

STUDIES ON THE FORMULATION AND QUALITY CHARACTERISTICS OF VALUE ADDED CASSAVA-MANGO COMPOSITE FLOUR BISCUITS

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ABSTRACT

Biscuits are ready-to-eat and convenient food product containing important digestive and dietary principles of vital importance. The current research is aimed to develop value-added biscuits with good nutritional quality from cassava flour (CF) and mango flour (MF) and to evaluate the quality characteristics of formulated biscuits. MF was used at levels of 10, 15, 20 and 25% to substitute CF for biscuit formulations. The biscuits were subjected to nutritional, microbiological and sensory analysis after development. The nutritional analysis of cassava flour confirmed that it contains 7.47% moisture, 1.37% minerals, 3.71% protein, 0.67% fat, 9.42% dietary fiber and 74.5% soluble carbohydrates. The amylose content in the cassava flour was 19.8% with the solubility of 3.26g/100g. The average moisture content of the biscuits was 6.93%. The protein, fiber, fat, ash and vitamin C content increased with increase in the proportion of MF, with the 20% MF showed the values of 8.11%, 2.33%, 15.9%, 2.71% and 23.5 mg/100 g, respectively. The pH decreased significantly with the increase in MF supplementation. The microbiological examination, in terms of total plate count revealed that there was no evidence for any microbes observed in the developed biscuits. Organoleptic assessment showed that supplementation of CF biscuits with MF up to 20% did not significantly affect the colour, crispiness and taste except aroma compared with the market sample (control). The supplementation of CF with MF had been successful for the formulation of biscuits with improved nutritional and sensory qualities with the universal standards for biscuits.

Key words: Biscuits, cassava-mango composite flour, quality evaluation, value addition.

INTRODUCTION

Biscuit is an energy food which is taken mostly in between meals by both young and old. They are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in an oven. They are ready-to-eat, convenient and inexpensive food product, containing digestive and dietary principles of vital importance (Giwa and Abiodun, 2010).

The bakery industry in Sri Lanka has grown tremendously over the recent years. According to Sudha and co-workers (2007), bakery products are varied by addition of value added ingredients. Among the added ingredients, dietary fiber has gained tremendous attention. Fruits and vegetables have been shown to contain high amount of soluble and insoluble dietary fiber (Mc Cleary *et al.*, 2010) which plays a major role in lowering serum cholesterol and

glucose level, while insoluble dietary fiber is essential in maintaining intestinal health.

Cassava (*Manihot esculenta*) is an important source of calories to millions of people particularly in the tropics (Lasekan *et al.*, 2004). The most important part of the cassava plant is the root, rich in starch. According to Montagnac *et al.* (2009), cassava starch functionalities as stabilizers and physical properties including rheological and visco-elastic characteristics are dependent on two distinct structural polysaccharide fractions amylose and amylopectin. Gelatinization and retrogradation are two important physical behaviors of starch that are influenced by these polymer fractions.

Gelatinization of cassava starch is manifested by irreversible changes such as swelling, crystallite melting, starch solubilization and disruption of molecular order within the starch granules when they are heated in water

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(Padonou *et al.*, 2004). The lower the amylose content, the better is the starch for the bakery industry. When, however, starch contains high percentage of amylose, it may be modified by oxidation to give the desirable physical properties. According to Aryee *et al.* (2006), the major limitations of cassava include low mineral and vitamin contents together with toxicity by cyanogenic glycosides. Mango is a good source of provitamin A, vitamin C, minerals (Badifu *et al.*, 2000) and rich in fiber. Therefore, incorporation of mango flour into cassava flour for the production of biscuits will increase the nutritional value of the product.

Mango (*Mangifera indica* L.) is commonly found in Sri Lankan market and continuous supply is available throughout the year. Mango is not only being consumed raw or cooked as meal, but are also processed into various food products, including jellies, juices, puree, nectar and processed into fruit leather. Unripe mango pulp has high starch content and high levels of hemicellulose, cellulose and carotenoids.

Composite flours are a mixture of flours made from tubers rich in starch such as cassava, yams, sweet potato and / or protein rich flours of soybean, groundnut and / or cereals such as maize, sorghum, millet, rice, buckwheat, with or without wheat flour (Shittu *et al.*, 2007). Use of composite flours have many advantages in developing countries since they can substitute importation of wheat flour while encouraging the use of flour produced from locally grown crops. Therefore, the aim of the present study was to use of mango flour at different levels (i.e 10, 15, 20 and 25%) to substitute the cassava flour in formulating the biscuits and to evaluate the nutritional characteristics and sensory attributes of the cassava-mango composite flour biscuits.

MATERIALS AND METHODS

Materials

Cassava roots (*Variety: Gari*) and mangoes (*Variety: Chembatan*) were obtained from Research Station of the Department of Agriculture, Sri Lanka. Other materials used for this study mainly sugar, margarine, milk powder, baking powder, salt and egg were purchased from a commercial market.

Preparation of Cassava flour

The method of IITA (1990) was adopted for the processing and preparation of the cassava flour for biscuit production. Three kilogram of cassava roots were washed, manually peeled with knife, washed again and cut into chips. To remove cyanide content, chips were soaked for 9 hours in water at ambient temperature of 30°C and 85% relative humidity (RH). The water was changed at every 3 hours interval after that the chips were rinsed and dried in a heat pump (cooling with dehumidifier) dryer at 40°C for 24 hours. The dried chips were milled into flour using a hammer mill (LAB MILL-240) and the resultant flour was sieved into a particle size of 100 µm. The flour was packed in polypropylene bags and stored at ambient conditions until the sample was taken for the biscuit production.

Preparation of Mango flour

The method of Bandifu *et al.* (2000) was adopted to produce mango flour. Five kilogram of moderately ripe mangoes was washed, peeled using a sharp kitchen knife and the mesocarp was sliced from the hard seed. The slices were trimmed and spread on metal trays. They were dried in a heat pump dehumidifier dryer at the temperature of 40°C for 3 hours. The dried mango slices were milled using hammer mill and sieved into particle size of 100 µm. The mango flour was packed in polypropylene bags and stored at ambient conditions for subsequent use of the study.

Biscuit formulation and preparation

Composite flours with different proportions of cassava and mango flour were used for the for-

mulation of biscuits as shown in Table 1. A digital weighing balance and a blender (Philips, HR 1702) were used for weighing and mixing the flours respectively. Margarine and sugar were mixed in a mixer at a medium speed until a light and fluffy cream was formed. One whole egg (medium size) and milk powder were added while mixing. Then cassava flour, mango flour, baking powder and salt were slowly introduced into the mixture. The dough obtained was rolled on a flat rolling sprinkled with flour to a uniform thickness of 0.4 cm using wooden rolling pin and guiding sticks. Using a biscuit cutter, circular biscuits of 5.8 cm diameter were cut, placed on greased baking trays and baked in an electric oven at 150°C for 15 minutes.

The treatments are listed as follows:

- T₁ – Biscuits with 100% of cassava flour
- T₂ – Biscuits with 90% of cassava flour + 10% of mango flour
- T₃ – Biscuits with 85% of cassava flour + 15% of mango flour
- T₄ – Biscuits with 80% of cassava flour + 20% of mango flour
- T₅ – Biscuits with 75% of cassava flour + 25% of mango flour
- Control – Market sample

Nutritional analyses

All chemicals used were ACS reagent grade and purchased from Sigma–Aldrich (St. Louis, USA) unless otherwise specified. The nutritional characteristics of the mango flour supplemented biscuit samples were determined using recommended standard AOAC methods (2002). The samples were analyzed for moisture, protein, fiber, ash, vitamin C and pH. The soluble carbohydrate content was calculated by difference. All analyses were performed in triplicates.

Amylose content

Amylose content was determined according to Wade (1988) with modifications. Amylose percentage was estimated from 0.5 g starch using the Megazyme amylase and amylopectin assay kit by quantitative precipitation of amylopectin with concanavalin A, quantitative estimation of amylose on hydrolysis using amylase/ amyloglucosidases and estimation of glucose by glucose oxidase assay. The analyses were performed with two replicates.

Microbiological examination

The microbial assessment was carried out by estimating total plate count on biscuit samples using the method of Olaoye *et al.* (2007).

Table 1: Biscuit formulations with different percentage of cassava and mango flour mixtures

| Ingredients | Treatments | | | | |
|-------------------|----------------|----------------|----------------|----------------|----------------|
| | T ₁ | T ₂ | T ₃ | T ₄ | T ₅ |
| Cassava flour (g) | 100 | 90 | 85 | 80 | 75 |
| Mango flour (g) | - | 10 | 15 | 20 | 25 |
| Sugar (g) | 35 | 35 | 35 | 35 | 35 |
| Margarine (g) | 40 | 40 | 40 | 40 | 40 |
| Milk powder (g) | 10 | 10 | 10 | 10 | 10 |
| Baking powder (g) | 2 | 2 | 2 | 2 | 2 |
| Salt (g) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Egg | 1 | 1 | 1 | 1 | 1 |

(T₁ – Biscuits with 100% of cassava flour ; T₂ – Biscuits with 90% of cassava flour + 10% of mango flour; T₃ – Biscuits with 85% of cassava flour + 15% of mango flour; T₄ – Biscuits with 80% of cassava flour + 20% of mango flour; T₅ – Biscuits with 75% of cassava flour + 25% of mango flour).

Each sample of 10 g was taken aseptically and homogenized in 90 ml sterile distilled water; in a blender for 2 min. Serial dilutions, using 1 ml of homogenates were made in 9 ml sterile distilled water, dispensed in test tubes. A volume of 1 ml of each dilution was pour plated in sterile petri dishes, using the plate count agar, incubated at 37°C for 24-36 hours. Counts of visible colonies were recorded.

Sensory analyses

The sensory attributes including colour, aroma, crispiness, taste and overall acceptability were evaluated by a trained 30 member panel, using a seven point hedonic scale with 1 representing the least score (Dislike extremely) and 7 the highest score (Like extremely).

Statistical analyses

The experiment was conducted using Complete Randomized Design, consisted of five treatments replicated three times. Quantitative data analysis was carried out using GENSTAT discovery Edition 3 (VSN International). Data obtained in nutritional analyses were subjected to Analysis of Variance (ANOVA) and mean separation was done with Duncan's Multiple Range Test (DMRT). Descriptive statistics was done on sensory attributes and the means were compared using the Friedman test.

RESULTS AND DISCUSSION

Nutritional analyses

The results of nutritional analysis with respect to moisture, protein, fiber, ash and soluble carbohydrate of the whole cassava biscuits and mango flour supplemented biscuit samples are as presented in Table 2. There was no significant differences ($p < 0.05$) in relation to moisture content in all the developed biscuit samples made with different percentage of cassava flour compared with the market sample (control). The average moisture content of the biscuits made with mango flour was 6.93%. Ogunjobi and Ogunwolu (2010) reported that, total moisture content for biscuits

should not exceed 10% and 6% is the best for extended storage. Therefore, the moisture contents of the biscuits supplemented with mango flour were within the acceptable level and may not have adverse effect on the quality attributes of the product. Ashoush and Gadallah (2011) reported that moisture contents in mango peel supplemented biscuits showed higher moisture content of 9.76% than control biscuit (7.34%) made from cassava flour.

There were significant differences ($p < 0.05$) in protein level of the supplemented biscuits proportional to the level of mango flour addition. The protein content increased with increased percentage of mango flour. This could be due to the protein content of the mango flour since other ingredients in the formulation for all the samples were in the same proportion. Increase in the levels of cassava flour resulted in decrease in the protein content and our findings were supported by Oluwamukomi *et al*, (2011). Though, the highest protein content of 8.26% was found in biscuit sample supplemented with 25% of mango flour, this biscuit sample was not significantly different from the sample supplemented with 20% of mango flour. From the results, it showed that supplementation of cassava flour with mango flour in biscuit formulation had increased the protein content of the biscuits. Similar findings were reported in a study by Chinma and Gerneh (2007) on cookies produced from cassava, soybean and mango composite flours.

The fiber content of the biscuits significantly increased ($p < 0.05$) with the increasing levels of incorporation of mango flour, while the biscuits made with 100% cassava flour had least value of 1.31% for fiber. Our findings were in accordance with the results of Amusa and co-workers, (2002). This could be due to the high fiber content in the mango flour used in this study. The fiber content of the biscuits supplemented with 10 and 15% of mango flour were significantly different from the samples supplemented with 20 and 25% of

mango flour. For the biscuits made with 100% cassava flour, the fiber content was significantly different from all other tested samples. However, these values were within the range reported for high fiber cookies by Camire *et al.* (2007).

The values obtained for the ash contents indicated that there were no significant differences in the total ash content of the biscuits supplemented with 15, 20 and 25% of mango flour while samples made from 10% mango flour supplementation were significantly different from them. The ash content found in the biscuits supplemented with mango flour was higher than that reported for biscuits made from 100% cassava flour. The soluble carbohydrate contents was highest for biscuits made from 100% cassava flour and this was expected as the cassava flour composed of mainly soluble carbohydrate rich materials, compared to the composite flour mixtures with mango flours. Our findings were sup-

ported by Nuwamanya *et al.* (2010).

The amylose content in the cassava flour was 19.8% with the solubility of 3.26g/100g. Amylose content in the flour is important in almost all starch properties with low amylose contents leading to increased relative crystallinity of starch due to the reduced amorphous regions within the starch granule (Dixon *et al.*, 2007). Amylose content also affects the retrogradation properties of starch where high amylose starches have increased retrogradation tendencies caused by the aggregation of amylose which acts as nuclei during the process amylopectin retrogradation.

The influence of amylose on the pasting properties depends on its leaching out of the amylopectin network during heating into the solution affecting the starch's visco-elastic properties (Mali *et al.*, 2005). Increase in amylose content leads to increase in the pasting temperature due to the prolonged escape of amy-

Table 2. Nutritional characteristics of biscuits made from cassava flour supplemented with mango flour

| Treatments | Moisture (%) | Protein (%) | Fiber (%) | Ash (%) | Soluble Carbohydrate (%) |
|----------------|------------------------|------------------------|------------------------|-------------------------|--------------------------|
| T ₁ | 6.85±0.02 ^a | 5.85±0.03 ^a | 1.31±0.03 ^a | 1.83±0.01 ^a | 68.76±0.03 ^{bc} |
| T ₂ | 6.95±0.01 ^a | 7.41±0.05 ^b | 1.62±0.01 ^b | 2.09±0.02 ^a | 66.27±0.04 ^b |
| T ₃ | 6.85±0.03 ^a | 7.80±0.03 ^b | 1.84±0.02 ^b | 2.47±0.02 ^{ab} | 65.25±0.02 ^b |
| T ₄ | 6.95±0.05 ^a | 8.11±0.02 ^c | 2.33±0.03 ^c | 2.71±0.01 ^b | 64.00±0.03 ^a |
| T ₅ | 7.05±0.03 ^a | 8.26±0.02 ^c | 2.53±0.01 ^c | 2.92±0.01 ^b | 63.27±0.02 ^a |
| Market Sample | 6.92±0.06 ^a | 8.27±0.03 ^c | 2.44±0.02 ^c | 2.87±0.02 ^b | 66.25±0.02 ^b |

Values are means of replicates ± standard error.

Means of each column followed by the same letters are not significantly different at p<0.05.

(T₁ – Biscuits with 100% of cassava flour; T₂ – Biscuits with 90% of cassava flour + 10% of mango flour; T₃ – Biscuits with 85% of cassava flour + 15% of mango flour; T₄ – Biscuits with 80% of cassava flour + 20% of mango flour; T₅ – Biscuits with 75% of cassava flour + 25% of mango flour, Market sample - Control)

lose out of the amylopectin network during the gelatinization of starch leading to prolonged swelling of starch granules (Defloor *et al.*, 2008) hence increasing the temperature required to form a starch paste.

The swelling power of cassava starch depends on the ability of certain components of starch, especially amylose to solubilize in water, hence, allowing water to attack starch molecules. Thus, increases in swelling power are a function of increased solubility (Ceballos *et al.*, 2006). In the use of starch for biscuits production and other dietary applications, especially in solution, starch with high swelling power is required given its high digestibility and the advantages that come with the increases in size attained in this case. However, the swelling power of cassava starch is affected by the presence of reducing sugars in the mango flour which lead to unavailability of total starch for water absorption (Charles *et al.*, 2007). The starch content also affects the

swelling power since increase in total starch leads to increase in swelling power (Cameron *et al.*, 2007).

Addition of mango flour significantly increased the vitamin C content of the biscuit samples ($p < 0.05$) as shown in Figure 1. Biscuits supplemented with 25% of mango flour had the highest value of 24.61 mg/100 g for vitamin C and this sample was not significantly different from the biscuit supplemented with 20% of mango flour. The least value for vitamin C content of 1.78 mg/100 g was recorded for the biscuits made from the 100% cassava flour. This result has shown that mango flour can be a source of vitamin C supplementation in cassava flour biscuits.

The Figure 1 indicates that the pH of the biscuit samples decreased significantly ($p < 0.05$) with mango flour supplementation. The biscuit samples supplemented with 10 and 15% of mango flour were significantly different

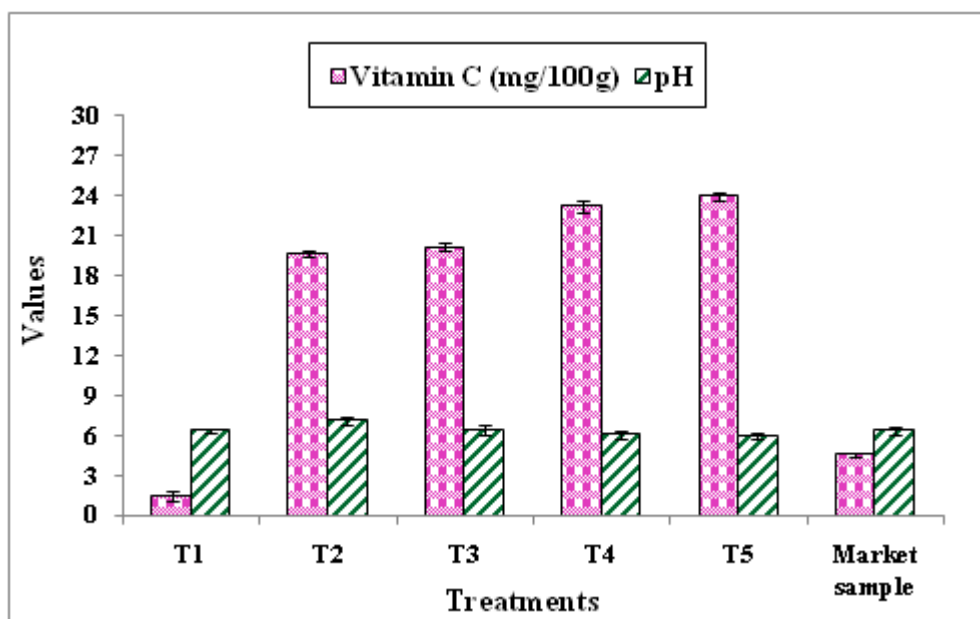


Figure 1: Vitamin C and pH content of biscuits made from cassava flour supplemented with mango flour

Values are means of triplicates.

Vertical bars indicate the standard errors.

(T₁ – Biscuits with 100% of cassava flour ; T₂ – Biscuits with 90% of cassava flour + 10% of mango flour; T₃ – Biscuits with 85% of cassava flour + 15% of mango flour; T₄ – Biscuits with 80% of cassava flour + 20% of mango flour; T₅ – Biscuits with 75% of cassava flour + 25% of mango flour, Market sample - Control)

from samples supplemented with 20 and 25% of mango flour and the control sample. The pH values in all the biscuit samples were >6.0 being considered non acidic food product. Oyewole *et al.* (1996) reported that pH is an important parameter associated to biscuit texture (crispiness, hardness) and flavour.

Microbiological assessment

The microbiological examination, in terms of total plate count revealed that there was no evidence for any microbes observed in the formulated biscuit samples. Therefore, these biscuits were suitable for consumption. Limits of microbial counts have been recommended in most foods to keep them safe for consumption (Ogunjobi and Ogunwolu, 2010). The product should however be well kept after processing in suitable packaging materials capable of preventing contamination and the subsequent proliferation of spoilage microorganisms.

Sensory evaluation

Data on the sensory evaluation of the biscuits in terms of colour, aroma, crispiness, taste and overall acceptability were analyzed using Friedman test and the results are shown in Table 3. In terms of colour, biscuits supplemented with 20% of mango flour obtained highest score by the panelists compared to other tested treatments. Broyart *et al.* (1998) reported that the initial acceptance of baked products is much influenced by colour, which can also be an indicator of baking completion.

Crispiness is perceived when food is chewed between molars, and is usually expressed in terms of hardness and fracturability. In this study, there was no significant difference ($p < 0.05$) in crispiness among the biscuit samples made with different proportions of composite flour except the biscuits made with 25% of mango flour. It was found that the acceptability of the taste for the formulated bis-

Table 3: Sensory qualities of biscuits made from cassava flour supplemented with mango flour

| Treatments | Colour | Aroma | Crispiness | Taste | Overall acceptability |
|----------------|--------------------|-------------------|-------------------|-------------------|-----------------------|
| T ₁ | 5.53 ^{ab} | 5.30 ^a | 6.78 ^b | 6.40 ^b | 5.97 ^a |
| T ₂ | 5.63 ^{ab} | 6.44 ^b | 6.71 ^b | 6.42 ^b | 6.22 ^{ab} |
| T ₃ | 5.72 ^{ab} | 6.63 ^b | 6.63 ^b | 6.51 ^b | 6.34 ^{ab} |
| T ₄ | 6.44 ^b | 6.81 ^b | 6.60 ^b | 6.50 ^b | 6.77 ^b |
| T ₅ | 4.97 ^a | 5.52 ^a | 6.01 ^a | 5.39 ^a | 5.42 ^a |
| Market sample | 5.91 ^{ab} | 5.49 ^a | 6.78 ^b | 6.49 ^b | 6.27 ^{ab} |

Values are means of 30 replicates.

Means of each column followed by the same letters are not significantly different at $p < 0.05$.

Seven point hedonic scale: 1- dislike extremely, 7- like extremely.

(T₁ – Biscuits with 100% of cassava flour ; T₂ – Biscuits with 90% of cassava flour + 10% of mango flour; T₃ – Biscuits with 85% of cassava flour + 15% of mango flour; T₄ – Biscuits with 80% of cassava flour + 20% of mango flour; T₅ – Biscuits with 75% of cassava flour + 25% of mango flour, Market sample - Control)

cuits was not affected by up to 20% substitution of mango flour.

There was significant difference ($p > 0.05$) in terms of overall acceptability among tested samples. However, cassava flour biscuits supplemented with 20% of mango flour had higher score among the formulated biscuits. The findings of the sensory attributes such as colour, crispiness, taste and overall acceptability of cassava and mango flour blend biscuits are in the deviated pattern of the results obtained by Sukhcharn *et al.* (2008). These different directions of score patterns may be due to the different rates of preference and acceptable values of panelists and quality of finished products that were developed.

Based on the results obtained in the sensory evaluation, the supplementation of cassava flour with mango flour up to 20% for the biscuits production did not significantly ($p < 0.05$) affect the colour, crispiness, taste and overall acceptability except aroma when compared with the control (market sample). However, biscuit with 25% of mango flour was significantly different from the other samples in all parameters evaluated. The overall acceptability results showed that biscuits supplemented with 10 and 15% of mango flour were not significantly different and these were the samples preferred by the assessors next to biscuits supplemented with 20% of mango flour.

CONCLUSIONS

This study revealed that the quality of cassava flour biscuits could be improved with supplementation of mango flour, in terms of protein, fiber, ash and vitamin C. The physicochemical analyses showed that protein, fiber, ash and vitamin C content increased with increase in the proportion of mango flour in the formulated cassava-mango composite flour biscuits except for pH. Microbiological test revealed that there was no total plate count observed in the tested samples. Based on the sensory assessment, the supplementation of cassava flour with mango flour up to 20% for

the biscuits production did not significantly ($p < 0.05$) affect the colour, crispiness, taste and overall acceptability except aroma when compared with the control (market sample). The overall acceptability results showed that biscuits supplemented with 20% of mango flour were preferred by the most of the panelists. The combination of cassava flour and mango flour, which are local raw materials for biscuits making will reduce the cost of production when compared with the use of imported wheat flour. Therefore, mango flour addition in cassava flour biscuits formulation found to be suited better for the production and nutritional enrichment of the biscuits.

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