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Development of jackfruit (*Artocarpus heterophyllus*) bulb and seed flour-based pasta

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Abstract

Jackfruit (*Artocarpus heterophyllus*) is one of the major edible foodstuffs rich in carbohydrates and fiber. This study investigated the reduction of postharvest losses of jackfruits by value addition. Jack fruit seeds (JFS) flour and Jackfruit bulbs (JFB) flour were used as raw material. JFB and JFS were subjected to mechanical drying, grinding and sieving (particle size <200μm) to yield the JFS flour and JFB flour. The composite flour consists of different ratio of JFS, JFB, and cassava flour (CF), corn flour and semolina. The proximate composition, physical properties and cooking characteristics of developed pasta were determined. Sensory attributes of the pasta were evaluated using Hedonic scale (7-points) with 36 semi-trained panelists. The best composite flour formulation was JFS: JFB: semolina: CF: corn flour, at the ratio of 40:40:10:5:5. Crude protein (13.26±0.18%), crude fiber (4.91±0.61%) and ash (3.35±0.04%) were

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higher in the best selected composite flour than the other treatments. Carbohydrate content (71.28%) was the lowest in T3 formulation. However, there was no significant difference ($p>0.05$) in moisture content among the treatments, whereas, hardness and water activity differed significantly ($p<0.05$) among the treatments. The best selected formulation exhibited higher water absorption (1.20±0.02 g/g) and cooking time (8.6±0.2 min) than the other treatments while cooking loss (13.3±0.4%) was lower than the other treatments except the control. Lightness value of pasta was decreased with increasing the amount of JFS and JFB flour. In conclusion, value added jackfruit flour pasta has a higher potential for commercialization as a convenient food for the consumers with busy lifestyles.

Keywords: cassava, composite flour, convenient food, jackfruit seed, pasta

INTRODUCTION

Jackfruit tree (*Artocarpus heterophyllus*) belonging to genus Artocarpus is a well-known perennial tree in Sri Lanka (Boning, 2006; Peiris, 2015). The tree originated in India and is commonly known as "*Kos*" (Sinhala) and "*Pala*" (Tamil) in Sri Lanka (Prakash *et al*., 2009). Edible parts of jackfruit tree consist of immature, mature and ripe fruits. Jack fruit is one of the popular staples during scarcity of food in Sri Lanka (Ranasinghe *et al*., 2019). Mature fruit is the largest tree-borne fruit, having up to 35 kg weight, 90 cm length, and 50 cm diameter (Nair *et al.,* 2017). The fruit contains a large number of fleshy bulbs, spikes and seeds which is covered by the fleshy white cotyledon (Ranasinghe *et al*., 2019).

Jackfruit is a good source of digestible carbohydrate (bulb-10%, seeds - 22%), vitamin A and protein (1.6%) (Hettiaratchi *et al*., 2011). The fiber content of immature and ripe jackfruit is 2.6% and 0.8%, respectively (Ranasinghe *et al.,* 2019). Jackfruit meal has low glycaemic index (GI) due to presence of higher fiber content, slowly available glucose, intact starch granules in seeds and influence of different sources of carbohydrates (Hettiaratchi *et al*., 2011). Further, jackfruit is rich in minerals, bioactive phytochemicals, polyphenols, carotenoids, flavonoids and it is devoid of saturated fats and cholesterol (Nair *et al.,* 2017; Swathi *et al., 2019*). According to Priya Devi *et al*, (2014), 100g of jackfruit contains potassium (107 mg), calcium (20 mg), phosphorous (41 mg), iron (0.56 mg), β-carotene (175 mg), thiamine (0.03 mg), riboflavin (0.13 mg), niacin (0.40 mg) and vitamin

C (7 mg). Antimicrobial, anti-diabetic, anti-inflammatory and antioxidant properties were also reported by Waghmare *et al*. (2019). Jackfruit is also having a chemical "Jacalin" which is useful in preventing colon cancer, AIDS etc. (Waghmare *et al*., 2019).

Utilization of jack fruits has gained only little attention during the past decades. Jackfruits are abundant during the season and substantial postharvest losses are experienced. At present, there is a higher consumer preference and demand for value added convenient food products. Therefore, the value-added products of jackfruit would be a good source of income for the industry as well as a nutritional meal for the people. Therefore, this study was designed to evaluate the potential of producing value added food products using the jackfruit. For this purpose, some other plant raw materials such as CF, corn flour and semolina were selected.

Cassava (*Manihot esculenta* Crantz) is one of the most cultivated and consumed plants after maize, rice and wheat in the world (Mombo *et al*., 2016). The root of cassava is composed of 85- 90% of carbohydrate, 1 - 3% of crude protein and lesser content of vitamins and minerals (Stupak *et al.,* 2006). Several medicinal properties in cassava due to presence of different phytochemicals were reported (Zekarias *et al*., 2019). In Sri Lanka, surplus cassava is available during the season. Therefore, utilization of cassava also benefits the farmers. Hard durum winter wheat is used to make semolina. Semolina contains high protein content and possesses favorable cooking quality. Thus, the presence of semolina as an ingredient in pasta is responsible for better appearance with smooth clear surface, high resistance to breakage, flexible and dry finished product. Corn starch, a thickening agent improves the textural quality of pasta and prevents stickiness and reduces the cooking loss (Fuad and Prabhasankar, 2010).

Pasta is an extruded dough product of Italian style food similar to spaghetti. The demand for pasta is increasing because of the convenience for cooking, palatability and extended shelf life (Nilusha *et al*., 2019). The World Health Organization (WHO) and Food and Drug Administration (FDA) identified pasta as a suitable vehicle for incorporation of nutrient supplements (Chillo *et al.,* 2008). Pasta enrichment with minerals, vitamins, fiber provides additional health benefits to the consumers. Despite the availability and nutritional benefits of jackfruit, the consumer products of jackfruit available in the market are limited. Therefore, the objectives of this study were to formulate composite flour mixtures using

JFS: JFB: semolina: CF: corn flour, to produce jackfruit flour based pasta and to minimize the postharvest losses of jackfruits during the season.

MATERIALS AND METHODS

Sample collection

Mature jack fruits (cultivar *Waraka*) were collected without damage from the fruit from Peradeniya, Sri Lanka, while cassava roots were collected from the open market in Kandy, Sri Lanka.

Preparation of flour samples

Jackfruit bulbs and jackfruit seeds were separated from mature jackfruits by removing the surrounding hard outer layer and fleshy white bulbs. The cotyledons of the seeds were separated and washed thoroughly. JFB, JFS and cassava roots were blanched in boiling water for 8 minutes and drained. The blanched samples were cut into small pieces and dehydrated in a hot air circulation tray dryer (Model No. stdq-2, China) at 55 ^{o}C for 6 hours. Subsequently, JFB flour, JFS flour, and CF were ground and sieved to receive uniform particle size (ASTM E11:87, mesh No 50 for 300µm). The ground flour samples were packed in high-density polyethylene (HDPE, 300 gauge) bags and stored at ambient temperature (28±2 ^{o}C).

Production of pasta

Initially experimental trials were conducted using JFS, JFB (*Madullu*) flour and CF formulations using the pasta machine (Pasta maker DOLLY-La Monferrina, Italy). The JFB:JFS flour ratio of 1:1 was selected based on the results of the pre-trials. Further experiments were conducted using four composite flour formulations of JFS:JFB:CF: corn starch: semolina, as treatments, T1 - 30:30:10:10:20, T2 - 35:35:7.5:7.5:15, T3 - 40:40:5:5:10, T4 - 35:35:0:0:30 and the control (0:0:0:0:100). Egg, salt and water were added into the flour mixture and all the ingredients were mixed in the extruder properly. Then pasta was made by extruding through a selected molding disk (for shape) in the extruder. The pasta was collected from the extruder and steamed for 10 minutes. The steamed pasta was dehydrated using the tray dryer (Model No. stdq-2, China) at 50 C for 3 hours. Finally, the samples of jackfruit pasta were air cooled, packed in HDPE (300 gauge) bags and stored at the ambient temperature (28±2 ^{o}C) for further experiments.

Sensory evaluation

Sensory evaluation of developed pasta samples was conducted using Hedonic scale (1-extremely dislike, 7-extremely like), with a panel of 36 semi-trained panelists on colour, aroma, taste, texture, and overall acceptability. The collected data was analyzed by non-parametric analysis, Friedman test using MNITAB (version 17).

Figure 1. Pasta produced from the composite flour formulations.

Ratio of JFS flour: JFB flour: semolina: CF: corn flour. Treatment 1. T1- 30:30:20:10:10, Treatment 2. T2 - 35:35:15:7.5:7.5, Treatment 3. T3 - 40:40:10:5:5, Treatment 4. T4 - 35:35:30:0:0, and the control - 0:0:0:0:100.

Determination of proximate composition

Moisture content (MC), crude protein (CP), crude fat (CF), crude fiber (CFb) and ash contents of different treatments were determined using the methodology, AOAC 934.01, 984.13, 920.39, 962.09 and 942.05, respectively (AOAC, 2006). Total carbohydrate content was calculated using formula 1 (FAO, 2003).

Total carbohydrate (%) = [100 – (moisture + crude protein + fat + crude fiber + ash)] (1)

Determination of hardness, water activity and colour

Hardness: Hardness of the pasta samples was determined using a texture analyzer (SHIMADZU EZ-X series) under compression mode with a sharp cutting blade probe. The peak force at the point the cutting blade snaps the piece of pasta under compression was measured as the fracture force in N.

Water activity: Water activity of the pasta samples was measured using the water activity meter (Hydrolack3 ROTHRONIC).

Colour: Colour of the pasta samples was measured using a colorimeter (CS-10, China). Colour measurement was expressed as lightness (L*), a* and b* values.

Determination of cooking characteristics

Water absorption

Water absorption is the amount of water absorbed by the pasta during cooking. Water absorption was determined using the method described by Ojure and Quadri’s (2012) with minor modifications. Pasta (50 g) was cooked, rinsed with water and drained. Then weighted the cooked pasta sample and calculated the water absorption (g/g) using the formula (2).

$$\text{Water absorption}\left(\frac{\text{g}}{\text{g}}\right) = \frac{(\text{Final weight} - \text{Initial weight})}{\text{Initial weight}} \qquad (2)$$

Cooking time

A sample of pasta (10 g) was cooked in a covered glass beaker with 300 mL of boiling water. Cooking time was measured when the pasta in the center of container became transparent or fully hydrated (Ojure and Quadri, 2012).

Cooking loss

Cooking loss of the pasta samples was determined using the method described by Ojure and Quadri (2012) with minor modifications. A pasta sample (10 g) was cooked in 300 mL of boiling water. The dissolved solid content of the pasta sample during cooking was determined by evaporating the cooking water without pieces of pasta using oven dry method at 100 °C. Weight of the dried residue was measured and cooking loss (%) was determined using the formula (3).

$$\text{Cooking loss (\%)} = \frac{\text{Weight of dried residue in cooking water (g)}}{\text{Initial weightt of pasta (g)}} \text{ X } 100 \quad (3)$$

Statistical analysis

One-way Analysis of Variance (ANOVA) was used to determine significant differences ($p \geq 0.05$) between the treatments of the parametric data, and means separation was done using the Tukey test using Minitab 17 Statistical Software. Data of the sensory evaluation were analyzed by non-parametric Friedman test. Means separation was conducted using Wilcoxon Signed Ranks Test using SPSS Statistics 20 Software. All the data were expressed as the mean of three independent measurements as mean± standard deviation.

RESULTS AND DISCUSSION

Sensory evaluation

Pasta produced using the formulation T3 (40:40:10:5:5, JFS:JFB :semolina:CF:corn flour) was scored the highest mean score for all the sensory attributes (Figure 2). The highest ratio (40 %) of JFS and JFB flour was in the T-3 composite flour mixture, thus consumer preference of pasta was scored as the highest for all sensory attributes. In a similar study on noodles, Kumari *et al*. (2018) reported the sensory scores were increased while adding JFS flour in flour formulation for noodles. However, there was no significant difference (p>0.05) between the pasta produced from T3 and T2 treatment formulations with respect to flavour and aroma. Treatment formulation T1 was scored for the least means for texture, aroma and overall acceptability (Figure 2). This indicates that as lower percentages (30 %) of JFS flour and JFB flour decreases the consumer preference over the sensory attributes of pasta. The control past sample without JFB and JFS flour was scored the lowest mean scores for colour and flavor. The incorporation of JSF flour and JFB flour has improved the colour and flavour of pasta. Treatment -3 formulation was significantly different (p<0.05) from the other treatments in terms of colour, texture and overall acceptability. There was a significant difference (p<0.05) for overall acceptability of treatments T3 and T2 with the other three formulations (T1, T4 and the control). Similarly, there was a significant difference (p<0.05) for flavour in-between both T3 and T2 verses T1, T4 and the control. The best formulation, T3 was selected based on the nonparametric statistical analysis of mean scores of the sensory panel.

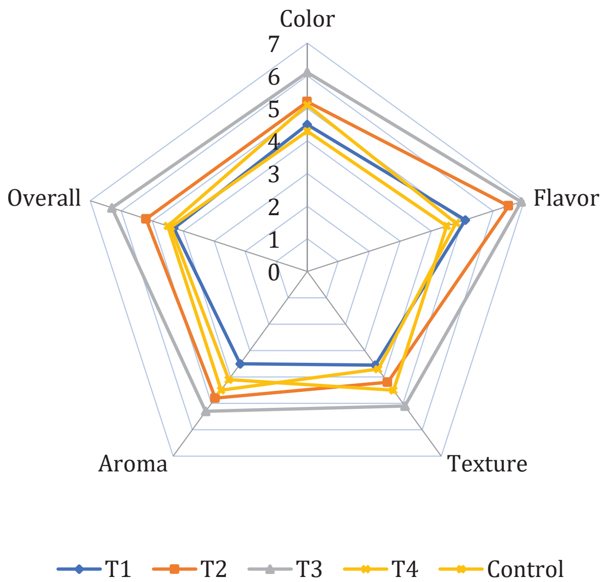

Figure 2: Mean scores of sensory attributes of jackfruit flour based pasta.

Proximate composition

The proximate composition of developed pasta formulations is given in Table 1. The best selected composite formulation-T3 possessed the highest quantity of jackfruit seed and bulb flour. Therefore, the highest percentages of crude protein, crude fiber, and ash were determined, and the values were significantly different ($p<0.05$) compared to the other treatments. Hettiaratchi *et al*. (2011) reported that a considerable amount of protein, fiber and minerals are present in jackfruit bulbs and seeds. Thus, higher contents of protein, dietary fiber and ash were determined in pasta developed from composite formulation of treatment 3 than the other treatments. The lowest percentages of crude protein and crude fiber were measured in pasta developed using treatment 1 (T1) formulation because of the lowest percentage of JFB and JFS flour (60 %) in the formulation. There was no significant difference ($p>0.05$) in moisture content among the pasta samples of all treatments except the control sample. Moisture content of the control pasta sample was the highest and significantly different ($p>0.05$) against the treatment formulations. Protein and ash content was increased significantly while incorporation of JFS flour, however moisture content of pasta was not significantly different ($p \leq 0.05$) (Waghmare *et al*., 2019).

Carbohydrate content was reduced by 5.39%, 6.16%, 8.13% and 5.35% in T1, T2, T3 and T4, respectively, compared to the control sample. The reason was that JFS flour and JFB flour contain lesser quantities of carbohydrate compared to semolina. Therefore, the highest amount of carbohydrates was determined in the control sample. Similar observation was reported on carbohydrate content of jackfruit seed flour incorporated biscuit formulation (Islam *et al.,* 2015).

Hardness, water activity and colour of pasta

Hardness is an important parameter of pasta for both the processors and the consumers. Harder or tougher the pasta, mouth feel during the bite or eating is not preferred by the consumers. Disintegration and breakages of pasta during packaging and distribution is comparatively high in pasta with softer or lesser hardness (Kumari *et al.,* 2017). The hardness and water activity values of pasta formulations are given in Table 2. The lowest hardness value and water activity were measured in the control sample due to the lowest protein content while hardness and water activity values were not significantly different ($p<0.05$) in jackfruit flour

Table 1: Proximate composition of pasta developed using composite flour formulations

Treatment	Moisture content (w/w)%	ash (w/w)%	Crude protein (w/w)%	Crude Fat (w/w)%	Crude fiber (w/w)%	Carbohydrate*
T1	6.04±0.05^{b}	3.02±0.24^{ab}	11.90±0.21^{b}	1.52±0.02^{b}	3.50±0.28^{b}	74.02
T2	5.76±0.01^{b}	3.19±0.05^{ab}	12.40±0.14^{b}	1.30±0.01^{c}	4.10±0.28^{ab}	73.25
T3	5.99±0.04^{b}	3.35±0.04^{a}	13.26±0.18^{a}	1.21±0.02^{c}	4.91±0.61^{a}	71.28
T4	5.43±0.71^{b}	2.79±0.06^{b}	12.25±0.07^{b}	1.72±0.03^{a}	3.75±0.21^{b}	74.06
Control	7.65±0.26^{a}	0.62±0.03^{c}	9.86±0.18^{c}	1.04±0.04^{d}	1.42±0.05^{b}	79.41

Values with same letters within a column are not significantly different at $p > 0.05$., n= 3.

* Obtained from subtraction method

Table 2: Hardness, water activity, cooking time, cooking loss and water absorption values of developed pasta

Treatment	Hardness (N)	Water activity	Cooking time (minutes)	Cooking loss (%)	Water absorption (g/g)
T1	64.50 ± 3.25^{a}	0.57 ± 0.01^{a}	8.10 ± 0.07^{b}	15.04 ± 0.17^{a}	1.10 ± 0.07^{a}
T2	63.29 ± 5.93^{a}	0.53 ± 0.00^{ab}	8.32 ± 0.10^{ab}	14.31 ± 0.28^{ab}	1.08 ± 0.01^{a}
T3	68.60 ± 4.30^{a}	0.55 ± 0.01^{ab}	8.65 ± 0.18^{a}	13.25 ± 0.35^{b}	1.20 ± 0.02^{a}
T4	51.81 ± 6.84^{ab}	0.53 ± 0.01^{ab}	8.40 ± 0.14^{ab}	14.58 ± 0.31^{a}	1.12 ± 0.07^{a}
Control	39.40 ± 2.51^{b}	0.52 ± 0.02^{b}	7.11 ± 0.14^{c}	11.31 ± 0.15^{c}	0.90 ± 0.02^{b}

Values with same letters within a column are not significantly different at $p > 0.05$., $n = 3$.

incorporated pasta samples. The highest hardness value, 68.60±4.30 N was reported from T3 formulation with 80 % JFS and JFB flours and the highest among the four treatments. Thus, T3 contains the highest amount of protein and performs the highest hardness value. Kumari *et al*. (2017) reported flour protein content has a positive correlation with hardness in noodles. Therefore, a similar trend, a positive correlation with hardness of pasta against protein content of JFS and JFB flour content was observed. Pasta developed from T4 with 70% jackfruit flour possessed the lowest hardness value (51.81±6.84 N) among treatment formulations and not significantly different ($p>0.05$) among the treatments T1, T2 and T3 samples.

Noodle was produced using JFB and JFS flour with good firmness quality because of higher protein and fiber contents in jackfruits bulb flour (Kumari *et al*., 2017). In our experiment on pasta using JFS and JFB flour was also performed the similar result. The best textural quality and hardness was yielded from 80 % of JFB:JFS, 1:1 formulation.

Lightness (‘L’ value), yellowness (‘b’ value) and ‘a’ values of pasta formulations are given in Figure 3. There was no significant difference ($p>0.05$) among the jackfruit flour incorporated samples for the ‘L’ value. However, the control sample possessed the highest lightness value and significantly different from jackfruit flour incorporated pasta samples. Lightness value of pasta was decreasing by increasing JFS and JFB flour. The reason was higher protein content JFS and JFB flour subjected to a browning reaction during drying of pasta. Thus, lightness value was decreased. T1 formulation with the lowest JFB flour (30 %) and JFS flour (30 %) possessed the highest lightness value among four composite flour treatments. A similar observation, a negative correlation of brightness of noodle versus flour protein content was reported by Kumari *et al*. (2017). Therefore, addition of jackfruit flour in composite flour formulation is a limitation due to reduction of lightness compared to the control. Lightness of pasta can be a visual perception or preference of pasta by the consumers compared to the ordinary pasta available in the market. Higher protein content in jackfruit flour and bulb flour is responsible for such colour changes.

There was a significant difference ($p<0.05$) of ‘a’ and ‘b’ colour values among the pasta samples. Yellowness was increased by increasing JFS and JFB flour because of carotenoid pigments in JFB flour. Carotenoids are the main compounds that contribute to the yellow color of jackfruits (Yi *et al.,* 2016).

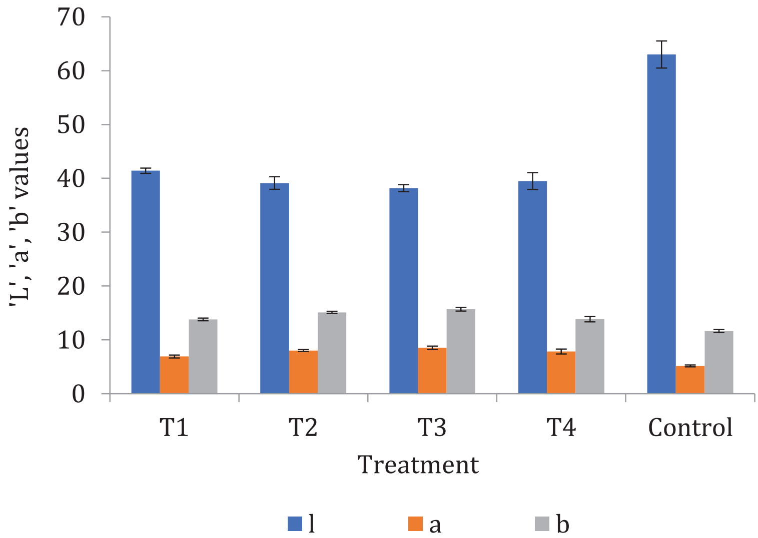

Figure 3: Lightness ('L' value), yellowness ('b' value) and 'a' value of Jackfruit pasta

Cooking characteristics of pasta

The cooking characteristics of the developed four pasta formulations are given in Table 2. There was a significant difference ($p<0.05$) on cooking time and cooking loss among the treatments (Table 2). The highest cooking time, 8.65±0.18 minutes, was measured in pasta (Treatment T3) with the highest percentage of JFB and JFS flours. The gelatinization efficiency reduces due to higher amount of fiber in higher content of JFB and JFS flour, added composite formulation and resulted in a lengthy cooking time (Kumari *et al.*, 2017). Leached out pasta particles quantity to the cooking water is represented by cooking loss value. The lowest cooking loss value was measured in T3 treatment, while the highest measured in T1 treatment with the lowest quantity of JFB and JFS flour. Availability of a substantial amount of fiber in JFB flour and protein in JFS flour is the reason to reduce the cooking loss of pasta produced from T3 formulation. Therefore, a negative relationship in-between the quantity of JFS and JFB flour verses cooking loss was evident from the experiments. The control with semolina possesses the lowest cooking loss value than all four treatments due to lower contents of fiber and protein in semolina than the pasta developed using other four composite flour formulations.

There was no significant difference ($p>0.05$) among jackfruit flour incorporated treatment samples for water absorption (Table 2). However, T3 formulation shows the highest water absorption value than T1, T2 and T4. Control sample possessed the lowest water absorption value than all the treatment samples. JFS flour has a good water holding and binding ability (Abraham and Jayamuthunagai, 2014). The water absorption of pasta is determined by the openness in the gluten structure of pasta (Sun-Waterhouse *et al*., 2013).

CONCLUSIONS

Development of composite flour formulations using JFB and JFS flour was successful and the composite flour formulation treatment 3 (T3), consists with JFS flour: JFB flour: semolina: CF: corn flour, 40:40:10:5:5, was selected as the best composite flour for jack fruit based pasta production. The best formulation was further tested and confirmed as the most suitable formulation using proximate composition, physical properties, cooking characteristics and consumer acceptability test. T3 formulation contains comparatively higher nutrient content and consumer acceptability than other formulations. The developed JFS and JFB composite pasta formulation has a higher commercial potential for mass scale production as a convenient food for the consumers with busy lifestyles in the urban areas.

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DECLARATION OF CONFLICT OF INTEREST

Authors have no conflict of interest to declare

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