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Effects of Salt Concentrations on the Functional Properties of Some Legume Flours

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Abstract: The effect of various salt concentrations on the functional properties of gourd seed, white melon, yellow melon and bulma cotton seed was investigated. The studies on the effect of salts commonly used in food industries such as NaCl, KCl, Na_2SO_4, K_2SO_4 and CH_3CO_2Na on the functional properties of the sample suggested that water absorptivity, emulsification, foamability and gelation were affected by the salts and that these effects were functions of the types of salt considered and their various concentrations. The data generated showed that salts may be used at appropriate concentrations to enhance or inhibit the functionalities of the flours.

Key words: Salt concentrations, legume flours, gourd seed, white melon, yellow melon, bulma cotton seed

Introduction

Plant sources of protein are the major ways of protein intake in many developing nations (Oshodi, 1992). Some of these nations are in dearth food supply especially that of protein. Legumes are increasingly used by thickly populated regions of the world to alleviate the impasse of low protein diet. However, some of the functionality of these legumes have not been well articulated and are termed underutilized. Some of these under utilized seeds such as gourd seed, white melon, yellow melon and bulma seed are reported in this present paper.

Gourd seed (*Legarania vulgaris*) is an annual herb with a climbing or trailing habit. The leaves are about 10-40cm wide. Sometimes with 3-7 lobes and hairy on the lower surface. It belongs to the family of cucubitaceae which is found predominantly in tropical Africa. The leaves are edible when cooked and seeds can either be roasted or used as soup condiment.

White melon (*Cucumeropsis edulis*) is an annual climbing vine with lobed flowers 13-20cm in diameter. The fruit is about 18cm in length with shinning and white flesh. The mature fruit may be ready for harvesting within 200 days from the planting period and normally 2-5 fruits weighing 0.8-1.5kg are produced per plant.

Yellow melon (*Colocynthis citrullus*) is a creeping annual crop which belongs to the gourd (*cucubitaceae*) family. It possesses hairy stems, triangular leaves and small yellow flowers. It is widely cultivated plant in Nigeria (Aoyenuga, 1978; Akobundu *et al*., 1982). It is very popular condiment in local soup when cooked and mixed with pepper, onions, palm oil, fish/meat and salt. It forms well known “egunsi soup” which can compliment carbohydrate foods.

Bulma cotton seed (*Cochlospermus reliogiosum*) is a native of tropical Asia and it is cultivated in several parts of West Africa especially Nigeria. The fruits are often hairy obriod capsule endocarp and the seeds are covered with long cotton hairs or silk. The long cotton hairs are closely or loosely attached to membranous outer testa. The seeds can serve as condiment, sources of foods and soup ingredient when toasted. Oshodi and Ekperigin (1989) reported that in order to successfully introduce a new supplementation into any food item, it is important to find out whether the supplementation possesses appropriate functional properties for food application and consumer acceptability.

The addition of salt may increase the total water content of the protein system at specific water activity value, although it may decrease the preferential binding of water to the protein. These effects are marked by dependent on anion and cation components (Sathe and Salunkhe, 1981; Altchul and Wilke, 1985; Oshodi and Ojokan, 1997; Ogungbenle *et al*., 2002).

The effect of salt is significant because, in many foods, salt concentrations are approximately 0.2-0.3M (Altchul and Wilke, 1985). This work will provide information on the selective use of salt for the enhancement of food properties.

Materials and Methods

The gourd seed, white melon, yellow melon where purchased from Erekesan market in Akure while bulma cotton seed was harvested from University of Ado Ekiti, Nigeria. The whole seeds were thoroughly washed in distilled water and air dried, then made into flours using blender. The flours were packaged in polythene bags and stored in freezer until used. The salts used for the study were: NaCl, KCl, Na_2SO_4, K_2SO_4 and CH_3CO_2Na. The concentrations of salt solutions used were: 0.5 1.0, 2.0, 5.0 and 10.0% w/v respectively. The procedure of Inklaar and Fortuin (1969) was used for the emulsion capacity and stability. Two grams of protein flour was made into a slurry in $40cm^3$ of water in a conical flask by

Table 1: Least gelation concentration of the samples in various salt concentrations

Samples	Salt/%	0.0	0.5	1.0	2.0	5.0	10.0
A		18	14	10	12	12	12
B		6	6	4	4	4	4
C	KCl	12	10	8	6	6	4
D		16	16	14	14	12	12
A		18	16	16	14	14	14
B		6	6	4	4	4	4
C	NaCl	12	10	10	8	8	6
D		16	16	16	14	12	12
A		18	14	14	14	12	12
B		6	6	6	6	4	4
C	K_2SO_4	12	10	10	10	8	6
D		16	14	14	12	12	12
A		18	14	14	14	12	12
B		6	6	6	4	4	4
C	Na_2SO_4	12	10	10	8	8	6
D		16	14	14	14	12	12
A		18	16	16	16	14	14
B		6	4	4	4	4	4
C	CH_3COONa	12	10	10	10	8	8
D		16	16	16	14	12	12

A = Gourd seed, B = White melon, C = Yellow melon, D = Bulma cotton seed

stirring at 1000 rpm for 15 min. After 10cm^3 of vegetable oil was added over a period of 5min with stirring at 1000 rpm, stirring was continued for some minutes. The system was transferred to a centrifuge tube, heated in a bath maintained at 85°C for 15min with occasional stirring and then cooled for 15min in a water-bath maintained at 25°C. The tube was finally centrifuge at 3000 rpm until the volume of oil separated from the emulsion was constant. Results were expressed as percentage of oil that separated from emulsion layer.

Foaming capacity and foaming stability were determined by method (Coffman and Garcia, 1977). 2% w/v salt solution was homogenized for 1 min in a food blender at maximum speed and the contents were immediately poured into a 100cm^3 graduated cylinder. Foaming stability was the foam volume increase immediately after mixing. Foaming stability was measured as the foam volume after 2h.

Water absorption capacity was determined by method (Beuchat, 1977). One gram of the flour was mixed with 10cm^3 of the salt solutions. The sample was allowed to stand at 25°C for 30min. centrifuged at 5500rpm for 30min and the volume of the supernatant noted in a 10cm^3 graduated cylinder. Density of water assumed to be 1.000g/cm^3. The volume of water absorbed was converted to gram.

The method of Sathe *et al*. (1982) was used for lowest gelation concentration with slight modification. Sample suspensions of 2-20% w/v were prepared in salt solution. From each suspension, 10cm^3 was put in a test tube and heated for 1h in a boiling water bath followed by a rapid cooling in a cold water bath. The test tubes were further cooled for 4°C for 2h. The lowest gelation was determined as that concentration which did not fall when the test tube was inverted.

The experimental procedures were slightly modified by exchanging distilled water with appropriate salt solutions.

Results and Discussion

Table 1 indicates the variation of least gelation concentration in the various concentration of salts. The least gelation concentrations for gourd seed, white melon, yellow melon, bulma cotton seed are 18.0, 16.0, 12.0 and 16.0% respectively. The addition of salts resulted in a general decrease in least gelation concentration which depended on the concentration and nature of salts under consideration and values obtained in the presence of salts ranged 12-16%, 14-16%, 6-10% and 12-16% for gourd seeds, white melon, yellow melon and bulma cotton seed respectively. It was observed that the addition of salts at relatively low concentration (0.5%) improved the gel forming properties of the samples studied and this effect was well pronounced with the use of KCl and Na_2SO_4. The results obtained in the presence of salts especially for bulma cotton seed are higher than those of benniseed reported (Oshodi and Ojokan, 1997) and bovine plasma protein concentration (2% to 4%) reported (Ogungbenle *et al*., 2002). At high concentration of salts (10.0%), the gelling capacities of the samples are improved better than at low salt concentrations. The ability of protein to form gels and provide a structural matrix for holding water, flavours, sugars and food ingredients is useful in food applications and in new products development. The values obtained for emulsion capacity and stability for the samples are presented in Table 2 and 3. These results showed that the samples have good emulsion capacity and stability depended on the salt concentrations and type of salts under consideration. There was steady and progressive

Table 2: Emulsion Capacity of the Samples in Various Salt Concentrations

Samples	Salt/%	0.0	0.5	1.0	2.0	5.0	10.0
A		18.5±0.02	17.1±0.2	17,6±0.1	17.8±0.4	18.3±0.1	16±0.5
B		175±0.3	95±0.3	94±0.4	92.5±0.1	91±1.0	90.5±0.2
C	KCl	61±0.9	59±0.2	56±0.3	57±0.1	56±0.4	55.5±0.1
D		29±0.4	26±0.2	25±0.3	25.8±0.6	26±0.5	24±0.3
A		18.5±0.01	17.8±0.4	17.5±0.1	17±0.3	16±0.2	15±0.1
B		175±1.0	94.1±0.9	93±0.2	92±0.1	91±0.7	90±0.3
C	NaCl	61±0.8	58±0.2	57±0.1	56±0.3	55±0.1	54±0.4
D		29±0.3	25±0.4	24.8±0.6	24.5±0.1	25±0.2	23±0.5
A		18.5±0.03	17.5±0.01	16±0.1	15.5±0.3	15±0.1	14±0.3
B		175±0.8	91±0.6	88±0.3	91±0.2	93±0.4	92.5±0.3
C	K_2SO_4	61±0.3	62±0.2	61.5±0.1	61±0.4	62±0.5	59±0.9
D		29±0.5	28±0.2	27.5±0.1	27.8±0.3	28±0.9	24.5±0.5
A		18.5±0.3	17±0.04	15±0.3	14±0.2	13.5±0.1	13±0.3
B		175±0.9	96.5±1.0	96.0±1.5	95±0.7	94±0.8	93±0.9
C	Na_2SO_4	61±0.2	62±0.2	61.5±0.1	61±0.4	62±0.5	59±0.9
D		29.0±0.6	24±0.3	23±1.0	23.5±0.3	24±0.1	19±0.4
A		18.5±0.1	17.9±0.3	17.8±0.2	17.5±0.4	17±0.1	16±0.2
B		175±2.0	97±1.0	96±0.8	95±0.6	94±0.5	93.5±0.4
C	CH_3COONa	61±0.6	58.5±0.3	58±0.1	57±0.2	56±0.6	55±0.5
D		29±0.4	27±0.1	27.2±0.3	27.5±0.7	25.5±0.3	24±0.4

Table 3: Emulsion Stability of the samples in various salt concentrations after 24hr

Samples	Salt/%	0.0	0.5	1.0	2.0	5.0	10.0
A		0	9.2±0.3	9.3±0.1	8.5±0.5	8.0±0.2	8.3±0.1
B		0	83 V 0.4	84.9±0.1	82.8±0.3	85±0.2	86±0.4
C	KCl	0	26±0.3	24. 5±0.6	25.6±0.1	25.6±0.3	24±0.5
D		0	12.5±0.4	11.6±0.1	13.5±0.3	14±0.1	13.3±0.4
A		0	9±0.01	9.5±0.03	8.0±0.04	7.5±0.05	7.9±0.02
B		0	82.5±0.1	84.8±0.3	82.5±0.4	87.1±0.2	85±0.1
C	NaCl	0	25±1.0	23.5±0.3	24±0.2	22±0.1	23±0.5
D		0	12±0.1	10±0.3	13±0.2	13.5±0.1	12.5±0.4
A		0	7.0±0.1	8.0±0.2	8.5±0.3	7.5±0.1	7.6±0.2
B		0	80.2±1.0	81.2±0.9	81.5±0.8	82.5±0.3	83±0.2
C	K_2SO_4	0	26±0.9	28±0.7	26±0.1	25±0.2	25.5±0.3
A		0	6±0.3	8±0.5	7±0.1	6.0±0.3	6.5±0.4
B		0	81.2±0.3	84.0±0.5	85.0±0.1	87.0±0.6	83.5±0.3
C	Na_2SO_4	0	27 V 0.3	28±0.5	30±0.3	25±0.1	23±0.4
D		0	13±0.4	12±0.2	14±0.4	12.5±0.3	11±0.5
A		0	8±0.02	9±0.01	8.5±0.03	8.0±0.02	8.2±0.03
B		0	82.7±0.3	84.9±0.2	85±0.1	85.9±0.4	84.0±0.4
C	CH_3COONa	0	24±0.5	26±0.4	23±0.3	22.5±0.1	23.5±0.6
D		0	15±0.6	14±0.4	16±0.3	17±0.1	13.5±0.5

A= Gourd Seed, B = White melon, C= Yellow melon, D= Bulma cotton seed

increase in emulsion capacity with salt concentrations up to 5.0% salt. There was a general decrease in emulsion capacity as the salt concentration was increased for other samples studied up to 10% salt solutions. Table 3 indicates the emulsion stability and it was measured by the volume of water separated after some time. Table 3 further shows that no water was separated after 24h in the absence of salts and there was also a steady increase in the quality of water separated in the presence of salts used. The degree of water separated varies from salt to salt. In the presence of CH_3COONa, Na_2SO_4 and NaCl, the value of water separated from the emulsion of the samples was almost consistent up to 5% of these salts while the presence of KCl and K_2SO_4 the amount of water separated increases progressively as the salt concentration increased. Three separate mechanisms that appear to be involved in the formation of a stable emulsion may be (i) reduction of interfacial tension, (ii) electrical charge and (iii) formation of a rigid interfacial film (Mcwatters and Cherry, 1981). The surfactancy of proteins is related to their ability to lower the interfacial tension between water and oil in the emulsion. The surface activity is a function of the ease with which protein can migrate to absorb at, unfold and rearrange at an interface and presumably salts reduce the surface activity of gourd, white melon and bulma cotton seed and thereby increase interfacial tension which leads to a decrease in emulsion capacity. Salts may also reduce charge repulsion between the proteins and enhance hydrophilic association at the interface (Kinsella, 1979).

Table 4: Foaming capacity of the samples in various salt concentrations at zero hour

Samples	Salt/%	0.0	0.5	1.0	2.0	5.0	10.0
A		18.7±0.05	19.2±0.1	21±0.3	19±0.5	23±0.4	24.5±0.2
B		6±0.02	4.3±0.01	6.1±0.03	8.3±0.2	9±0.04	12.5±0.1
C	KCl	24.7±0.2	26.5±0.5	26±0.1	28±0.8	29.8±0.1	30.5±0.3
D		14.7±0.2	19±0.1	19.5±0.5	21±0.3	23±0.1	24±0.3
A		18.7±1.0	19±0.3	20.5±0.2	18±0.1	22±0.3	23±0.4
B		6±0.01	4.2±0.03	6.0±0.06	8±0.01	8.5±0.03	13±0.0.4
C	NaCl	24.7±0.1	26±0.2	25±0.1	28±0.6	29.5±0.4	30±0.3
D		14.7±0.1	18±0.3	19±0.3	20±0.5	22±0.3	23±0.2
A		18.7±0.2	20±0.1	22±0.3	23±0.3	25±0.1	26±0.4
B		6±0.03	3.5±0..4	4±0.01	4.5±0.02	6±0.04	8±0.06
C	K_2SO_4	24.7±0.8	28±0.4	26±0.1	30±0.3	32±0.8	34±0.3
D		14.7±0.6	20±0.9	19±0.5	20±0.8	21±0.2	22±0.3
A		18.7±0.3	24±0.1	25±0.2	20±0.3	23±0.2	24±0.1
B		6±0.06	5±0.01	4±0.02	3.5±0.04	4.2±0.05	6±0.1
C	Na_2SO_4	24.7±0.6	28.5±0.5	.275±0.4	31±0.2	33±0.1	35±0.9
D		14.7±0.6	21±0.2	20.5±0.1	21.9±0.4	22±0.3	24±0.1
A		18.7±0.1	19.8±0.3	21.0±0.4	22±0.5	22.5±0.4	24.0±0.1
B		6±0.01	6.9±0.04	8.0±0.0.6	10±0.01	12±0.02	2.5±0.01
C	CH_3COONa	24.7±0.6	27±0.1	26.0±0.3	29±0.2	30±0.3	32±0.4
D		14.7±0.8	18.5±0.2	18.8±0.4	21±0.5	23±0.1	24±0.6

Table 5: Foaming stability of the samples in various salt concentrations at zero hour

Samples	Salt/%	0.0	0.5	1.0	2.0	5.0	10.0
A		9.0±0.2	10.5±0.1	15±0.1	16±0.3	20±0.5	22±0.1
B		5.5±0.02	5.6±0.3	6.5±0.03	7±0.1	7.2±0.6	8±0.4
C	KCl	12.5±0.1	13.8±0.5	13.9±0.4	14.1±0.1	14.8±0.1	15±0.2
D		7.0±1.0	8.5±0.8	9.0±0.1	9.5±0.3	11±0.4	12±0.5
A		9.0±0.1	10±0.7	14±0.4	15.5±0.2	19.5±0.5	20±0.8
B		5.5±0.9	5.8±0.3	6.0±0.4	6.5±0.3	7.0±0.4	7.8±0.6
C	NaCl	12.5±0.2	26±0.6	23.6±0.1	14±0.3	14.2±0.2	14.5±0.1
D		7.0±0.9	8.2±1.5	0.5±0.8	9.0±0.4	9.5±0.5	10.5±0.1
A		9.0±0.6	11±0.5	15±0.1	17±0.2	21±0.2	24±0.8
B		5.5±0.1	5.9±0..3	7.3±0.05	7.5±0.4	8±0.1	9.3±0.2
C	K_2SO_4	12.5±0.1	14.1±0.4	14.9±0.5	15±0.6	15.2±0.8	15.4±0.3
D		7.0±0.5	10.5±0.8	12±0.4	12.5±0.2	13±0.3	16±0.8
A		9.0±0.3	12±0.8	16.5±0.6	17±0.3	20±0.2	23.5±0.5
B		5.5±0.2	6.5±0.3	7.0±0.4	9±0.01	9.2±0.3	10±0.2
C	Na_2SO_4	12.5±0.6	14±0.2	14.5±1.0	14.9±0.6	15±0.9	15.8±0.6
D		7.0±0.8	10±0.5	11.5±0.8	12±0.4	12.8±0.3	15±0.1
A		9±0.9	13±0.2	16.5±0.1	18±0.9	22±0.3	25.0±0.9
B		5.5±0.01	6.0±0.3	7.5±0.2	10±0.4	10.3±0.1	11±0.5
C	CH_3COONa	12.5.±0.5	14±1.0	15.1±0.3	15.8±0.2	15.9±0.3	16.2±0.6
D		7.0±0.6	9.5±1.0	10±0.9	11.5±0.9	13±0.1	15±0.1

A = Gourd Seed, B = White melon, C = Yellow melon, D = Bulma cotton seed, Error as standard deviation

The observed decrease in emulsion stability (Table 3) may be due to increased contact leading to coalescence which thereby reduces stability (Parker, 1987).

The effect of salts on the foaming capacity is presented in Table 4. The foaming capacity depends on the type of salt under consideration. For most of the salts used, there was an increase in foaming capacity of the samples with increase in concentration of salts from 0.5% to 10%. This may be due to the fact that salts usually reduce surface viscosity and rigidity of protein films but increase spreading rate, thereby weakening interpeptide attractions and increasing foam volume for certain protein (Altchul and Wilke, 1985). In the case of bulma cotton seed, salts at appropriate concentrations aid foaming, presumably by aiding diffusion and spreading at the interface, but high levels of salts will depress foaming (Altchul and Wilke, 1985). The improved foaming capacity of these samples studied in the presence of salts may consequently improve their functionalities to be useful for the production of cakes (Johnson *et al*., 1979; Lee and Love, 1993) and whipped topping where foaming is an important property (Kinsella, 1979). Foaming stabilities after 24hrs are shown in Table 5 which, imply that all salts used at various concentrations had significantly improved the foaming stabilities of the samples studied.

The results for water absorption capacities of gourd seeds, white melon, yellow melon and bulma cotton seed in different salt solutions are presented in Table 6.

Table 6: Water Absorption capacity of the samples in various salt concentrations

Samples	Salt/%	0.0	0.5	1.0	2.0	5.0	10.0
A		100±0.3	65.0±0.3	48.6±0.1	45.0±0.2	35.0±0.1	27.5±0.3
B		200±0.8	160±0.5	140±0.1	130±0.7	126±1.0	120±0.2
C	KCl	117±1.2	80±0.6	70±0.3	65±0.1	33±0.5	30±0.1
D		175±1.8	90±0.1	78±0.3	75±0.4	62±0.2	50.6±0.1
A		100.0±0.9	60±0.1	45.5±0.2	40±0.4	30±0.1	25±0.3
B		200±0.9	155±0.1	135±0.3	125±0.9	122±0.1	109±0.6
C	NaCl	117±1.0	58±0.8	50±0.1	40±0.2	35.5±0.4	30±0.3
D		175±1.5	88±0.6	75±0.1	70±0.2	50±0.3	40.5±0.5
A		100±0.1	80.5±0.2	80±0.3	70±0.1	60.5±0.2	50±0.1
B		200±0.5	195±1.0	190±0.8	175±0.9	170±1.5	160±0.6
C	K_2SO_4	117±0.9	94±0.6	80±0.3	70±0.4	55±0.3	50±0.5
D		175±1.0	160±0.8	150±0.5	145±0.2	140±0.1	130±0.9
A		100±0.2	80±0.1	70.5±0.3	60±0.2	50±0.5	40.5±0.2
B		200±2.0	155±0.3	135±1.0	125±1.5	122±0.7	109±0.5
C	Na_2SO_4	117±1.3	95±0.1	85±0.2	75±0.1	60.5±0.7	60.0±0.6
D		175±1.3	150±0.6	149±0.8	140±1.5	130±1.0	120±0.8
A		100±0.8	59±0.7	40±0.1	30.5±0.3	30±0.2	25±0.1
B		200±1.0	150±0.3	140±0.4	135.5±0.3	129±0.1	120±0.5
C	CH_3COONa	117±1.5	58.5±0.6	54±0.3	40.5±0.1	35±0.2	30±0.4
D		175±0.9	87.5±0.6	73±0.8	65.5±0.5	45.5±0.6	40±0.1

A = Gourd Seed, B = White melon, C = Yellow melon, D = Bulma cotton seed, Error as standard deviation

The water absorption capacities in distilled water were found to be 100% for gourd seed, 200% for white melon, 117% for yellow melon and 175% for bulma cotton seed. These values are lower than that of protein concentrate of Adenous breviflorus benth flour (201%) reported (Oshodi, 1992). But this value is also lower than quinoa (147%) and pearl millet (115%) reported (Oshodi *et al*., 1999), sun flower protein concentrates (107% and 137%) reported (Lin, 1974) and some varieties of lima bean (*Phaseolus lunatus*) reported (Oshodi and Adeladun, 1993) (130. 1-142.2%). The present values reported for white melon and bulma cotton seed were comparable and fall within the range of some seeds reported (Lin, 1974). This implies that high water absorption of these samples may make them more susceptible to heat denaturation (Kinsella, 1979). Table 6 further indicated a progressive decrease in water absorptivities with increase in salt concentration generally up to 10%. The decrease or increase in water capacity varies with type of salt. This may be due to the fact that the effect of salt vary with the cation and anion species involved (Kinsella, 1979). The observed trend at low salt concentrations may be due to masking of charges which may reduce electrostatic interaction and hydration but increase hydrophobic interaction. At high concentrations of salts, the macro molecules preferentially bind the ions, that is, the proportion of water to salt in the vicinity of macro molecules is greater than the ratio in bulk phase solvent (Kinsella, 1979). Salts bound to protein may depend on the ions and the ability of the ions to enhance hydration, when protein attracts such ions (electrostatic effect). The moderately high water absorptivity in the presence of Na_2SO_4 compared to other salts used may be due to the high hydration potential of Na_2SO_4 (Kinsella, 1979). At high salt concentration (10%), electrostatic effects are apparently of little importance with regards to the amount of water bound to protein because of competitions between the ions and proteins for water become predominant (22, Kinsella, 1979). Furthermore, at low concentrations of salts (ions), macro molecules preferentially bind the ions, that is more ions are associated with the macromolecule than in the case of bulk solution. Therefore, water absorptivity at relatively low salt concentrations obtained may be an advantage in the production of meat analogues where the capacity of the matrix to imbibe and hold water and to stimulate the juiciness and texture of the product is critical (Ogungbenle *et al*., 2002). However, it is pertinent to note that water binding capacity caused by addition of salt may cause the protein to imbibe disproportionate amount of water and dehydrate other components in the food system or vice versa for example, in bread baking the water binding capacity of added protein extender must be compensated to ensure proper hydration of flour protein (Kinsella, 1979).

Conclusion: It can be concluded that the functionality and potentiality of these flours can be improved/ inhibited by selective application of salts at appropriate concentrations.

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