STUDIES ON COCOA PROCESSING INFLUENCE OF MOISTURE REDUCTION AND MIXING ON THE CHANGES IN FERMENTATION AND QUALITY OF THE DRY BEANS IN MONSOON SEASON

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Proper fermentation and drying is an essential prerequisite for obtaining processed beans of acceptable quality. The pH of the processed beans and extent of fermentation of beans are the two critical characteristics recognised as important in determining the bean quality and are dependent on the method of processing i.e., fermentation and drying and raw bean characteristics. Different methods of fermentation and drying are adopted in several cocoa growing countries (Rohan, 1963; Wood, 1973).

Several factors such as temperature, moisture content and duration of fermentation affects the bean quality. Additionally processed bean quality is also governed by the fresh bean characteristics and harvesting seasons. Several studies have been conducted to obtain beans of acceptable quality by modifying fermentation procedures (Newton, 1968; Wilboux, 1963; Aitken and Lass, 1975; Liau, 1976). It is clear from the previous studies that suitable fermentation and drying procedures have to be evolved depending on the raw beans characteristics and the seasonal variations at different locations. The present studies were conducted to monitor the seasonal variations in fresh bean characteristics and to evolve a suitable box fermentation and drying procedure for beans harvested during the wet season.

MATERIALS AND METHODS

The studies were conducted at the Centralised Cocoa fermentary of the Central Arecanut Marketing and Processing Cooperative Ltd. located at Puttur in Dakshina Kannada district of Karnataka state. The box type fermentation procedure is adopted in this fermentary with a capacity to handle 2 tonnes of beans per day. The method employed in the fermentary is to load 125 kg of depodded wet beans directly into the fermentation boxes of 60 × 60 × 45 cm size arranged in a cascade and the beans were fermented for a total period of 6 days with a daily mixing schedule for 5 days which is achieved by transferring the beans to the lower boxes in the cascade. At the end of the 6th day the beans are transferred to a "Samoan" type drier fuelled by fire wood.

As the fermentary receives cocoa pods from all the cocoa growing locations of Karnataka and several locations of Kasaragod district of Kerala, the samples obtained for the studies on raw bean characteristics and used for experiments with fermentation could be considered as representative of the major cocoa growing areas.

Bean characteristics

Beans reaching the fermentary during dry season from March to May and wet season from June to September were analysed in batches once in the fortnight for pH, titratable acidity, pulp content, moisture and bean weight following the analytical procedures suggested by Rohan (1963).

Experiment 1

In this study the main emphasis was to reduce the initial bean moisture by three methods: (1) Sweating of depodded beans in basket for 6 hrs; (2) Sweating of depodded beans in loose gunny sacks for 6 hrs; (3) Forced removal of moisture using a mechanical press; (4) Control beans loaded to fermentation boxes as such after depodding. Alteration of aeration, moisture and temperature during the fermentation by four different mixing schedules was attempted: (i) Turning of beans at 24 hrs interval (5 turnings in 6 day fermentation period); (ii) Turning of beans on 1st, 2nd, 3rd and 4th day (4 turnings in 6 days); (iii) Turning on 1st, 3rd, and 4th day (3 turnings in 6 days); (iv) Turning on 1st, 3rd and 5th day (3 turnings in 6 days).

Experiment 2

In this experiment rapid substrate reduction of freshly depodded beans prior to fermentation was studied. Freshly depodded beans were spread in basket, in layer of 7.5 cm deep for 18 hrs before loading fermentation boxes. Another treatment of pressing the beans with mechanical press to remove moisture after the substrate reduction for 18 hrs. The treatments were; (1) Substrate reduction for 18 hrs; (2) Substrate reduction followed by pressing and (3) Control-beans loaded immediately after depodding. Four mixing schedules as detailed in Experiment-1 were followed.

For each treatment combination duplicate fermentation boxes were established and in all the cases, fermentation was terminated on the 6th day. In treatments involving substrate reduction (Experiment 2), fermentation period including the period allowed for substrate reduction was 6 days. Bean samples were withdrawn from the fermentation boxes for analysis and drying.

During the course of fermentation the following data were collected.

Temperature: Temperature of fermenting bean mass was recorded every day (24 hrs interval) before turning.

pH of the pulp and cotyledon: Bean samples were drawn daily from each fermentation box to determine the pulp and cotyledon pH.

Quality of the processed beans: Beans obtained from the different treatments were processed by drying in an electrically heated cocoa bean drier for 8 hrs. at 50-55°C for the first two days and subsequently at 65°C. The beans were mixed at regular intervals to achieve uniform drying and the drying was terminated when the moisture content in beans reduced to 6-7 per cent. The processed beans (dry beans) were used for determining bean acidity (pH), extent of fermentation by the "cut test", 100 bean weight, moisture content and shell content as per the methods of Rohan (1963) and Bopaiah (1982).

RESULTS AND DISCUSSION

The characteristics of fresh cocoa beans during monsoon and summer is presented in Table 1. The pH of the cotyledon and pulp was not different. However, the pulp content, total soluble solids and bean weight varied considerably. Wet season beans had higher pulp content (47.31 per cent) with lesser total soluble solids (13.99).

Table 1—*Characteristic of fresh cocoa beans in monsoon and summer*

Season	pH		Mean pulp content (%)	Total soluble solids (T.S.S.)	Bean wt. (g)
	Coty.	Pulp			
Wet (Jun-Sep.)	6.70	3.87	47.31	13.99	0.86
Dry (Mar-May)	6.82	4.11	33.32	17.81	1.13

Experiment 1

Sweating of the beans in baskets or gunny sacks resulted in reduction of moisture to the extent by 6 per cent in 6 hrs. In basket 25 kg lots, while in gunny 50 kg beans were sweated. Mechanical press was used to reduce the moisture level by 15 per cent.

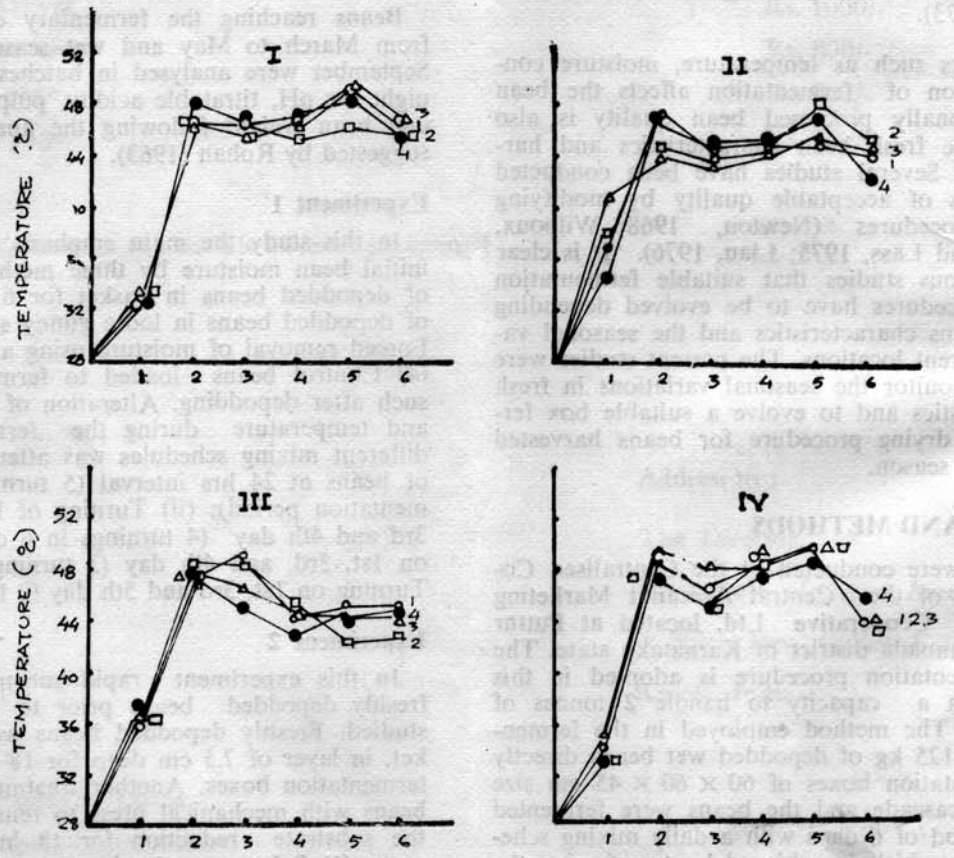

Figure I. Effect of moisture reduction and mixing schedules on the temperature profile during the fermentation of cocoa beans.

Moisture Reduction

1. Draining in baskets.
2. Draining in gunny sacks.
3. Mechanical pressing.
4. Control.

Mixing schedules

I. Daily mixing.
II. Mixing on 1st, 2nd, 3rd and 4th day.
III. Mixing on 1st, 3rd and 4th day.
IV. Mixing on 1st, 3rd and 5th day.

The temperature profile in different treatments during the fermentation is given in Fig. 1 above. The temperature was slightly higher during the initial stages of fermentation in the mechanically pressed beans. But from second day onwards the temperature levelled off. Temperature of 44-46°C was attained after 48 hrs. of fermentation. In general, both moisture reduction and mixing schedules did not indicate much difference in the temperature pattern during the fermentation.

The surface bean temperatures in the box was more than in the central core thereby indicating the prevalence of a temperature gradient within the box and the necessity for mixing to obtain an uniform temperature profile as possible during fermentation. Shepard (1976) also reported a similar observation during the fermentation of cocoa beans in Malaysia. In our studies it was recognised with all the treatments that the temperature of fermenting beans in the boxes increased initially from 30°C to 48°C.

Forstyth and Quensel (1957) observed the correlation between maximum temperature obtained and the extent of fermentation of cocoa beans. During the fermentation, a temperature increase of 44-48°C from the initial range of 30-32°C could be recorded which clearly indicated a high level of biological activity of the microorganisms present during the fermentation.

The pH of the cotyledon and pulp during the fermentation was monitored (Fig. 2). The cotyledon pH tends to reduce during the first two days of the fermentation and it attained the lowest level on the 3rd/4th day of fermentation. The pH increasing trend was recorded on the later period of fermentation (5th and 6th day). Decrease in acidity by mixing the beans during the last four days of fermentation (pH 5.2 to 6.2) in shallow boxes was reported by Anselni (1976) and Balasimha *et al.* (1982). The pulp pH showed an increasing trend during the fermentation period. However, moisture reduction did not affect pH.

The quality parameters of the processed beans (dry beans) were evaluated (Table 2). The moisture reduction treatments slightly improved the quality with res-

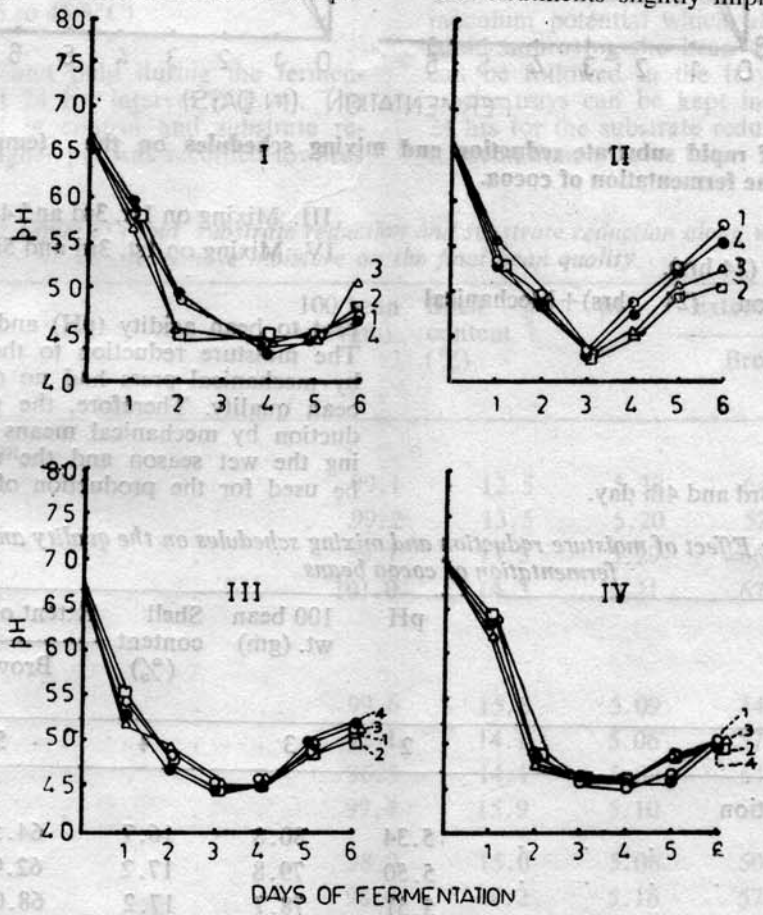

Figure 2 Effect of moisture reduction and mixing schedules on Cotyledon pH during fermentation of cocoa beans.
Treatment details : As in Figure 1.

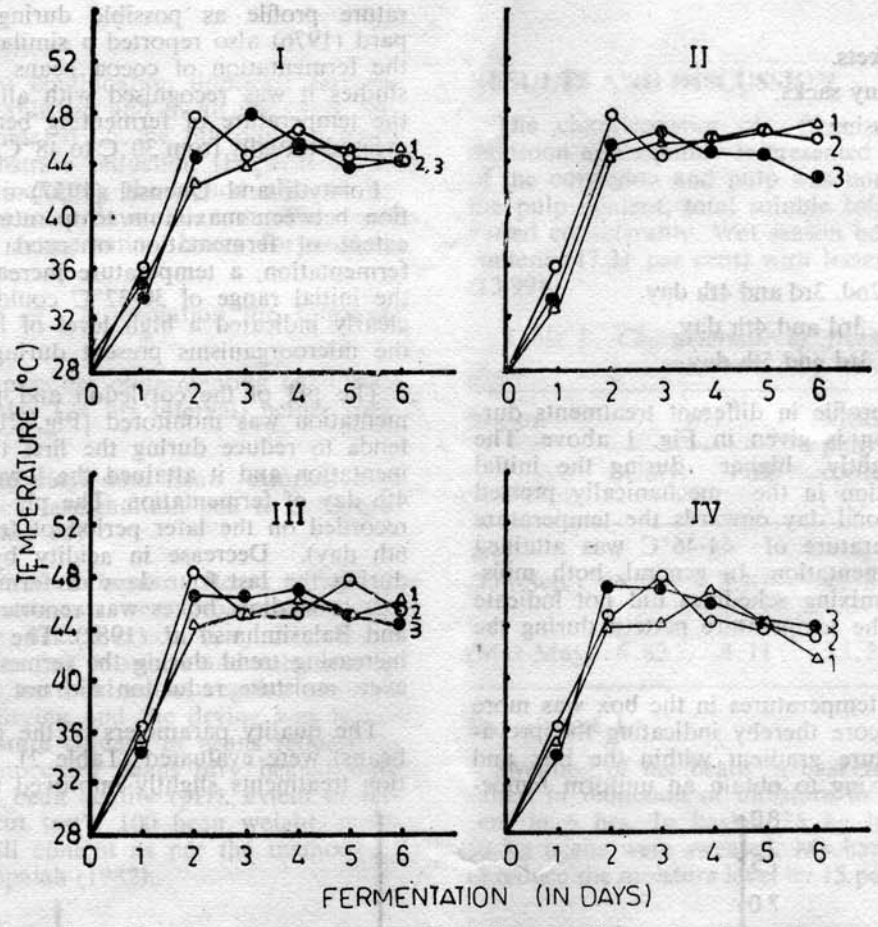

Figure 3. Effect of rapid substrate reduction and mixing schedules on the temperature profile during the fermentation of cocoa.

Treatments

1. Substrate reduction (24 hrs).
2. Substrate reduction (24 hrs)+Mechanical Pressing.
3. Control.

Mixing schedules

I. Daily mixing.
II. Mixing on 1st, 2nd, 3rd and 4th day.
III. Mixing on 1st, 3rd and 4th day.
IV. Mixing on 1st, 3rd and 5th day.

pect to bean acidity (pH) and extent of fermentation. The moisture reduction to the extent of 15 per cent by mechanical press had no deletarious affect on the bean quality. Therefore, the practice of moisture reduction by mechanical means could be followed during the wet season and the resultant sweating could be used for the production of alcohol or acetic acid.

Table 2 : Effect of moisture reduction and mixing schedules on the quality and extent of fermentation of cocoa beans

	pH	100 bean wt. (gm)	Shell content (%)	Extent of fermentation (per cent)		
				Brown	Brown/ purple	Purple
1	2	3	4	5	6	7
Method of moisture reduction						
1. Basket	5.34	80.8	16.7	64.5	26.5	11.0
2. Gunny sack	5.50	79.8	17.2	62.0	27.0	11.0
3. Mechanical press	5.51	78.7	17.2	68.0	20.5	11.0
4. Control	5.23	81.0	17.6	60.0	23.5	16.5

Table 2—(Contd.)

1	2	3	4	5	6	7
Mixing schedule*						
I	5.38	83.8	17.7	68.5	18.5	13.0
II	5.79	77.7	18.4	72.5	19.0	8.5
III	5.32	83.1	16.8	64.5	28.0	9.5
IV	5.56	83.7	16.8	53.5	32.0	19.5
CD (P=0.05)	0.16			3.2		
Grand Mean	5.44	80.9	17.3	64.7	24.4	11.4

*I = Daily mixing (5 times in six days)
II = Mixing on 1st, 2nd, 3rd and 4th day (4 times in 6 days)
III = Mixing on 1st, 3rd and 4th day (3 times in 6 days)
IV = Mixing on 1st, 3rd and 5th day (3 times in 6 days)

Experiment 2

In this study the beans were subjected to rapid substrate reduction prior to fermentation. The temperature pattern showed variation between the substrate reduction and control irrespective of mixing schedules (Fig. 3). But the temperature levelled off on the second day of fermentation (43.5 to 45.5°C).

pH of the cotyledon and pulp during the fermentation was monitored at 24 hrs interval (Fig. 4). The cotyledon pH decreased in control and substrate reduction alone and the higher pH was recorded towards the termination of fermentation (6th day). Analysis, for the quality of processed beans revealed that the substrate reduction alone has resulted in the improvement with regard to the bean acidity (pH) and extent of fermentation (Table 3). Allowing the beans in shallow layers might encourage the flow of sweat (reduction of substrate) and also increase the natural inoculum potential which ultimately might have helped in improving the bean quality. Substrate reduction can be followed in the tray method of fermentation, as the trays can be kept individually for a period of 24 hrs for the substrate reduction before stacking it for fermentation.

Table 3 : *Effect of rapid substrate reduction and substrate reduction along with pressing to remove moisture on the final bean quality*

	100 bean wt. (gm)	Shell content (%)	pH	Extent of fermentation (%)		
				Brown	Brown/ purple	Purple
A. Substrate reduction						
I	99.1	12.5	5.38	64.0	32.0	4.0
II	99.2	13.5	5.20	52.9	34.9	12.1
III	99.1	13.3	5.29	66.0	22.0	12.0
V	101.0	14.3	5.21	67.8	23.6	8.5
B. Substrate reduction* Mechanial Pressing						
I	99.6	15.5	5.09	54.4	29.7	14.5
II	95.1	14.1	5.06	57.8	26.9	15.2
III	96.5	14.1	5.09	54.7	28.6	13.7
IV	99.4	15.9	5.10	51.2	29.4	19.5
C. Control	98.9	15.0	5.06	50.0	32.0	18.0
Grand mean	98.6	14.2	5.16	57.9	28.8	13.0

*I, II, III, IV are mixing schedules as in Table 2.
Control = Mixing on 2nd and 4th day of fermentation.

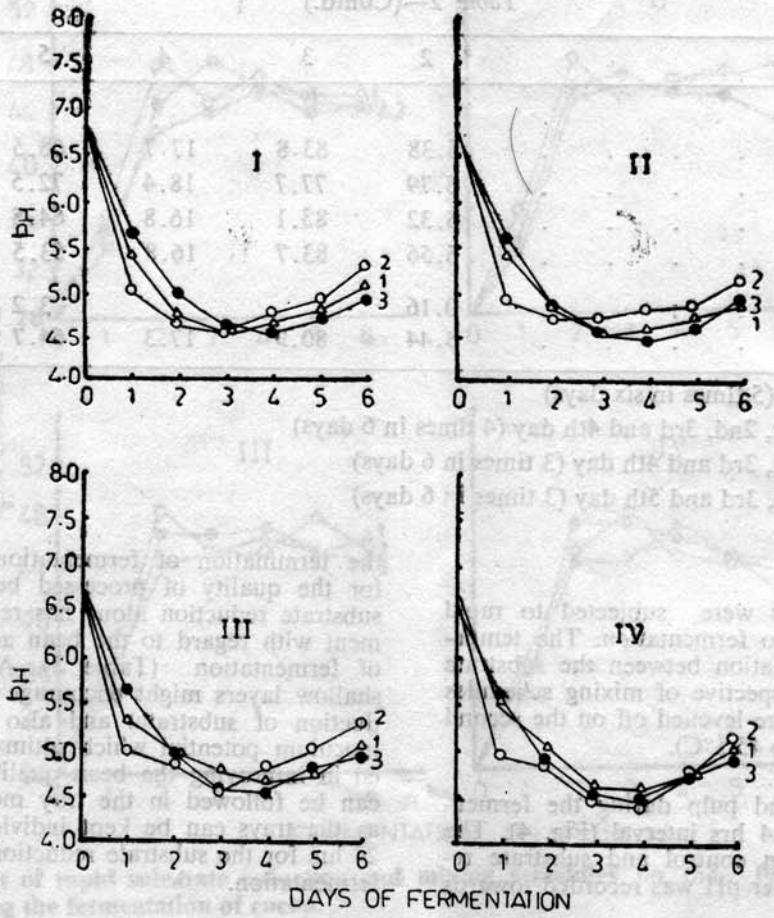

Figure 4. Effect of substrate reduction and mixing schedules on cotyledon pH during the fermentation of cocoa.

Treatment details : As in Fig. 3.

In conclusion the substrate reduction method could be followed with any mixing schedule to overcome the bean acidity problem for the wet season crop.

SUMMARY

Fresh cocoa beans were analysed for pH (cotyledon and pulp), pulp content, total soluble solids (T.S.S.) and bean weight in wet and dry season. Initial moisture reduction of cocoa beans was attempted in basket, gunny sacks and mechanical pressing prior to the fermentation. Four mixing schedules were followed during the fermentation to mitigate the aeration, moisture and temperature of the bean mass. Changes in temperature and cotyledon and pulp pH were monitored during the fermentation. Moisture reduction improved the bean acidity (pH). The experiment with substrate reduction prior to the fermentation of beans with four mixing schedules has improved quality of the dry beans. All the mixing schedules have similar effect on the bean acidity and extent of fermentation.

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Maize as a profitable intercrop in turmeric fields

Turmeric (*Curcuma longa*) is a long duration (nine months) crop with slow germination and growth. As a result, short duration varieties like maize, chillies and bhendi are grown as intercrops. In northern Telangana of Andhra Pradesh, maize is cultivated as an intercrop in turmeric, thus granting extra income to farmers before the harvest of turmeric.

Turmeric is also free from leaf spot (*Colletotrichum sp*) in the initial four month period, when maize is grown as an intercrop. In northern Telangana, intercropping is practised in red chelka/dubba soils supported by well irrigation. The popular turmeric varieties are Duggirala, Armoor, Mydukur (long duration) and those of maize are Pioneer, Ganga 5 and Deccan hybrid. Both crops are sown during the onset of the monsoons, that is between second and last week of June.

Turmeric finger rhizomes are dibbled in furrows at a spacing of 30 × 15 cm and maize at 60 cm within the same row. Studies at RARS, Jagital, showed that sowing maize between every second and third row of turmeric gave the maximum returns. This planting pattern assures complete maintenance of both crops with least competition.

The recommended fertilizer dose is 250 kg nitrogen, 100 kg phosphorus and 150 kg potash per hectare besides a minimum 25 tonnes of FYM compost and tank silt. Hundred per cent phosphorus, 66 per cent potash and 25 per cent nitrogen should be applied as basal dressing. Another two split dose of 25 per cent nitrogen must be given at 35 and 70 days. The remaining 25 per cent nitrogen and 34 per cent potash should be applied to the turmeric crop immediately after harvest of maize.

Generally maize and turmeric are harvested 110 and 250 days after planting. The yield of maize is 35 to 40 quintals/ha. The fresh rhizome yield of turmeric ranges from 250 to 300 quintals. Experiments conducted at Jagital showed that an additional net income of Rs. 5,000 per hectare could be had by growing maize as an itercrop in turmeric fields.

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