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The Effects of After-ripening, Heat and Nitric Acid on Seed Dormancy of Four Local Cultivars of Padi (*Oryza sativa* L.)

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ABSTRAK

Empat kultivar padi tempatan, iaitu MR 71, MR 73, MR 77 dan IR 42, mempunyai lebih daripada 80% bijibenih yang dorman sebaik sahaja selepas dituai. Proses selepas masak (after-ripening) terutama sekali di dalam bilik yang mempunyai penyaman udara adalah berkesan di dalam mengatasi kedormanan dan menambahkan percambahan masing-masing lebih daripada 80% dan 90% selepas lapan dan enam belas minggu. Perlakuan haba dan asid nitrik adalah kurang berkesan daripada proses selepas masak (after-ripening) kecuali untuk MR 71 di mana kedormanan adalah kurang. Percambahan adalah cuma 78%, 72% dan 69% diperolehi masing-masing untuk MR 77, MR 73 dan IR 42 dengan perlakuan haba atau asid nitrik yang paling baik. Pendedahan kepada 45°C untuk empat hari adalah yang paling baik. Kesan asid nitrik berbeza mengikut varieti. Untuk MR 71 dan MR 73, rendaman selama 6 – 12 jam dalam 0.3 M asid nitrik adalah optimum. Untuk MR 77 dan IR 42, rendaman dalam 0.5 M asid nitrik masing-masing selama 3 – 6 jam dan 12 jam adalah paling baik. Implikasi praktis kajian ini dibincangkan.

ABSTRACT

Four local cultivars of padi, namely MR 71, MR 73, MR 77 and IR 42, have more than 80% dormant seeds when freshly harvested. After-ripening, especially in the air-conditioned room was effective in overcoming their dormancy and increasing germination to more than 80% and 90% after eight and sixteen weeks respectively. Heat and nitric acid treatments were less effective than after-ripening. Except for MR 71 where dormancy was less severe, germination of only 78%, 72% and 69% was obtained for MR 77, MR 73 and IR 42 respectively with the best heat or nitric acid treatments. Exposure to 45°C for four days was best. The effect of nitric acid varies between varieties. For MR 71 and MR 73, soaking for 6 – 12 hours in 0.3 M nitric acid was optimal. For MR 77 and IR 42, soaking in 0.5 M nitric acid for 3 – 6 hours and 12 hours respectively was best. The practical implications of the study are discussed.

INTRODUCTION

One of the steps to counter labour shortage and stimulate mechanization in padi cultivation is encouragement of direct seeding either through broadcasting or drilling. The success of this practice rests on the ability to establish rapidly a uniform stand of young seedlings in the field. To achieve this, not only must environmental conditions be conducive, but the seeds sown must be capable of rapid and uniform germination. One factor which can prevent this is seed dormancy.

Although seed dormancy can cause erratic and low germination in the field, a degree of dormancy must, however, be maintained during breeding to prevent viviparous germination.

Various degrees of dormancy have been reported in the three subspecies of *Oryza sativa* L. (Nakamura, 1963; IRRI, 1968; Sukumara Dev, 1982). Of these, *indica* was the most dormant, followed by *javanica* and *japonica* (Ellis *et al.*, 1983). As these also contribute to the parentage of our locally selected varieties, various degrees of seed dormancy are encountered periodically in locally produced seeds. This problem is more common in freshly harvested seeds and if undetected can seriously reduce field establishment. The aim of the present study is to evaluate the degree of dormancy in the four local cultivars of padi and to evaluate the effectiveness of after-ripening, heat and nitric acid in overcoming it.

MATERIALS AND METHODS

Four local cultivars of padi, namely MR 71, MR 73, MR 77 & IR 42 were investigated. Random samples of freshly harvested seeds were obtained for each treatment using a soil sampler. Each treatment was replicated four times.

After-ripening during Storage

Freshly harvested seeds were stored in unsealed polythene bags in air-conditioned (22°C ± 1°C) and ambient (27°C ± 2°C) rooms for 0, 0.5, 1, 2 and 4 months. At each storage period, seed moisture and germination were evaluated according to the International Rules of Seed Testing (ISTA, 1976). The 130°C oven method was used for indexing moisture content while the roll towel method was used for germination. Germination was carried out under ambient conditions using 100 seeds per replicate.

Heat Exposure

The freshly harvested seeds were exposed in open trays to ambient, 40°C and 45°C for 0, 1, 2, 3 and 4 days. The seeds were spread out in a layer 2 – 3 cm thick, and periodically turned to ensure even exposure. Ventilated ovens were used for 40°C and 45°C exposure. After each treatment, seed moisture and germination were evaluated as before.

Nitric Acid Treatment

The fresh seeds were soaked in 0.1M, 0.3M and 0.5M nitric acid for 0, 3, 6, 12, 18 and 24 hours at ambient temperature. The seeds were periodically stirred to ensure uniform treatment. The soaked seeds were washed in running water for 30 minutes before they were germinated. For control, seeds were similarly soaked in distilled water.

RESULTS

After-ripening during Storage

Freshly harvested seeds of MR 71, MR 73, MR 77 and IR 42 were highly dormant and germination of less than 20% was obtained (Table 1). However, there was significant increase in germination during after-ripening in all four cultivars. For MR 71 and MR 73, after-ripening in the ambient or air-conditioned environment was equally effective in overcoming seed dormancy and high germination of 80% or more was observed by the eighth week. The exception was MR 73 seeds in the ambient room where a relatively low germination of 63% was obtained on the eighth week. However, by the 16th week, their germination was increased and was equivalent to that of the other treatments.

Seeds of MR 77 and IR 42 showed significant interaction between storage environment and duration of after-ripening ($p = 0.05$). In both cultivars, after-ripening in the air-conditioned room was more rapid and germination of more than 80% was observed by the eighth week. In contrast, only 53% – 58% germination was obtained in the ambient room for both varieties. A similar trend was observed on the 16th week.

The freshly harvested seeds have a relatively high moisture content of approximately 20% *(Fig. 1)*. After 16 weeks of storage, their moisture content was reduced to 14% – 16% in the ambient room and 11% – 13% in the air-conditioned room.

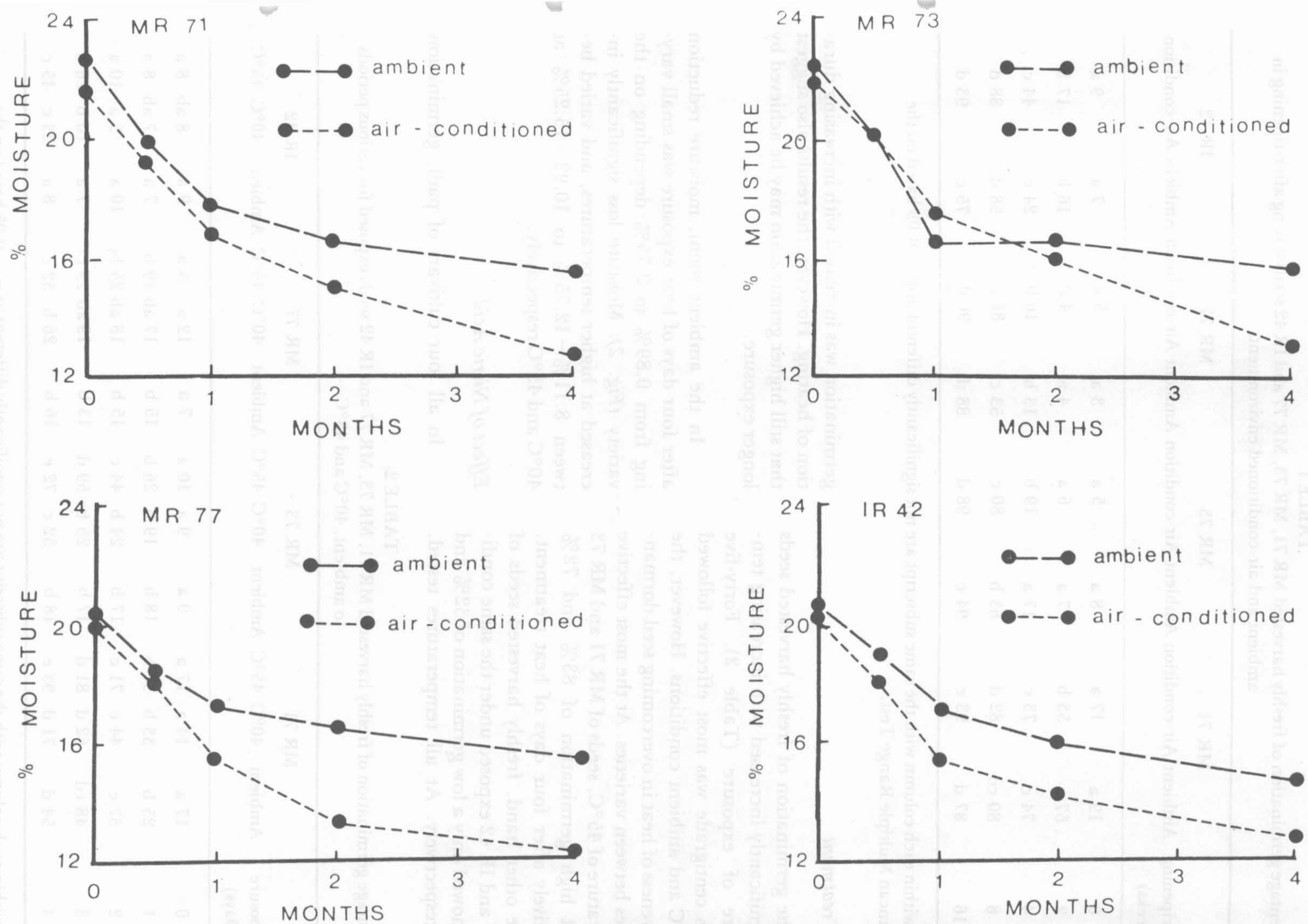

Fig. 1: Percentage moisture of MR 71, MR 73, MR 77 and IR 42 seeds during afterripening in the ambient and air-conditioned environments

TABLE 1

Percentage germination of freshly harvested MR 71, MR 73, MR 77 and IR 42 seeds during after-ripening in ambient and air-conditioned environments

	MR 71		MR 73		MR 77		IR 42	
After-ripening (weeks)	Ambient	Air-condition	Ambient	Air-condition	Ambient	Air-condition	Ambient	Air-condition
0	19 a	17 a	8 a	5 a	3 a	5 a	7 a	9 a
2	57 a	53 b	7 a	6 a	4 a	4 a	16 b	17 b
4	74 c	73 c	17 a	19 b	13 b	16 b	24 c	44 c
8	80 cd	82 d	63 b	80 c	53 c	81 c	58 d	88 d
16	87 d	93 e	94 c	98 d	88 d	96 d	75 e	93 d

Values within each column with the same subscript are not significantly different at p = 0.05 based on the New Duncan Multiple Range Test.

Heat Treatment

The germination of freshly harvested seeds was significantly increased with increasing temperature of exposure (Table 2). Forty-five degrees centigrade was most effective followed by 40°C and ambient conditions. However, the effectiveness of heat in overcoming seed dormancy varies between varieties. At the most effective temperature of 45°C, seeds of MR 71 and MR 73 showed high germination of 83% and 72% respectively after four days of heat treatment. On the other hand, freshly harvested seeds of MR 77 and IR 42 exposed under the same conditions showed only a low germination of 32% and 45% respectively. At all temperatures tested, germination was increased with increasing duration of heating. However, the results also suggest that still higher germination may be achieved by longer exposure.

In the ambient room, moisture reduction after four days of heat exposure was small varying from 0.89% to 2.75% depending on the variety *(Fig. 2)*. Moisture loss significantly increased at higher temperatures, and varied between 8.11% – 12.75% to 10.92 – 15.25% at 40°C and 45°C respectively.

Effect of Nitric Acid

In all four cultivars of padi, germination

TABLE 2

Percentage germination of freshly harvested MR 71, MR 73, MR 77 and IR 42 seeds exposed for various periods to ambient, 40°C and 45°C

	MR 71			MR 73			MR 77			IR 42		
Exposure (Days)	Ambient	40°C	45°C	Ambient	40°C	45°C	Ambient	40°C	45°C	Ambient	40°C	45°C
0	17 a	14 a	17 a	9 a	9 a	10 a	7 a	12 a	5 a	9 a	8 ab	8 a
1	25 b	33 b	37 b	18 b	19 b	26 b	15 b	17 ab	19 b	7 a	7 ab	8 a
2	37 c	44 c	71 c	17 b	24 b	44 c	15 b	18 ab	25 bc	10 a	5 a	10 a
3	48 cd	62 d	81 d	17 b	25 bc	59 d	13 b	19 ab	29 c	7 a	10 b	26 b
4	54 d	71 d	93 e	18 b	32 c	72 e	16 b	26 b	32 c	8 a	23 c	45 c

Values within each column with the same subscript are not significantly different at p = 0.05 based on the New Duncan Multiple Range Test.

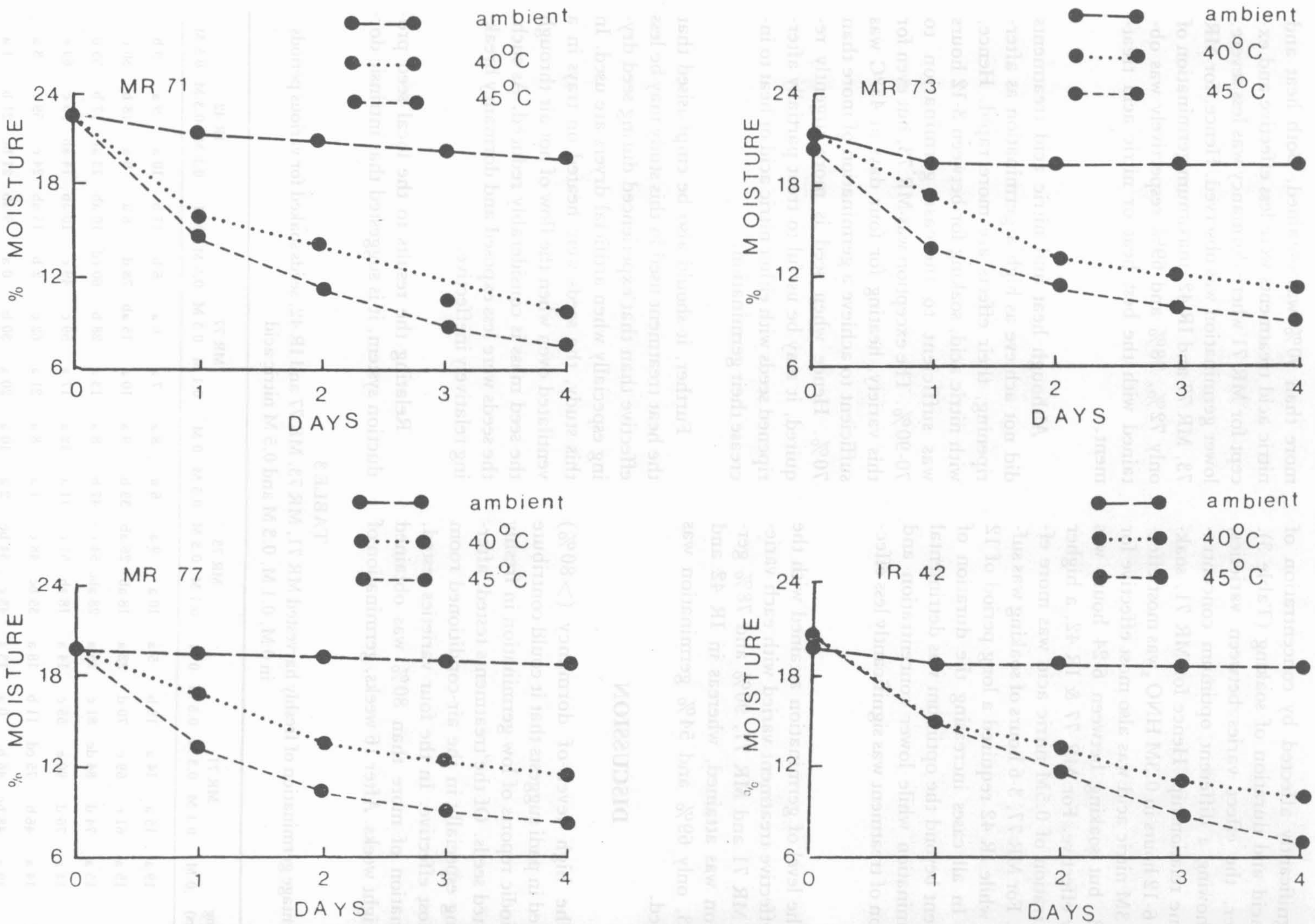

Fig. 2: Percentage moisture of MR 71, MR 73, MR 77 and IR 42 seeds during heat treatment at ambient, 40°C and 45°C temperatures

was significantly affected by concentration of nitric acid and duration of soaking (Table 3). However, the effect varies between varieties, each showing a different optimum concentration-time relationship. Hence for MR 71, soaking for 6-12 hours in 0.3M HNO_3 was most effective. 0.3M nitric acid was also most effective for MR 73, but soaking between 6-24 hours was equally effective. For MR 77 & IR 42, a higher concentration of 0.5M nitric acid was more effective. For MR 77, 3-6 hours of soaking was sufficient while IR 42 required a long period of 12 hours. In all cases increasing the duration of treatment beyond the optimum was detrimental to germination while lower concentration and duration of treatment was significantly less effective.

The level of germination attained with the most effective treatment varied with each variety. In MR 71 and MR 77, 90% and 78% germination was attained, whereas in IR 42 and MR 73, only 69% and 54% germination was observed.

DISCUSSION

The high level of dormancy (>80%) observed in padi suggests that it could contribute to periodic reports of low germination in freshly harvested seeds. Of the treatments tested, after-ripening especially in the air-conditioned room was most effective. In the four varieties tested, germination of more than 80% was obtained after eight weeks. After 16 weeks, germination of more than 90% was obtained. Both heat and nitric acid treatments were less effective and except for MR 71 where dormancy was less severe, lower germination was observed. Hence, for MR 73, MR 77 and IR 42, maximum germination of only 72%, 78% and 69% respectively was obtained with the best heat or nitric acid treatment.

Although heat and nitric acid treatments did not achieve as high a germination as after-ripening, their effects are more rapid. Hence, with nitric acid, soaking for between 3-12 hours was sufficient to increase germination to 70-90%. The exception was MR 73, but even for this variety, heating for four days at 45°C was sufficient to achieve a germination of more than 70%. Hence when seed is more urgently required, it may be useful to treat partially after-ripened seeds with either nitric acid or heat to increase their germination.

Further, it should also be emphasised that the heat treatment used in this study may be less effective than that experienced during seed drying especially when artificial dryers are used. In this study, the seeds were heated on trays in a ventilated oven when the flow of hot air through the seed mass is considerably reduced. As such, the seeds were less exposed and dormancy breaking relatively ineffective.

Relating the results to the local seed production system, it is suggested that intrinsic dor-

TABLE 3
Percentage germination of freshly harvested MR 71, MR 73, MR 77 and IR 42, seeds soaked for various periods in 0 M, 0.1 M, 0.3 M and 0.5 M nitric acid

Soaking	MR 71				MR 73				MR 77				IR 42			
(Hours)	0 M	0.1 M	0.3 M	0.5 M	0 M	0.1 M	0.3 M	0.5 M	0 M	0.1 M	0.3 M	0.5 M	0 M	0.1 M	0.3 M	0.5 M
0	19 a	15 a	14 a	13 b	5 a	10 a	9 a	6 a	8 a	7 a	6 a	6 b	17 b	10 a	9 a	9 b
3	15 a	61 c	69 c	70 d	22 a	18 ab	26 ab	39 b	9 a	10 a	15 ab	78 d	8 a	9 a	18 b	30 c
6	15 a	74 d	84 de	81 e	15 a	28 abc	54 c	47 b	8 a	13 a	28 b	60 cd	10 ab	13 ab	17 b	55 d
12	14 a	76 d	90 e	55 c	14 a	18 ab	51 c	11 a	12 a	17 a	59 c	49 c	10 ab	14 ab	53 c	69 e
18	14 a	46 b	75 cd	11 b	18 a	35 bc	48 c	1 a	8 a	21 a	62 c	2 b	13 ab	24 c	59 c	3 a
24	19 a	48 bc	46 b	0 a	13 a	43 c	34 bc	2 a	10 a	20 a	30 b	0 a	9 ab	21 bc	21 b	1 a

Values within each column with the same subscript are not significantly different at $p = 0.05$ based on the New Duncan Multiple Range Test.

mancy in a large proportion of freshly harvested seeds may be overcome during processing although no specific dormancy breaking treatment is incorporated on purpose. This is because seed drying basically involves a period of heat treatment, whether from solar or artificial sources. This exposure ensures that dormancy in a proportion of the freshly harvested seeds is overcome. Further, the processed seeds are generally stored for a period of approximately two to four months before resowing in the next season. This allows the remaining dormant seeds to after-ripen and decreases further the incidence of dormancy. However, in spite of this, occasional batches of padi cotaining a high proportion of dormant seeds are still encountered. This could be due to improper drying of relatively dormant varieties, coupled with exposure to a shorter after-ripening period when seeds are urgently required for field planting. It is recommended that when such seed lots are identified in presowing tests, the seeds should either be soaked overnight (up to 16 hours) in 0.3M nitric acid or heated for up to four days at 45°C to improve their emergence in the field.

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