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# ETHNOSCIENCE STUDIES OF NORTH MALUKU'S TRADITIONAL FOOD "PAPEDA": EXPLORING CHEMICAL CONCEPTS FOR SCIENCE LEARNING

***Humairah Ansar Tohe[1], Siti Sriyati[1], Winny Liliawati[1], Ansar Tohe[2]***
*[1]Pendidikan Ilmu Pengetahuan Alam, Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam, Universitas Pendidikan Indonesia*
*[2]Sejarah dan Kebudayaan Islam, Fakultas Ushuluddin, Adab, dan Dakwah, IAIN Ternate*
*E-mail: humairahat@upi.edu, sriyati@upi.edu, winny@upi.edu*

## ABSTRACT

Ethnoscience is a science learning approach that implements local wisdom (regional culture) using certain cultural products. Local wisdom can be in the form of foods, drinks, traditional ceremonies, dances, games, and languages. One of the local wisdom-based traditional foods is Papeda, a traditional food from North Maluku made from sago flour. The main problems addressed in this research are: 1) How is the the reconstruction of indigenous knowledge related to the process of making papeda into scientific knowledge? and 2) What chemical concepts are contained in the process of making papeda, and how is their relevance for science learning among students?. The purpose of this research is to reconstruct the indigenous knowledge into scientific knowledge and examine the chemical concepts in the process of making papeda for science learning. The research method used is descriptive qualitative research through interviews and literature studies. The results of this study indicate that the reconstruction of indigenous knowledge into scientific knowledge from the process of making Papeda can be used as a learning resource for students because it has relevance to various chemical concepts in science learning. The chemical concepts contained in the process of making papeda are substances and their changes, colloids, physical and chemical changes, thermochemistry, macromolecules (especially carbohydrates), and nutrients with their relationship to the digestive system.
**Keywords**: Chemistry, Ethnoscience, Local wisdom, Papeda, Sagu, Science learning

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## 1. INTRODUCTION

Education can not be separated from the culture that exists in society. Education does not only aim to create intelligent individuals but also to form cultured individuals. Education is not only a means to transfer knowledge to students but also to foster an attitude of love for their own culture. Thus, schools as educational institutions have a crucial role in the process of cultural preservation. (Pingge, 2017).

Indonesia consists of thousands of islands stretching from Sabang to Merauke and is inhabited by various tribes with their unique languages and cultures. The diversity of cultures and local wisdom in each region makes Indonesia a country with a high level of pluralism (Herimanto (2010) in Husni (2019). Local wisdom is an idea that arises and develops continuously in a society in the form of customs, values, rules/norms, culture, language, beliefs, and daily habits (Pingge, 2017).

Community habits and traditions are a form of local wisdom that has its characteristics and distinctiveness in each region. One of them is the local wisdom found in Ternate City, North Maluku Province, which is located in eastern Indonesia. In terms of culture, local communities in the North Maluku region have long consumed sago as a staple food for generations (Ibrahim et al., 2015; Hutapea et al., 2003). Indonesia is one of the largest sago-producing countries in the world, with the main sago-producing areas located in Papua and Maluku. Indonesia has several advantages, such as not only being able to produce sago at a lower cost but also being able to compete more effectively in the global market compared to other countries such as Papua New Guinea, Malaysia, the Pacific Islands, and the Philippines (Liborang, 2019). North Maluku, together with Maluku, is the region with the largest sago forest in Indonesia after Papua (Jamil, 2022).

Sago (Metroxylon sagu Rottb.) grows in forest conditions that are often poorly maintained. Sago's ability to grow in swampy areas or marginal soils where other carbohydrate-producing plants are challenging to grow is its characteristic (Hutapea et al., 2003). The sago plant has a vital role in the social, economic, and ecological aspects of North Maluku (BPTP North Maluku, 2014). Tulalessy (2016) stated that sago not only functions as a staple food but also as a cultural symbol and identity of the North Maluku people. Searching for sago in the forest and riverbanks is a community activity in eastern Indonesia (Rumalatu (1992) in Rosida, 2019).

Sago has a sizeable potential carbohydrate content to be used as a staple food. Sago has excellent potential as a supplier of Indonesia's carbohydrate needs to replace rice (Harling, 2018). In addition to its potential as a food source, sago also has potential as a source of animal feed, industrial food, energy source, and environmentally friendly cultivation (Santoso, 2017). As a source of carbohydrates, sago has been utilized by the community to be processed into various food products. The sago tree produces flour that is used in making various traditional dishes, such as papeda, bagea, and sago plates, which are an integral part of local culture. (Hutapea et al., 2003; Nurma, 2021).

Papeda is a processed product from sago flour. Papeda is made by dissolving sago flour in cold water and then doused with boiling water until it thickens and forms a gel. Papeda is served with fish sauce and combined with various additional dishes to complete the meal together (Ansar et al., 2021). The process of making papeda can be used as a source of learning for students. This process can be studied from the perspective of indigenous knowledge by observing the views and knowledge of the community, many of which have yet to be scientifically proven. This knowledge has been passed down from generation to generation and is part of the community's habits to this day. So, another study is needed from the perspective of scientific knowledge to reveal the scientific side of indigenous knowledge in the form of concepts, principles, theories, and laws scientifically. The process of translating original science concepts from the culture that develops in society into scientific knowledge is called the reconstruction of original science into scientific knowledge (Parmin et al., 2017).

Science learning in schools today should integrate cultural elements that develop in society into the science curriculum by using an ethnoscience approach. Ethnoscience in the learning process plays a vital role because students can improve their understanding of scientific concepts by studying aspects of science contained in the culture of their local community (Mayasari, 2017). In addition, through this approach, students can play a role in preserving their cultural heritage while linking it to the scientific knowledge they learn. Local wisdom can be incorporated into education as an effort to preserve the local culture found in an area. Science learning is closely related to knowledge gained from observation, proof, and experimentation through the scientific method (Rahmatiah et al., 2020). Therefore, this study was conducted to review aspects of indigenous knowledge and scientific knowledge in the process of making papeda to be integrated into science learning. The results of this study can be taught in schools to integrate local wisdom-based learning with chemistry concepts in science learning.

## 2. RESEARCH METHODS

This research uses descriptive qualitative research method. Descriptive qualitative research aims to narratively describe a situation or phenomenon using verbal descriptions to draw conclusions. Data collection in this study is conducted through interviews and literature review. Open-ended interviews are conducted, involving questions that include the process of sago flour production, the making of papeda, and the serving papeda. The participants interviewed were 2-3 people, consisting of local community members who have directly participated in the harvesting of sago and the making of papeda, and the local consumers of papeda. The literature review provides a written summary of various articles, journals, books, and other documents describing information related to the topic. The sources used in this literature review include scientific journals, books, research reports, and government documents. The search and collection of these literature sources are carried out through Google Scholar. The literature sources used in this study totaled 24 sources, with a publication time between of 2014-2023 years.

## 3. RESULTS AND DISCUSSION

### Sago Plants (*Metroxylon sago*)

Sago, with the scientific name *Metroxylon sago*, is a palm plant that grows in the tropics, including Indonesia. Etymologically, the term metroxlyon comes from Greek, with "metro" referring to pith or parenchyma (pith, the inner part of the stem), while "xylon" refers to xylem or wood, and "sago" refers to starch. The sago plant can be classified as a hapaxanth ("hapax" meaning once and "anthos" meaning flower), which is a plant that experiences flowering only once during its life cycle. In addition, sago is also included in the category of soboliferous plants, which reproduce through saplings in addition to seeds (Kementerian Pertanian Republik Indonesia, 2019).

According to Tjitrosoepomo (1993) in Kementerian Pertanian Republik Indonesia, 2019), the classification system of scientific names (taxonomy) of sago is as follows.

Kingdom : Plantae
Division : Spermatophyta
Subdivision : Angiospermae
Class : Monocotyledonae
Order : Arecales
Family : Arecaceae (Palmae)
Genus : Metroxylon
Species : *Metroxylon sagu*

**Figure 1. Sagu Plants**

Sago produces starch that is stored in the stem. The starch storage process takes place gradually over many years. Sago trunks contain 10-25% dry starch, and each mature sago trunk produces 100-300 kg dry starch. Flach (1997) in Kementerian Pertanian Republik Indonesia (2019) stated that the life cycle of the sago tree lasts 11-12 years with four growth phases, namely:

1. The initial growth phase, or clump formation phase, is characterized by the emergence of rosettes. This phase lasts for 3.5 years. In this phase, stem growth is slow, and about 90 leaves have been formed.
2. The stem growth phase, including the stem of the rosette, lasts 4.5 years. One new leaf is formed every month, so there will be 24 leaves and 54 traces of leaf attachment to the stem due to loose or fallen leaves. In this phase, the sago tree produces starch in large quantities.
3. The inflorescence phase (flowering) lasts for one year. In this phase, two new leaves are formed every month, and the level of starch production begins to decrease. The starch that was originally stored in the lower part of the stem begins to move to the upper part of the stem. Therefore, sago plants should be harvested at the beginning of this phase. The fruit ripening and seed formation phase lasts for two years.

Sago trees should be harvested at harvest maturity (early phase 3), which is before the plant flowers. If harvesting is delayed, the sago tree will continue its natural process of forming flowers, fruits, and seeds (phase 4). In this phase, the starch content in the stem decreases, and then the tree dies "for nothing" because it is not utilized for human needs.

Thus, the sago tree stores starch as energy as if it were only to produce flowers and fruit. After the flowers and fruits are formed, the energy is depleted, and the trunk rots. Subsequently, older saplings in the same clump will replace them (Kementerian Pertanian Republik Indonesia, 2019).

The topography of North Maluku Province is primarily mountainous and hilly, consisting of volcanic and coral islands and the mainland, as well as lowlands along the coast, creating favorable conditions for sago growth (Makmur, 2023). Sago grows in lowlands up to 300 meters above sea level in swampy areas on the coast and along flooded rivers. Sago grows on mineral soils, tidal swamp areas, and peat soils with shallow to medium depths (Schuiling, D.L., & Flach (1985) in Ibrahim et al., 2015)

In general, North Maluku residents need to gain knowledge about sago cultivation techniques. They rarely or never apply appropriate cultivation practices, such as the selection of good seeds, proper planting methods, and plant maintenance. Sago plants in this region grow and develop naturally without human intervention, which is indicated by the condition of sago fields that are not maintained and rarely cleaned, without replanting activities or adjusting plant spacing and water management. Traditionally, most farmers in North Maluku recognize the physiological signs that sago trees are ready for harvesting and know which sago trees have high production by observing the type of sago tree and its trunk diameter (Ibrahim et al., 2015). Sago plants also produce sustainably for decades as long as the sago forest area is allowed to develop naturally.

Culturally, residents of North Maluku have long consumed sago as a staple food. Research shows that people continue to manage sago and consistently consume papeda and sago at a frequency of two to three times a week (Jamil, 2022).

**Reconstructing Indigenous Knowledge into Scientific Knowledge in the Papeda-Making Process**

Papeda is a traditional food of the people of Maluku, North Maluku, Papua, and some areas in Sulawesi in the form of gel or paste. The principle of making papeda is by heating a suspension of sago starch until gelatination occurs. The sago starch is stirred in a little cold water until a suspension of a specific viscosity is formed, a viscosity that can still be stirred easily. The suspension is poured with hot water (boiling water) while stirring until it thickens (Rosida, 2019). The choice to consume papeda is due to the abundant availability of sago plants. Since ancient times, sago has been known and used by the local community as a staple food, and this tree continues to grow until now. However, its existence is currently threatened due to land conversion (Ibrahim et al., 2015) and due to differences in generations and areas of residence; for example, for people who live in urban areas, the consumption of sago as a staple food is threatened with being replaced by rice (Rosida, 2019).

Rice consumption has been declining from 2005 to 2019, with an average annual decrease of 0.7%. Efforts are being made to increase the rate of decrease in rice consumption to promote local food diversification among the population. By 2024, the target is to increase sago consumption to 0.40 kg per capita per year, with a focus on sago-producing regions, including North Maluku province. (Badan Ketahanan Pangan, 2020).

Papeda is still in demand and is considered a culinary heritage and regional identity of the North Maluku community (Jamil, 2022). Papeda is translucent white and has a thick, chewy, and sticky gel-like texture. Papeda, with its fresh taste, is usually eaten and served with yellow fish sauce and several other additional dishes. Papeda is usually eaten with side dishes such as fish, meat, coconut, vegetables and other types that have high nutrition.

**Figure 2. Sago flour is the essential ingredient for making papeda**

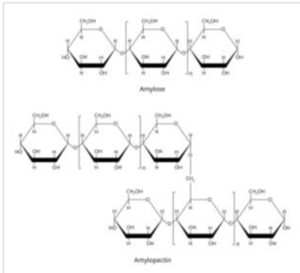
**Figure 3. Papeda as traditional food**

The processing of sago starch until the making of papeda by the community still uses traditional methods with manual tools. The stages of harvesting sago trees, are taking sago starch by scraping the pith, washing sago starch using water, then allowing it to form sago starch sediment, then drying it. The sago flour that is obtained is used as the essential ingredient for making papeda and other processed foods from sago flour, such as sagu lempeng. The series of processes from the initial stage to the final stage contains a lot of indigenous or local knowledge that can be linked to scientific knowledge. The results of this study can then be integrated with the concept of chemistry as one of the learning resources in science learning. The reconstruction of indigenous knowledge into scientific knowledge is shown in Table 1.

**Table 1. Reconstructing Indigenous knowledge into Scientific Knowledge in the Papeda-Making Process**

| Topic | Indigenous Knowledge | Scientific Knowledge |
|---|---|---|
| Selection of sago as a base for papeda | Sago grows widely in the North Maluku area, especially in the lower lands, making it a staple food for the community to this day. | The sago area in Indonesia is very large, around 1.28 million ha, or 51.3% of the total sago area in the world, but its utilization is only 10%, or around 128,106 ha (Kementerian Pertanian Republik Indonesia, 2019). The sago forests in Maluku and North Maluku cover an area of 50,000 hectares, with sago consumption increasing year by year (Lasamahu & Pesiwarissa, 2019). |
| Sago is a local food rich in carbohydrates. | Sago is a staple food, along with rice and sweet potatoes, and is used as papeda and sago bakar (sago plate) for | The advantage of sago over other commodities is that it has a high carbohydrate content (84.7 g per 100 g), higher than rice (80 g per 100 g) and wheat flour (77.3 g per 100 g) (Badan Ketahanan Pangan, 2020). |

| Topic | Indigenous Knowledge | Scientific Knowledge |
|---|---|---|
| | the community because it is considered to be filling. | |
| The process of harvesting sago tree | Sago trees that are tall, have a large trunk diameter and have yet to flower are ready to harvest because they are believed to contain a lot of sago meat or starch. | The criteria for a sago tree to be ready for harvest visually are that the plant has the most prominent and tallest trunk, the number of leaves on the top/crown is 3-4 midribs, and flowers have not yet appeared (the top has swollen and flowers will appear soon). Harvest delays occur when flowers have appeared and bloomed. When sago flowers appear and bloom, all energy reserves in the form of starch in the stem have been used by plants so that the starch yield decreases dramatically (Kementerian Pertanian Republik Indonesia, 2019). |
| The process of making sago starch | Sago trees that are ready for harvest are then cut off using traditional tools. The inner part of the trunk is then dredged to obtain the starch.<br><br>Sago starch, found in the deepest part of the trunk, has a softer texture and is easier to extract than the harder and fibrous bark. | Sago starch is mainly found in the pith or inner part of the sago tree trunk. The pith is a parenchyma tissue located in the center of the stem and serves as the primary storage of starch in sago trees. Sago starch is stored in these parenchyma cells in the form of starch granules. The pith can reach a considerable diameter depending on the age and size of the sago tree. The innermost part of the trunk contains the highest concentration of starch. As one moves outward towards the bark, the starch content decreases, and the tissue begins to become more fibrous and lignified (Rosida, 2019). |
| | The sago starch obtained is then poured with a large amount of water. This "washing" process produces liquid sago from the coarse fiber/dregs. The liquid sago is left until it settles. The settled sago starch is then taken out and dried.<br><br>**Figure 4. Sago starch, after being produced from sago tree trunks** | The addition of water is essential in the extraction process because it helps dissolve and release starch granules from sago pulp, which consists of water-insoluble parts of the sago plant, such as fibers, proteins, minerals, and a small portion of starch remaining after the extraction process (Kamal et al., 2017). After that, there is the formation of a colloidal solution, in which the starch particles are dispersed in water in the form of tiny particles that are not visible to the naked eye. However, when the starch solution is allowed to stand still for a long enough time, a precipitation process occurs. This process is influenced by several factors, including the greater specific gravity of starch than water, which causes the starch particles to tend to sink to the bottom (Jane (1995) in Compart et al., (2023). |
| The process of making papeda: the stage of dissolving sago flour with a small quantity of cold water | Sago flour is dissolved with a small amount of cold water to dissolve the flour, as well as to prevent large lumps of flour from forming, before | When sago starch is dissolved in water, it does not form a homogeneous solution but rather a suspension. The starch molecules will begin to interact with the water molecules. This interaction causes hydration of the starch where the water |

| Topic | Indigenous Knowledge | Scientific Knowledge |
|---|---|---|
| | adding a large amount of water. This process also prevents the papeda from failing in its gel formation. | molecules bond to the starch molecules, facilitating the dispersion of the starch in water and resulting in a suspension mixture (Donmez et al., 2021; Compart et al., 2023). Dissolving the sago starch with a small amount of water also helps prevent the formation of large starch lumps when it is later added to hot water directly. This helps to create the initial consistency in papeda making. |
| The process of making papeda: the stage of adding boiling water to the sago flour mixture | The boiling water helps to create the papeda's viscosity and gel-like properties. | Chemically, sago starch contains 27.4% amylose and 72.6% amylopectin (Rosida, 2019). Amylopectin will interact more effectively than amylose with water, forming a denser structure resulting in greater viscosity and gel strength. (Compart et al., 2023).  **Figure 5. Amylose and amylopectin structure** The gelatinization process between starch and water results in the swelling of starch granules as water enters into the starch structure. Initially, water penetrates the amorphous region of the starch granules, causing them to swell and absorb water. As the temperature increases, the hydrogen bonds in the starch molecules break, which disrupts the starch granule structure to become more "loose". This process results in the formation of a viscous paste or gel as the starch molecules hydrate and interact with water molecules, leading to an increase in viscosity and the formation of a gel network. The gel network traps water molecules, giving the gel its characteristic texture and properties (Donmez et al., 2021). |
| The process of making papeda: the stirring process is vital in making papeda | When sago flour is added to boiling water, the stirring process is carried out quickly, aiming to accelerate the formation of gel in papeda. | Stirring is necessary to ensure even heat transfer, accelerate and ensure starch gelatinization, form a consistent gel, and control the viscosity of the mixture. Stirring affects the viscosity of the mixture. Before heating and gelatinization, the mixture of sago starch and water has a low viscosity. After heating and gelatinization, the viscosity increases due to gel formation. This is because the starch molecules form a network that increases the resistance to flow (Juwahir et al., 2023). |
| Papeda Serving | The warm, fresh papeda served with the sour and | Warm papeda is often served with a yellow fish sauce flavored with turmeric, lime, and spicy. Aside |

| Topic | Indigenous Knowledge | Scientific Knowledge |
|---|---|---|
| | spicy yellow fish sauce gives the perfect blend of flavors.  **Gambar 5. Papeda served with yellow fish sauce** | from flavor issues, turmeric contains curcumin compounds that have been shown to have anti-inflammatory, antioxidant, and antimicrobial properties that can suppress the production of inflammatory compounds in the body and kill bacteria. In addition, research also shows that curcumin can increase the activity of digestive enzymes and stimulate bile secretion, which can increase the absorption of nutrients, especially fat, from food (Ulfah, 2020). Lime contains vitamin C, which is essential for the immune system, as well as flavonoid compounds that have antioxidant and anti-inflammatory properties (Farida et al., 2021). The spicy taste of chili or pepper is caused by the compound capsaicin, which has positive effects on health, including increasing the body's metabolism, lowering the risk of heart disease, and increasing insulin sensitivity (Nima, 2021). |
| Papeda Serving | Papeda is usually served with various additional dishes, such as vegetables, chili sauce, sago lempeng, boiled bananas, and boiled cassava. Eating papeda alone is not very filling, like eating rice in general.  **Figure 6. Serving papeda with complementary dishes** | Starch, in the context of papeda, only sometimes provides optimal fullness due to its thick, chewy texture and low fiber and protein content. Chemically, sago starch, which is the primary source of starch in papeda, has a high carbohydrate content. However, this starch tends to have a fragile molecular structure and is easily digested (due to its gel/starch form that undergoes a gelatinization process), so it can be digested quickly by the body without providing sustained satiety. In addition, these starches also have a high glycemic index, which means they can cause a rapid spike in blood glucose levels, but also a rapid drop afterward, which can trigger early hunger pangs. In contrast, other sources of carbohydrates, such as boiled bananas or boiled cassava, tend to contain more fiber and other nutrients, which slow down the absorption of carbohydrates in the body and provide a longer-lasting feeling of fullness. Thus, although the starch in sago starch has a significant carbohydrate content, its structure and chemical properties may affect the level of satiety felt by the body (Metagarakusuma, 2016; Donmez et al., 2021). |
| Papeda Serving | Papeda is eaten warm because when it gets cold, the papeda will harden. | When starch is cooled, a physical change occurs in the starch structure called retrogradation. The process of starch retrogradation involves the recrystallization of the starch structure after the starch has gelatinized. At the chemical level, retrogradation occurs because the starch molecules re-form stronger hydrogen bonds after cooling, leading to the re-formation of a denser, stiffer, and drier crystalline structure (recrystallization) of starch (Donmez et al., 2021). |

Indonesian culture is very diverse and rich in indigenous knowledge that can be reconstructed into science. This knowledge has the potential to make a significant contribution to the learning process with an ethnoscience approach. One of the traditional foods in North Maluku Province is papeda. The reconstruction of indigenous knowledge about the process of making papeda into the context of scientific knowledge gives scientific meaning to existing cultural beliefs. The process of making papeda that has been reconstructed into scientific knowledge can be used as a learning resource for students because it has relevance to various chemical concepts in science learning.

The chemical concepts involved in the process of making papeda and can be implemented with science learning are (1) in the material of substances and their changes, sago flour mixed with water does not form a homogeneous solution but remains separate, creating a heterogeneous mixture or suspension; (2) colloidal material, when the mixture of sago flour with cold water is added with water at a high temperature, the starch granules in sago flour absorb water and expand. This process causes the breakage of hydrogen bonds in the starch structure, which then releases starch molecules such as amylose and Amylopectin in water to become thicker and form a gel. Gel is a type of colloid in which the dispersed phase (starch molecules) forms an entangled network in the continuous phase (water), resulting in a springy and elastic semi-solid structure or what is called a gel (Anwar & Irmayanti, 2019); (3) physical and chemical changes, such as mixing sago starch in water to form a suspension is a form of physical change, while the gelatinization process is a form of chemical change due to molecular interactions that occur (breaking of hydrogen bonds in starch granules) resulting in changes in the physical structure of sago starch to gel;

(4) thermochemical material, the process of heating water to boiling is an application of the concept of heat, it is transferred from the heat source to water, increasing the kinetic energy of water molecules so that the temperature rises to the boiling point. When boiling water is added to the mixture of sago starch and water, heat is transferred from the hot water to the starch granules through conduction, then stirring the mixture of sago and boiling water helps the heat distribution evenly through convection, ensuring that all starch granules are uniformly heated; (5) macromolecules, because starch is one form of macromolecules, namely carbohydrates where these carbohydrates have an essential role for the body because of their role as a source of energy in the body. In addition, the physical and chemical properties of carbohydrates are also studied; and (6) food substances and nutrients and their relationship with the digestive system, papeda is served with other additional dishes to fulfill its nutritional content, and papeda, which is not too filling like rice, is closely related to the human digestive system.

## 4. CONCLUSION

Based on the study conducted, the tradition of making papeda is one of the local wisdom and local cultural heritage in Ternate, North Maluku Province. In the process of making papeda, there are aspects of scientific knowledge that are the result of the reconstruction of indigenous knowledge passed down from generation to generation. The study of indigenous knowledge and scientific knowledge is carried out based on an ethnoscience approach that has a relationship with chemistry concepts and can be used as a source of science learning in schools. The chemical concepts contained in the process of making papeda are substances and their changes, colloids, physical and chemical changes, thermochemistry, macromolecules (especially carbohydrates), and nutrients with their relationship to the digestive system.

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