *et al*., 2006). Therefore, biscuits are potential carrier for incorporation of dietary fiber and antioxidants from inexpensive natural sources that can provide functional attributes.

In the current study, chausa variety of mango that has an aromatic, pleasant and sweet flavor was used for making mango peel powder and mango kernel powder. These powders were then used to prepare biscuits with higher dietary fiber and antioxidant content. The results of this study will highlight potential use of these powders in the preparation of bakery product like biscuits.

METHODOLOGY

Procurement of mango seeds and kernel

Mangoes were purchased from wholesale market, located in Azadpur, New Delhi. Chausa variety of mango was chosen for the investigation of this study. The samples of mango seeds and peels were then taken out for further study

Preparation of mango peel powder (MPP), mango kernel powder (MKP)

Mangoes were peeled and the pulp and mango seed were separated. Hand peeler was used to remove the peel of mangoes. These peels were then washed and dried for 6 hrs. at 55°C. The dehydrated peels were crushed in a mixer to convert it to a powder and stored in a deep freezer for further use. The seeds were washed and dried for 6 hrs. at 60°C. Then the kernels were decorted and chopped into small slices and again dried for 5 hrs. at 60°C. The dried kernels were crushed in a mixer to prepare powder and stored in a deep freezer (Yadav *et al*., 2017).

Analysis of prepared mango peel powder (MPP) and mango kernel powder (MKP)

The prepared MPP and MKP were analyzed according to the standard analytical methods. The parameters were moisture content (AOAC, 2000), ash (AOAC, 2000), protein (AOAC, 2000), fat (AOAC, 2000), crude fiber (AOAC, 2000) and total phenols (kikuzaki & Nakatani, 1993.

Incorporation of Mango peel powder and Mango kernel powder in biscuits

The Mango peel powder (MPP) and Mango kernel powder (MKP) were used to make biscuits. Five variations of biscuits were prepared by substituting the WWF with the MPP and MKP. The basic recipe of biscuit was used (Khanna *et al*., 2001). The ingredients of the basic recipe were whole wheat flour, sugar, butter, baking powder and milk. Variations of biscuits were formulated from a mixture of whole wheat flour and Mango peel and kernel powder.

Table 1 Development of biscuits by substituting whole wheat flour (WWF) with Mango peel powder (MPP) and Mango kernel powder (MKP)

Variations	Whole wheat flour (WWF) (gm.)	Mango peel powder (MPP) (gm.)	Mango kernel powder (MKP) (gm.)
M_1	42.5	7.5	-
M_2	37.5	12.5	-
M_3	42.5	-	7.5
M_4	37.5	-	12.5
M_5	25	-	25
M_6 (Control)	100	0	0

Analysis of the product

Analysis of the final product was done. Standardized procedures were used for the physical, chemical and sensory parameters.

Statistical analysis

The data obtained were tabulated on the master sheets and statistical technique (ANOVA) was used to establish significance.

Locale of the study

The analysis of raw material and the final product were done in the college laboratory.

RESULTS & DISCUSSION

The mango peel and kernel powder have been well established as gluten free alternatives for wheat (Yatnatti *et al*. 2014). These two fiber rich products can be easily converted to powder and used for substitution of whole wheat flour and refined wheat flour. The mango peel and mango kernel powder were prepared as per the standard methods suggested by Ajila *et al*. (2011) and Yadav *et al*. (2017) respectively. Both powders were chemically analyzed for crude fiber, moisture, ash, fat, protein and total phenols. Biscuits were prepared using whole wheat flour and mango peel or kernel powder. The changes in the process parameters due to the substitution of whole wheat flour with different ratios were recorded.

Analysis of raw material

The analysis of the respective flours is discussed as under. Table 2 summarizes the proximate composition of the flour

Table 2 Analysis of raw Whole wheat flour (WWF), Mango Kernel powder (MKP), Mango Peel powder (MPP)

S. No	Constituents	WWF	MPP	MKP
1	Ash (%)	0.65 ± 0.01	8 ± 0.33	6 ± 0.1
2	Moisture (%)	13 ± 0.01	10 ± 0.1	10 ± 0.6
3	Fat (%)	0.82 ± 0.1	0.89 ± 0.26	13 ± 0.44
4	Crude fiber (%)	0.50 ± 0.02	8.5 ± 0.44	10 ± 0.31
5	Total phenols (mg GAE/g)	3.4 ± 0.2	19.06 ± 0.3	21 ± 0.3

Values are means of replicates ± standard error. n=3

Whole wheat Flour

The values from the present investigation for fat and crude fiber were lower in the present investigation than the reported values. However, the value of ash is in the range of reported values. The chemical composition of whole wheat flour is very close to what previous workers have reported. The difference in the variety, cultivation area and conditions of the climate are some of the reasons for the variations in the result of the present study as compared to previous studies.

Mango Peel Powder

Mango peel powder used in the present investigation had moisture (10%), fat (0.89%), crude fiber (8.5%), ash (3.58%) and total phenol (19.06mg GAE/g). Baddi *et al*. (2015) observed that the peel of mango contained protein (3.8%), fat (2.6%), fiber (8.9%), ash (2.9%) and moisture (3.4%). Rana (2006) reported that the chemical composition of peel depends upon many factors viz. species and variety of seed, kernel size, shape, maturity, thickness of the outermost layer, length of time and conditions of storage. The above factors might have also contributed to the variation in proximate composition of the mango peel analyzed in the present investigation.

Mango Kernel Powder

Mango kernel powder used in the present investigation had a moisture (10%), fat (13%), crude fiber (10%), ash (8%) and total phenols (21mg GAE/g). Mutua *et al*., (2017) reported protein (5.95%), fat (11%), crude fiber (9%) and ash (6%). The values of fat, crude fiber and ash are in accordance with previous studies.

Blends of whole wheat flour and mango peel powder

Two variations of biscuits were prepared using different amount of mango peel powder and whole wheat flour. In the first variation, mango peel powder was used at 15% and in the second variation mango peel powder was used at 25%. The details of preparation are mentioned in Table 3.

Table 3 Amount of ingredients used in preparation of biscuits with mango peel powder

S.no	Ingredients	Incorporation of 15% of mango peel powder (gm)	Incorporation of 25% of mango peel powder (gm)
1	Whole wheat flour	42.5	37.5
2	Mango peel powder	7.5	12.5
3	Butter	25	25
4	Baking powder	A pinch	A pinch
5	Castor sugar	25	25
6	Milk	As required	As required

Fig 1 Mango peels biscuits.M-1 (15% Mango peel powder), M-2 (25% Mango peel powder), Control-(100% whole wheat flour)

Proximate composition of the biscuits made with mango peel powder

The analysis of biscuits incorporated with peel powder was done with standardized procedures. The proximate composition includes ash content, moisture content, fat and crude fiber. The details of proximate analysis are mentioned in Table 4.

Table 4 Proximate composition of biscuits made with a blend

Proportion of mango peel powder%	Moisture%	Ash%	Crude fiber%
Control	4.9±0.03	1.26±0.02	3.8±0.14
15%	5±0.25	4.83±0.61	5.6±0.28
25%	5.50±0.25	5±0.03	7.2±0.30

Values are means of replicates ± standard error. n=3

From the result presented in Table 4, the values of crude fiber were 5.6% and 7.2% for 15% and 25% respectively. The level of crude fiber in biscuits increased with blending of whole wheat flour with mango peel flour and hence improved the nutritional quality of biscuits. Furthermore, Ajila *et al*. (2008) also recorded the similar pattern in fiber content of biscuits with increasing level of supplementation of mango peel powder. This increase can be attributed to (Ajila *et al*. 2008). In the present study, a value of 4.83% for ash content was obtained in 15% and 5% in 25%. The moisture content increased from 4.9 (control) to 5% for up to 15% level of mango peel powder incorporation and further increased to 5.50% in the case of biscuits containing 25% mango peel powder. Ajila *et al*. (2007) suggested that the increase in moisture content may be due to increased water absorption of dietary fiber present in mango peel powder and also during mixing, the water required to prepare the biscuits might increase the moisture level in biscuits. In the present study, a value of 4.83% for ash content was obtained in 15% level and 5% in 25% level.

Three variations of biscuits were prepared using different amount of mango kernel powder and whole wheat flour. In the first variation, mango kernel powder was used at 15%, second variation was done at 25% and third variation was done at 50%. The details of preparation are mentioned in Table 5.

Table 5 Amount of ingredients used in preparation of biscuit with mango kernel powder

S. No	Ingredients	Incorporation of 15% of mango kernel powder (gm)	Incorporation of 25% of mango kernel powder (gm)	Incorporation of 50% of mango kernel powder (gm)
1	Whole wheat flour	42.5	37.5	12.5
2	Mango kernel powder	7.5	12.5	12.5
3	Butter	25	25	25
4	Baking powder	A pinch	A pinch	A pinch
5	Castor sugar	25	25	25
6	Milk	As required	As required	As required

Figure 2 Mango kernel biscuits, M-3 (15% Mango kernel powder), M-4(25% Mango kernel powder), M-5 (50% Mango kernel powder)

Proximate Analysis of biscuits made with mango kernel powder

The analysis of biscuits incorporated with kernel powder was done with standardized procedures. The details of proximate analysis are mentioned in table 6

Table 6 Proximate composition of biscuits made with a blend of whole wheat flour and mango kernel powder

Proportion of mango kernel powder%	Moisture%	Ash%	Crude fiber%
Control	4.9±0.05	1.26±0.13	3±0.1
15%	4.89±0.05	2.44±0.22	3.9±0.18
25%	4.99±0.1	2.50±0.14	4.2±0.4
50%	6.15±0.02	2.65±0.3	8.3±0.25

Values are means of replicates ± standard error. n=3

From the result present in Table 6, it was observed that almost all the components of proximate composition showed an increase. There is a change in fiber content and a less impact on ash and moisture content in biscuits. Among the proportion, lowest moisture contents was observed in 15% level (4.89%) having highest content at 50% (6.15%) level. The highest crude fiber content among proportion was observed at 50% level (6.5%) and lowest was observed at 15% level i.e., 1.64%. Similarly as the proportions increased, the levels of other parameters also increased. Among the different proportions, 50% level showed to have a high level of crude fiber, ash, moisture.

Effect of substitution of Mango peel and kernel powder on physical characteristics of biscuits

Biscuits were prepared by replacing whole wheat flour with mango peel powder and mango kernel powder to the proportion of 15, 25 and 15, 25, 50 % respectively. Weight, diameter, thickness and spread ratio of prepared biscuits were then evaluated. The data obtained are given in Table 7:

As observed in Table 7, the weight of biscuit increased from12.9gm. to 13gm. This indicates that there was an increase in weight of biscuit with incorporation of mango peel powder. The difference in weight of biscuits could be attributed to the compositional difference between whole wheat flour and mango peel powder. The result showed that mango peel powder proportions caused change in biscuit diameter compared with 3.8mm for control. Incorporation of 25% of mango peel powder in biscuits showed less diameter value (3.8mm) without much difference with control. It was also observed that using mango peel powder at all levels in biscuit preparation significantly increased the thickness when compared with 0.5mm for control. The higher thickness was recorded (0.53mm) by mango peel powder at 15%. Concerning to spread ratio, it was observed that replacing 25% of wheat flour by mango peel powder recorded the highest value 8.67mm. Spread ratio of cookies is used as a quality indicator for producing cookies. The main components that have an influence on cookie spread are sugar and flour.

The biscuits prepared with mango kernel were also checked for weight, diameter, thickness and spread ratio. In these variations also, the weight of biscuit increased from12.9gm. to 13gm. This indicates that there was increase in weight of biscuit with incorporation of mango kernel powder. Compositional differences in the flour could be attributed to the change in the weight of the biscuits. There is significant change in the biscuit diameter as compared to the control

biscuits (3.8mm). The highest diameter (9.25mm) was found by mango kernel powder at 50%. Incorporation at 25% showed less change in diameter compared to control biscuits. In terms of thickness, less change was observed at 15% (0.54%) and more change was observed at 25% i.e. 1.6%. Using mango kernel flour at all levels in biscuit preparation did not increase the spread ratio when compared with 7.6mm for control except at level 25% which showed the spread ratio as 2.4mm.

In comparison to the control sample, the product developed with 15% mango kernel powder was similar in color and appearance as the difference in sensory score was insignificant. However, the product with 25% mango kernel powder showed a significant difference ($p<0.05$). The biscuits made from the blends containing kernel powder at 25 percent and 50% did not score much.

Table 7 Effect of incorporation of mango peel powder and mango kernel powder on physical characteristics of biscuits

Proportion of mango peel powder (%)	Wt. before drying (gm.)	Wt. after drying (gm.)	Moisture loss (%)	Thickness (T) (mm)	Diameter (D) (mm)	Spread ratio (SR) (mm) (D/T)
Control	14.9±0.03	11±0.06	26	0.5±0.01	3.8±0.03	7.6
15% (M1)	15.3±0.03	13±0.03	15	0.53±0.02	4.13±0.05	8.67
25% (M2)	15±0.05	12.9±0.05	14	0.51±0.02	3.9±0.05	7.64
15% (M3)	16±0.06	13.1±0.03	18.1	0.54±0.01	4±0.02	7.40
25% (M4)	15±0.03	12.9±0.02	14	1.6±0.03	3.9±0.02	2.4
50% (M5)	15.9±0.02	13±0.03	18.2	0.6±0.02	4.25±0.01	7.08

*Average of 5 biscuits. Values are means of replicates ± standard error. n=3

Effect of substitution of MKP and MPP on Sensory characteristics of biscuit

The biscuits developed using blends of whole wheat flour with mango peel and kernel powder were subjected to sensory evaluation.

Evaluation of different variations of biscuits was done by a panel of 30 members consisting of faculty members and student of the college. The mean sensory scores for color, texture, taste, flavor and overall acceptability of biscuits prepared using blends of whole wheat flour with mango (peel and kernel) are presented in Table 8.

Table 8 Sensory score of biscuits made from flour supplemented with mango peel and mango kernel powder

Treatment	Texture	Color & Appearance	Taste	Flavor	Overall Acceptability
M_1	6.8±1.06	6.9±1.02[a]	6.2±1.58	6.1±1.4	6.5±1.5
M_2	5.9±1.06	5.8±1.56[b]	5.5±1.77	5.1±1.71	5.3±1.67
M_3	6.6±1.39	6.6±1.5	6.5±1.52	6.4±1.73	6.6±1.29
M_4	6.4±1.1	6.6±1.29	6.4±1.59	6.4±0.3	6.5±1.59
M_5	7.1±1.11	4.8±1.7[a]	3.3±1.7	2.7±1.6	3.5±2.09
Control	7.1±1.11	7.3±1.23[b]	7.1±1.19	6.9±1.7	7.1±1.4

The inclusion of peel powder upto 15 percent brought a color change with respect to control sample. However, biscuits prepared using 25 percent peel powder were in acceptable range. The biscuits made from blend containing mango peel powder score maximum. However, a statistical significant difference were observed ($p<0.05$). For taste and flavor, the biscuits made from mango peel powder at 15 percent showed highest mean sensory score. The biscuits developed using 25 percent level of peel powder scored in acceptable range. The highest mean sensory score was showed by biscuits made from wheat flour followed by the biscuits prepared using blends containing 15 percent kernel powder and 15 percent peel powder. The biscuits made using blends with 25 percent peel flour scored significantly lower than the other sample. After conducting the sensory evaluation, it can be concluded that the mango peel powder can be successfully incorporated up to 15 % resulting in to a product with higher mineral content and crude fiber without adversely affecting sensory scores.

For taste and flavor parameter, the sensory score was highest for the biscuits prepared with mango kernel powder at 15 and 25 percent. A higher percentage of mango kernel powder (50%) was unacceptable by the panelists owing to slight grittiness and branny mouth feel.

After conducting sensory evaluation, it is concluded that mango kernel powder can be included upto 25% as it can lead to increase in crude fiber and minerals content without an adverse effect on the sensory scores.

CONCLUSION

From above discussion it can be concluded that every year a considerable amount of bio-active material that can play a vital role to cure and prevent many diseases is going waste. In the present study, when bio waste of mango fruits (mango peel and mango kernel) both in powder form were analyzed separately by replacing at different levels on proximate, physical, sensory and total phenols of biscuits by incorporating MPP (mango peel powder) and MKP (mango kernel powder), fiber content of biscuits improved from 3.8% to 7.2% in Mango peel biscuit and from 3.8% to 6.5% in Mango kernel biscuit. Also, total phenol levels were also high in mango peel powder and mango kernel powder when compared to whole wheat flour. However, in case of mango peel biscuits at 25% level the taste was acceptable but the color was the major problem and due to this reason these biscuits scored less as compared to control biscuits. Again in case of mango kernel biscuits at 50 % level both taste and color were not acceptable. To curb these problems, Acceptable biscuits can be prepared by adding some other flavors like cocoa powder in both the flours without affecting their overall acceptability. In addition, this study is very important to show the way of putting the by-product to a good use in a bakery industry. Therefore, mango peel and mango kernel have a great potential to be used as functional ingredient in biscuit formulation and to improve the functional properties of biscuit.

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