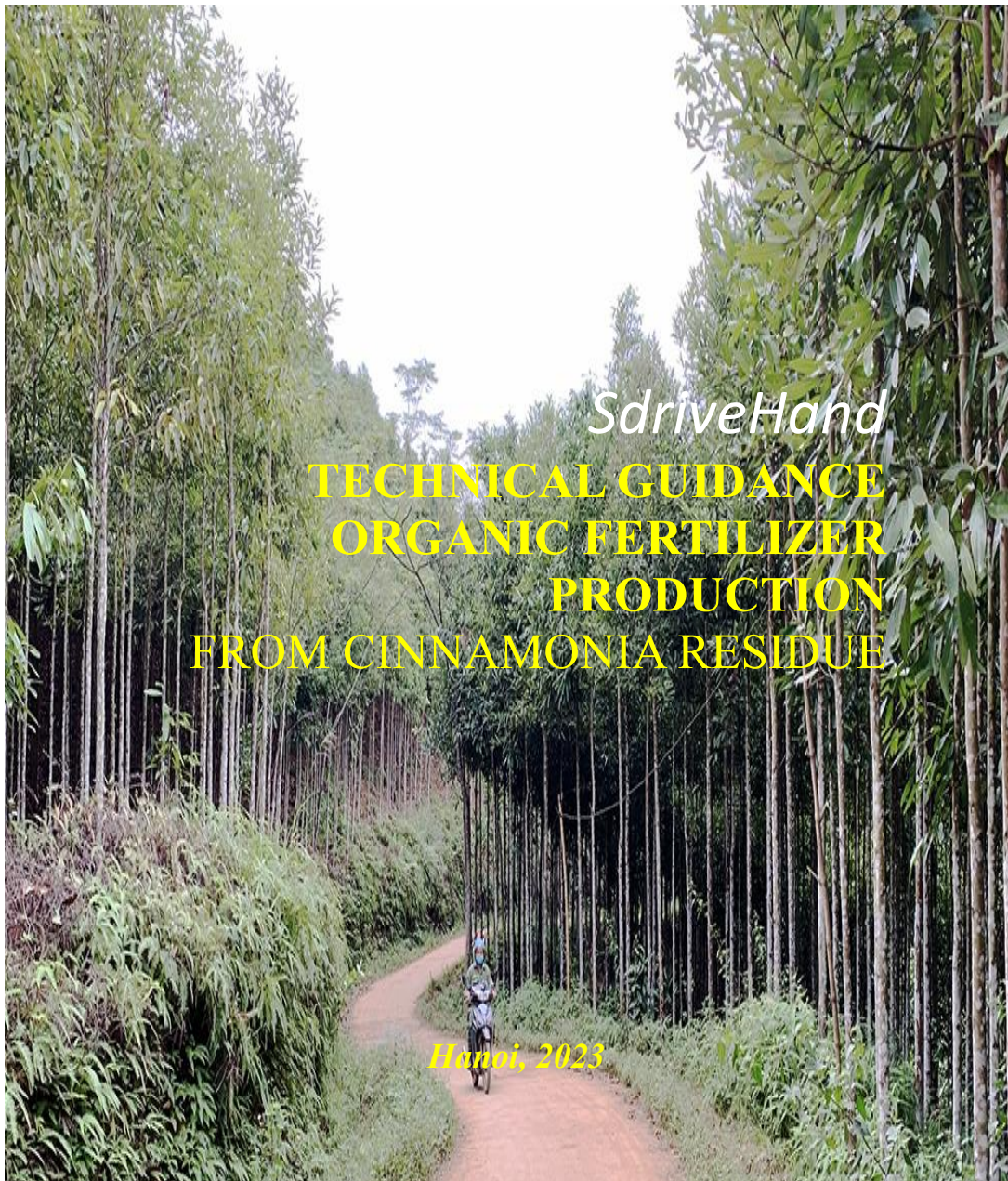


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**TECHNICAL GUIDANCE
ORGANIC FERTILIZER
PRODUCTION
FROM CINNAMONIA RESIDUE**

Hanoi, 2023



PREFACE

In Vietnam, cinnamon trees are grown mainly in the provinces of Yen Bai, Lao Cai, Thanh Hoa and Quang Nam, etc. This tree species has contributed significantly to creating livelihood for farmers. However, in many localities, cinnamon plantations are still not sustainably managed because most of the organic matters from cinnamon forests are harvested in the form of branches, leaves and stems without being returned to balance soil nutrients. To develop cinnamon forests more sustainably, it is necessary to restore soil fertility by adding necessary organic substances.

Vinh Yen commune is a locality in Bao Yen district, Lao Cai province. The livelihood of people here depends largely on growing, processing and providing products from cinnamon trees. The main products are produced locally including cinnamon bark, essential oil, cinnamon wood, etc. However, a large number of by-products that have not been used effectively are cinnamon residue obtained after the oil extraction process. Due to high essential oil content, cinnamon residue cannot be used directly for plants. These products are still being purchased for burning by traders at low prices. With these facts, the idea of producing organic fertilizers from cinnamon residue has been formed and implemented to take advantage and reasonably use this raw material source, thereby improving the soil, aiming toward sustainable production.

Under support from the Japan Center for International Forestry Promotion and Cooperation (JIFPRO) and the Strengthening Sustainable Natural Resource Management Project (SNRM2), Vinh Yen Agricultural and Service Cooperative has successfully produced organic fertilizers from cinnamon residue and cinnamon ash. On that basis, a technical manual was developed to guide people through the basic steps and knowledge to help them conveniently apply the organic composting process into production in practice.

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LIST OF ACRONYMS

NN&PTNT	Ministry of Agriculture and Rural Development
QCVN	National Standards
TCVN	Vietnam standard
JICA	Japan International Cooperation Agency
SNRM2	Project to Strengthen Sustainable Natural Resource Management
JIFPRO	Japan Center for International Forestry Cooperation and Promotion

I. GENERAL REGULATIONS

1.1. Scope

This handbook provides technical instructions for producing organic fertilizer from cinnamon residue on a concentrated and small scale and at households. This process is suitable for use in organic farming.

1.2. Applicable subjects

Organizations and individuals produce organic fertilizer from cinnamon residue in Bao Yen district, Lao Cai province and in places with similar conditions.

1.3. Normative references

TCVN 13263-9:2020. Fertilizers – Part 9: Determination of pH;

TCVN 6846:2007 (ISO 7251:2005). Microbiology of food and animal feeding stuffs - Horizontal method for the detection and enumeration of presumptive *Escherichia coli* - Most probable number technique;

TCVN 9294:2012. Fertilizers - Determination of total organic carbon by Walkley-Black method;

TCVN 9290:2018. Fertilizers - Determination of total lead content by flame and electrothermal atomic absorption spectrometry;

TCVN 9291:2018. Fertilizers - Determination of total cadmium content by flame and electrothermal atomic absorption spectrometry;

TCVN 9297:2012. Fertilizers – Method for determination of moisture;

TCVN 10676:2015. Fertilizers - Determination of total mercury content by cold vapour atomic absorption spectrometry;

TCVN 10780-1:2017. Microbiology of the food chain - Horizontal method for the detection, enumeration and serotyping of Salmonella - Part 1: Detection of Salmonella spp.

TCVN 11403:2016. Fertilizers - Determination of arsenic content by atomic absorption spectrometry;

QCVN 21:2009/BTNMT. National Technical Regulation on Emission of Chemical Fertilizer Manufacturing Industry;

QCVN 40:2011/BTNMT. National Technical Regulation on Industrial Wastewater.

1.4. Terms and definitions

1.4.1. Cinnamon residue

The product is obtained after the process of extracting essential oils from cinnamon stems, branches and leaves. The main component of cinnamon residue is carbohydrates.

1.4.2. Organic fertilizer

- Organic fertilizers used for fertilizing roots that are formulated by natural organic ingredients and meet quality indicators defined in national technical regulations (Cultivation Law 2018).

- Organic fertilizers include different types of fertilizers which are produced mainly from natural organic substances (excluding synthetic organic substances) that have been treated through physical processes (such as drying, grinding, sieving, mixing, moisturizing) or biological processes (such as aging, fermentation, extraction). They are further classified according to the compositions and functions of main quality indexes or production processes as specified in national technical regulations (Decree No. 84/2019/ND-CP).

1.4.3. Microbial preparation

- The product contains one or more strains of live microorganisms; has been selected at a density that meets current standards; has the ability to decompose aerobic or anaerobic cellulose into soil fertilizers, creating conditions to improve crop productivity and agricultural product quality, increase soil fertility, and at the same time does not cause adverse effects on humans, animals, plants, ecological environment and agricultural product quality.

- The quality meets the standards specified in TCVN 6168: 2002 on Microbial preparation for cellulose degradation.

II. TECHNIQUES TO PRODUCE ORGANIC FERTILIZER FROM CINNAMON RESIDUE

2.1. Prepare

2.1.1. Incubation location

The selected organic fertilizer composting location must meet the following criteria:

- Far away from domestic water sources and concentrated residential areas;

- Needs to be flat and well-drained; Convenient for gathering, spreading materials and transporting compost; The surface of the annealing site should be as hard as possible (use a hoe or shovel to wedge it tightly). There should be a drainage system around to avoid water leaking outside;

- The incubation area is suitable for the amount of raw materials. The incubation location should be covered to avoid rain and sun..

2.1.2. Apparatus and tool

- Turning machine, excavator (if any) or hoe, shovel, rake: used to mix compost materials and periodically turn compost piles;

- Pump (if any): used to get water to mix nutrient solution and moisten materials;
- Scale: used to accurately measure ingredients put into the compost pile;
- Temperature machine (or thermometer): used to check compost pile temperature;
- Tanks, reamers or specialized mixing equipment: used to store water and nutrient solutions;
- Tarpaulin, plastic, ...: used to cover compost piles; Helps avoid sun, rain and ensures the temperature of the compost heap (5m²/ton of material).

2.1.3. Ingredient

Cinnamon residue (crushed) ⁽¹⁾	700 kg
Livestock waste (if any) ⁽²⁾	300 kg
Ash burns cinnamon residue	40 kg
Fish meal ⁽³⁾	6kg
Molasses	6kg
Lime powder	5kg
Microbial preparation ⁽⁴⁾	2kg

Note:

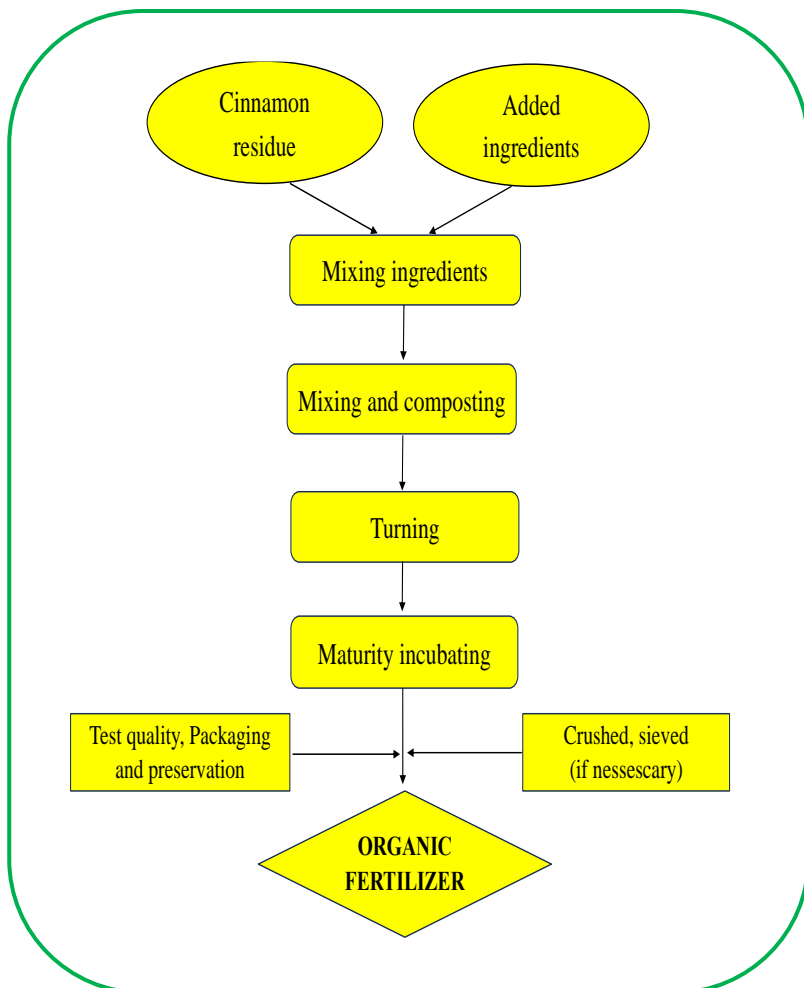
(1): Cinnamon residue size < 2 cm. The incubation process will be faster if the cinnamon residue are crushed to a size of 0.3-0.5 mm.

(2): If there is no livestock waste, replace it with cinnamon residue (crushed) with an amount equivalent to + 1 kg of fish meal.

(3): Type of raw materials for animal feed. Fish meal can be replaced with soybean meal or rice bran or corn bran in an amount of 10 kg.

(4): The amount of use varies according to the guidelines for use of each type of microbial preparation.

2.2. Flow chart for process



2.3. Process description

2.3.1. Mixing ingredients

- Dissolve molasses in 100 liters of clean water to create a nutrient solution; Divide the nutrient solution into 5 equal parts;

TECHNICAL GUIDELINES FOR ORGANIC FERTILIZER PRODUCTION From cinnamon residue

- Mix well cinnamon ash + fish meal + microbial preparation; Divide the mixture into 4 equal parts;
- Divide the amount of lime and livestock waste into 4 equal parts;
- Move materials to incubation location. Spread a layer of cinnamon residue with a thickness of 20-25 cm, sprinkle evenly in the order of 1 part lime, 1 part livestock waste (if any) and 1 part cinnamon ash + fish meal + microbial preparation; Use a hoe/shovel/scrapper to mix well; Use a reamer to water the nutrient solution evenly onto the surface of the ingredients. Continue doing as above until all the ingredients are used up. Add clean water (if necessary) (Figure 1).

Note:

- *The moisture of the material after mixing reaches 60-65%. Check the moisture level as follows: Pick up a handful of ingredients and hold it firmly in your hand. If there is no water seeping out between your fingers, the ingredients are too dry and need to add more water. If the water seeps out between your fingers and drips, the ingredients are too wet, you must mix in more dry ingredients to dry them out. If the water seeps evenly through your fingers, the material has reached 60-65% moisture (Figure 2);*



Figure 1. Mixing



Figure 2. Checking material moisture

- 4/5 of the nutrient solution is used in the ingredient mixing step, the remaining 1/5 of the nutrient solution will be used in the mixing and incubation step.

2.3.2. Mixing and composting

- Pile up the ingredients (Figure 4). The height of the compost pile is about 1.0-1.2 m high, about 1.5-2.0 m wide and of appropriate length (Figure 3).

- After creating a compost pile, use the remaining nutrient solution to water evenly on the surface of the compost pile.

- Use tarpaulin or plastic to cover the surface of the compost pile (Figure 5); Cover with a layer of leaves on top to protect from the sun (if any).

Note: Do not compress the compost pile tightly

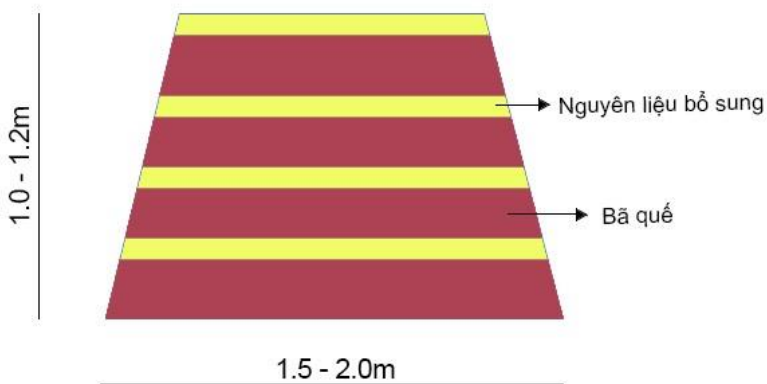


Figure 3. Cross sectional dimensions of compost pile



Figure 4. Pile up



Figure 5. Covering the compost pile

2.3.3. Turning

- 7-10 days after composting (when the compost pile temperature is $> 55^{\circ}\text{C}$), stir the first time; Periodically mix 15 days after the previous mixing to create the best conditions for microbial activity; provides oxygen, while also preventing the compost pile from overheating. After 2 months of composting, mixing can be done 30 days after the previous turning if the compost pile temperature is $< 50^{\circ}\text{C}$; Check the temperature and moisture of the compost pile, add water if the compost pile is dry. Check microbial activity in the compost pile.

- How to check the temperature of the compost pile: Insert a thermometer into 5 positions on the compost pile; 1 point in the middle and 4 points in the 4 corners. Read results after 3-4 minutes (Figure 6)



Figure 6. Check compost pile's temperature

- Check microbial activity: There are signs of microbial activity when a white, uniform, short-fiber layer is seen on the surface of the material. The temperature of the compost pile is at least 20°C higher than the ambient temperature, which also demonstrates microbial activity (Figure 7).



Figure 7. Signs of microbial activity

- How to turn the compost pile (Figure 8):

+ Clear a small area next to one side of the compost pile, about 40-50 cm from the edge of the compost pile;

+ Use a rake / hoe / shovel to transfer all the materials located on the outer layer of the compost pile into the cleaned soil next to the compost pile;

+ Scoop and stir the compost pile's ingredients onto the newly gathered outer ingredients so that the outer layer of the old compost pile becomes the center of the newly mixed compost pile;

+ After mixing, use tarpaulin, plastic, and palm leaves to cover the compost pile and use trees or bricks to press down on the edges of the tarp and plastic;

- Incubation time: 4-5 months.

Note: Use an excavator or mixer (if available) to mix organic and supplementary materials or turn the compost pile.



Figure 8. Mixing

2.3.4. Maturity incubating

- After finishing the incubation process, remove the tarpaulin / plastic, mixed, pile up and stacked for 1-2 weeks with the purpose of stabilizing quality before being used.

- Check the maturity of the compost pile in terms of color and temperature stability:

- + Ingredients are dark brown; uniform in color;
- + Temperature equal to or 5°C higher than ambient temperature.

2.3.5. Quality requirements and product testing methods

Quality’s criterias and limiting factors of organic fertilizers are specified in QCVN 01-189:2019/BNNPTNT.

Status	Criteria	Test method	Unit	Required quality level
first	Organic matter content	TCVN 9294:2012	%	≥ 20
2	Moisture	TCVN 9297:2012	%	≤ 30

TECHNICAL GUIDELINES FOR ORGANIC FERTILIZER PRODUCTION
From cinnamon residue

Status	Criteria	Test method	Unit	Required quality level
3	pH	TCVN 5979:2007	-	≥ 5
4	Arsenic (As)	TCVN 11403:2016	mg/kg	≤ 10
5	Lead (Pb)	TCVN 9290:2018	mg/kg	≤ 200
6	Mercury (Hg)	TCVN 10676:2015	mg/kg	≤ 2
7	Cadmium (Cd)	TCVN 9291:2018	mg/kg	≤ 5
8	<i>Salmonella</i>	Ref. TCVN 10780-1:2017	CFU/25g	Not detected (negative)
9	<i>E. coli</i>	Ref. TCVN 6846:2007	MPN/g	$\leq 1.1 \times 10^3$

2.3.6. Packaging and preservation

- Products after incubating are crushed, sieved (if necessary; used for commercialization) to ensure uniformity; packaged in bags; stored in cool places, avoid direct contact with sunlight;
- Storage period is 12 months.

III. GUIDELINES FOR ENVIRONMENTAL PROTECTION

- To ensure surrounding environmental conditions, the selected composting location must be at least 500 m away from domestic water sources and concentrated residential areas.

- Wastewater treatment: Organic fertilizer production facilities must arrange a wastewater collection system which re-irrigates compost piles to ensure fertilizer's quality and environmental protection. In case of discharging waste into the environment, wastewater from production which belongs to industrial

wastewater and must be treated according to QCVN 40:2011/BTNMT.

- Treating bad odors that arise:

- + Arrange the factory well to ensure good air circulation.

- + For large scale concentrated production facilities, it is necessary to build a system to collect, treat and release exhaust gases to ensure that emissions from organic fertilizer production facilities must meet QCVN 21:2009/BTNMT.

IV. INSTRUCTIONS

- Use as a source of decomposed manure to put down basic fertilizer or apply additional fertilizer:

- + Use for nursery: Dosage: 4% organic fertilizer per pot. Mix organic fertilizer well with potting mix before planting in pots (including 95% soil + 4% organic fertilizer + 1% NPK mineral fertilizer).

- + Put down basic fertilizer: Dosage: 0.5-0.7 kg of organic fertilizer per tree. After digging the hole, mix the organic fertilizer with 1/3 the soil in the bottom of the planting hole, then fill the hole with soil (must be done 10 to 15 days before planting).

- + Apply additional fertilizer: Dosage: 0.7-1.0 kg of organic fertilizer per tree. Apply 0.3-0.4 m away from the root; Apply once a year for the first 3 years.

- Or use as a source of organic substrates in the production of mineral organic fertilizers, microbial organic fertilizers, etc.

References

1. Law No. 31/2018/QH14 dated November 19, 2018. Law on farming.
2. Decree No. 84/2019/ND-CP dated November 14, 2019. Regulations on fertilizer management.
3. Ministry of Agriculture and Rural Development. Decision No. 14/QD-BNN-TCLN dated January 5, 2022 of the Minister of Agriculture and Rural Development. Issue technical instructions for nursery, planting, care, nurturing, exploitation, preliminary processing and preservation of Cinnamon products (*Cinnamomum cassia* BL).
4. QCVN 01-189:2019/BNNPTNT. National technical standards on fertilizer quality.
5. TCVN 7185:2002: National Standard for Microbial Organic Fertilizers.
6. TCVN 6168: 2002: National Standard on Cellulolytic Microbial Preparations.
7. Robert Rynk. 1992. On-farm composting handbook, NRAES-54, New York.
8. Mirsa RV, Roy RN, Hiraoka H. 2003. On-farm composting method, Food and Agriculture Organization of the United Nations, Rome.

Annex. Several factors affect the quality of the composting process

1. Material size

The smaller the material size, the greater the contact surface with microorganisms and the faster the decomposing rate. Therefore, the raw materials should be crushed.

2. Size of compost pile

The size of the compost pile affects the amount of oxygen supplied to the pile. Limit the height of the compost pile to ensure the pile is always in well-ventilated conditions. Maintain adequate oxygen levels, avoid creating anaerobic conditions that slow down the composting process and reduce the compost's quality.

3. C:N and C:P ratio

Carbon (C), nitrogen (N), phosphorus (P), potassium (K) are essential nutritional elements for microorganisms in the compost pile to grow and develop, and the balance between these nutrients is also very important, especially the ratio of C:N and C:P in the raw materials. The best C:N ratio is from 25:1 to 30:1. If this ratio is higher than 40:1, it will limit the growth and development of microorganisms, causing the incubation process to be prolonged. If the C:N ratio is lower than 20:1, it will lead to the excess of N. The excess N can be evaporated into the air in the form of ammonia or nitrogen oxide, and generate bad odors that pollute the surrounding environment. The appropriate C:P ratio in the digestion process is from 70:1 to 150:1.

4. Moisture

Too wet or too dry both negatively affect decomposition. When the moisture drops below 40%, microbial activities decrease. If the moisture is too high, it will make it difficult for oxygen (air)

to penetrate the compost pile, creating conditions for anaerobic microorganisms to become active, making the composting time longer and the quality of organic fertilizer products reduce. Suitable moisture is 60-65%.

5. Temperature

When the temperature increases, the incubation process goes well, all types of pathogens are also killed. However, if the temperature increases above 65°C, many beneficial microorganisms will also be killed. To reduce the temperature, just turn the compost pile over again. The optimal temperature for the compost pile is 50-65°C.

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