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Imported Fire Ant Toxic Bait Studies: Evaluation of Carriers for Oil Baits[1]

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ABSTRACT

Wheat bran, puffed barley grits, corncob grits, corncob pith, okra and kenaf hurds, sawdust, vermiculite and various clay granules were evaluated as carriers for oil baits for the imported fire ant, *Solenopsis saevissima richteri* Forel. While satisfactory baits were made with several of the carriers, the corncob grits baits were the most practical and the easiest to formulate and distribute with conventional equipment. The most effective formulation tested consisted of corncob grits 85%, soybean oil 14.925%, and mirex, formerly called GC-1283, (dodecachlorooctahydro-1,3,4-metheno-2*H*-cyclobuta[*cd*]pentalene), or Kepone® (decachlorooctahydro-1,3,4-metheno-2*H*-cyclobuta[*cd*]pentalen-2-one) 0.075%. Field tests with this bait consistently gave more than 95% control at rates of 5 to 20 pounds per acre (1.7 to 6.8 gm. of insecticide per acre). Other tests showed that this bait did not lose its effectiveness when aged up to 48 days and that peanut oil, tallow, tallow oil, yellow grease, and grease oil compared favorably with soybean oil as the food attractant.

During the past 3 years several toxic baits have been developed for control of the imported fire ant, *Solenopsis saevissima richteri* Forel. Hays & Arant (1960) reported that a bait consisting of peanut butter and 0.125% of Kepone® (decachlorooctahydro-1,3,4-metheno-2*H*-cyclobuta[cd]pentalen-2-one) and packed in soda straws was 100% effective in eliminating natural infestations of imported fire ants. They also showed that a bait composed of tankage, fish meal, cooking oil, and Kepone (0.062%) gave 91.7% control. Bartlett & Lofgren (1961) found that baits formed of peanut oil, vermiculite granules impregnated with peanut oil or peanut meal saturated with peanut oil and the toxicant, Kepone, at concentrations varying from 0.1% to 1.0% were fairly effective in controlling imported fire ants. Lofgren et al. (1961) presented data showing that baits made of peanut meal plus peanut oil, peanut oil plus monoglycerides, peanut butter, flour plus soybean oil, cotton seed oil or peanut oil and whole wheat flour plus peanut oil, gave more than 90% control of imported fire ants when combined with the toxicant, Kepone (0.125% or 0.25%). They also reported on preliminary attempts to develop a dry granular bait by impregnating various porous manufactured breakfast cereals with oils. Data were presented on one field test in which a maximum control of 85% was obtained with one of the cereals impregnated with peanut oil containing 0.125% Kepone.

In our efforts to develop a bait for use as a treatment procedure in the Imported Fire Ant Eradication Program, it has been recognized that any truly practical bait must possess certain qualities aside from its effectiveness in killing imported fire ants. It must (1) be composed of readily obtainable low-cost materials, (2) be easily formulated, (3) be readily applied with conventional application equipment, (4) not be affected by normal amounts of rainfall immediately after application, (5) be capable of being applied as an overall treatment without hazard to man, domesticated animals, or fish and wildlife, and (6), not result in the accumulation of residues either in milk or meat of grass-foraging animals, or on vegetables from areas treated with it.

It was concluded that a granulated bait would most effectively satisfy the requirements listed above. This paper presents the results of an extensive series of tests which were conducted to evaluate carriers for fat or oil food attractants and to determine their effectiveness when combined with a good delayed action toxicant.

NONTOXIC BAIT STUDIES.—A series of tests was conducted with individual imported fire ant colonies to determine the acceptability of vegetable or animal fat or oil baits when impregnated on various porous, granular carriers. The method employed for the evaluations was the same as that described by Bartlett & Lofgren (1961). Essentially, it consisted of incorporating dye in the oil (0.25% Calco oil blue or red dye), offering the bait to an ant colony for 24 hours and then determining the percentage of 100 worker ants from the colony that contained dye. In preparing the bait formulations, the oils were poured over the granules as they were mixed in an electric food mixer. With the more porous carriers, it was necessary to heat the oils to 100° C. to 150° C. to obtain good penetration. It was in most instances possible, within the carrier's absorptive limits, to obtain dry flowable formu-

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lations. The various baits evaluated, the composition of each, and the results are recorded in table 1. In each test a soybean oil-white flour bait was used as the standard for comparison. In all of the studies, including those with toxic baits, a crude grade of the vegetable oils was used.

Puffed barley grits, aged pine sawdust, kenaf or okra hurds, and corncob pith formulations all gave results comparable to or better than the standard bait. Wheat bran and corncob grits were slightly less attractive; however, it is believed this was a result of a reduced amount of oil present in these formulations. The fresh pine sawdust formulation was definitely less attractive. The results with vermiculite were erratic and even at the highest oil concentration (75%) the feeding rate was reduced 25%. The feeding on the clay granular formulations varied from 10% to 47% as compared with 75% for the standard. All work with these carriers was discontinued when it was found that the oils would set up or harden on the granules within a few days to several weeks after formulation.

It was concluded from the tests and information on availability of the carriers that puffed barley grits, wheat bran, aged pine sawdust, and corncob grits were the only carriers worthy of extensive field tests for controlling imported fire ants.

TOXIC BAIT STUDIES.—In previous years considerable difficulty was encountered in obtaining a good evaluation of a bait in field tests when 1-acre plots were used because of cross feeding by the ants from one treated plot into another, or because of early reinfestation by colonies from adjacent untreated land or from plots where poor control was obtained. To minimize these problems, the tests were conducted on larger plots, 6 to 8 acres each. Three 1-acre sampling subplots were set up within the large plots. The subplots were at least 50 feet from each other and from the border of the large plot. Only one large plot was treated with each formulation. All of the plots were located in pastures. The control obtained with each bait was determined by the per cent reduction in active imported fire ant mounds on the subplots at intervals of 2, 4, 8, 16, and in some tests 26 weeks after treatment of the plot. An ant mound was considered active as long as more than 20 worker ants could be found, or if a wingless queen was found with less than 20 workers. This was done to eliminate from the counts small numbers of worker ants which are often found in old mounds that have been abandoned. Mounds where only alate males or females remained were considered inactive.

At the 16- or 26-week counts, incipient colonies were occasionally found which indicated reinfestation from mating flights. Since these colonies were not present at the time of treatment, they were excluded from the total number of active colonies on the plot. This was done so that the results of the tests would reflect only the effect of the baits on the ant population present at time of treatment. Only those colonies with very small mounds and a predominance of minim workers were excluded.

Hand-operated Cyclone seeders, or power-take-off model Cyclone seeders mounted on jeeps, were employed for distributing the bait in the early tests. In the latter tests where the corncob grits carrier was used exclusively, the bait was distributed with a jeep-mounted Buffalo turbine blower. The standard slurry bait was applied with a specially designed applicator which pumped the bait out each end of a 10-foot boom and dropped it directly to the ground in strips 10 feet apart (C. E. Stringer, C. S. Lofgren, and F. J. Bartlett, unpublished data). With the exception of the bran baits, the granular formulations were distributed uniformly over the entire plot. The bran baits were applied in 4-foot strips at 20-foot intervals across the plot.

Table 1.—Results of tests to determine the acceptability by imported fire ants of baits consisting of vegetable or animal fats and oils impregnated in various carriers.[a]

Bait Components				Worker Ants Containing Dye After 24 Hours (%)
Oil and Concentration	(%)	Carrier and Concentration	(%)	
		Test I		
Peanut	25	Bran, wheat	75	47
Soybean	25	Bran, wheat		65
Cottonseed	25	Bran, wheat		58
Peanut	67	Puffed barley grits	33	73
Soybean	67	Puffed barley grits		81
Cottonseed	67	Puffed barley grits		71
Soybean	16	Corncob grits	84	50
Cottonseed	16	Corncob grits		54
Soybean	40	White flour	60	69
		Test II		
Soybean	35	Sawdust, pine, aged	65	55
	25	Sawdust, pine, fresh	75	20
	40	White flour	60	40
		Test III		
Soybean oil	75	Kenaf hurds[b]	25	49[c]
	83	Corncob pith	17	58
	67	Okra hurds[d]	33	60
	50	White flour	50	47
		Test IV		
Soybean	50	Vermiculite	50	2
	60	Vermiculite	40	30
	67	Vermiculite	33	13
	75	Vermiculite	25	29
	40	White flour	60	40[e]
		Test V		
Soybean	35	Pikes Peak 9J66	65	10
	28	Creek-O-Nite	72	22
	29	Attaclay AARVM	71	31
	30	Florex ARVM	70	46
	36	Pikes Peak 9KLVM	64	47
	40	White flour	60	75

[a] 100 grams of bait scattered around each mound except in Test III, in which the amount of bait per mound was adjusted so that 16-⅔ grams of oil were available per colony. Six replications were made unless otherwise indicated.

The mesh size range of the granular carriers was as follows: puffed barley grits, 6–16; corncob grits, 10–40; sawdust, minus 8; okra and kenaf hurds and corncob pith, 8–30; vermiculite and various clay granules, 20–40.

[b] The granulated stalk of this plant; kenaf is also called ambary, *Hibiscus cannabinus* L.

[c] Four replications.

[d] The granulated stalk of this plant.

[e] Five replications.

All of the baits were formulated by the same procedure described under the section on nontoxic bait studies except that a large commercial type electric food mixer was used for mixing the granules and the toxicants were dissolved in the oil prior to impregnation.

The amount of toxicant in the various baits was based on the weight of oil in the bait rather than total formulation weight. Otherwise the amount of toxicant in the edible oil portion of the baits tested would have varied more than 7-fold depending on the absorptiveness of the carrier. The worker ants ingest only the liquid portion of solid foods (Wheeler 1910) and the toxicant is soluble only in the oil.

The standard bait in the tests where different carriers were compared consisted of 40% soybean oil containing 0.25% of Kepone, and 60% white flour. The rates of application in the different tests are recorded in the tables with the results.

RESULTS.—In Experiment 1, an evaluation was made of the effectiveness of soybean oil-Kepone bait when

formulated on wheat bran, puffed barley grits, and corncob grits. The maximum amount of oil which could be tolerated on the wheat bran and corncob grits carrier was 15% without becoming too oily. Even at this low oil content, the bran, because of its flat particles, would not flow readily and needed constant agitation to maintain a flow through the hand seeders. The concentration of Kepone in each of the baits was maintained at 0.25% on the basis of the weight of oil in the formulation. The results of the test are presented in table 2. The puffed barley grits formulation gave control comparable to that of the standard bait (98% and 97%) after 16 weeks. The corncob grits and bran baits gave 58% and 60% control, respectively, after the same time interval; there was a 40% reduction in the check plots.

Observations at the time of bait application in the previous test had shown that the ants would quickly pick up and carry the bran and corncob grit baits to the colony. The poorer control obtained was attributed to the small amount of oil and toxicant available per particle of bait. In order to compensate for this it appeared that either the oil-toxicant content on the carrier had to be increased, or the concentration of toxicant in the oil. The first of these alternatives was investigated in Experiment 2. Formulations of bran were prepared containing 15%, 20%, and 25% by weight of soybean oil. The concentration of Kepone in the oil in each bait was 0.25%. The results are presented in table 2. Because of the extremely dense growth of grass on the plots, it was impossible to make accurate counts of mounds at 8 to 16 weeks so the final count was made after 26 weeks. The data show that the speed of kill with the bait was directly proportional to the amount of oil and toxicant in the bait; however, after 26 weeks the per cent reduction in active mounds was comparable for the three formulations.

On the basis of these results, it was decided to retest the carriers in Experiment 1 with modifications in the bran and corncob grits formulations to compensate for the small amount of oil or toxicant per particle of bait. Since no satisfactory method had been found at this time to increase the amount of oil on the corncob grits carrier, the Kepone concentration in the oil was increased to 0.5%.

Table 2.—Control of imported fire ants with various toxic bait formulations consisting of porous carriers impregnated with soybean oil containing the toxicants, Kepone or mirex.[a] 1961.

Bait Formulation			Toxicant Concentration (%) in Oil[b]	Formulation Application Rate (lb./acre)	Avg. Pretreatment Counts of Active Mounds per Subplot	Per Cent Reduction in Active Mounds After Weeks Shown			
Carrier and Concentration (%)	Soybean Oil Concentration (%)					2	4	8	16
Experiment I (April)									
Wheat bran,	85	15	Kepone, 0.25	20	59	3	16	22	58
Corncob grits,	85	15	Kepone, 0.25	20	72	24	40	40	60
Puffed barley grits,	33	67	Kepone, 0.25	6	53	13	54	78	98
White flour,	60	40	Kepone, 0.25	6	57	0	30	70	97
Check	—	—	—	—	56	0	7	4	40
Experiment II (May)									
Wheat bran,	85	15	Kepone, 0.25	20	42	18	27	—	93[c]
	80	20	Kepone, 0.25	20	61	31	43	—	86[c]
	75	25	Kepone, 0.25	20	65	75	88	—	93[c]
Check	—	—	—	—	35	17	25	—	33[c,d]
Experiment III (June)									
Wheat bran,	60	40[e]	Kepone, 0.25	20	16	100	100	100	100
Corncob grits,	85	15	Kepone, 0.5	20	22	100	99	100	100
Puffed barley grits,	33	67[e]	Kepone, 0.25	6	19	100	100	100	100
White flour,	50	50[e]	Kepone, 0.25	6	20	98	100	98	100
Check	—	—	—	—	40	12	39	9	0
Experiment IV (July)									
Corncob grits,	85	15	Mirex, 0.25	20	21	13	84	100	95
			Mirex, 0.5	20	19	100	100	96	100
White flour,	50	47[e]	Kepone, 0.25	6	50	92	98	94	90
Check	—	—	—	—	23	48	16	22	6
Experiment V (Aug.)									
Corncob grits,	85	15	Mirex, 0.5	10	23	96	97	90	91
	62[f]	27	Mirex, 0.5	10	25	100	100	97	97
Aged pine sawdust,	65	35	Mirex, 0.25	10	20	100	100	98	98
			Mirex, 0.5	10	30	98	97	97	98
White flour,	50	50[e]	Kepone, 0.25	6	34	67	93	92	85
Check	—	—	—	—	35	8	8	16	14

[a] Average results from three 1-acre subplots located within a 6- to 8-acre plot.
[b] The concentration (%) of toxicant in the total formulation can be determined by multiplying the per cent of soybean oil by the per cent of toxicant in the oil and dividing the product by 100.
[c] Count made after 26 weeks.
[d] Average results from two plots. Third plot was plowed and count could not be made.
[e] 6% to 10% monoglycerides added to congeal the soybean oil and stabilize the formulation.
[f] The oil-impregnated corncob grits were coated with gelatin, as described in the text, at a concentration of 11% by weight of total formulation.

After the previous experiment was started, it was found that the bran-oil baits could be made containing 40% soybean oil. This was done by adding 10% by weight of monoglycerides to the soybean oil. The combination hardened on the bran, resulting in a formulation comparable in oiliness to the 24% formulation without monoglycerides. The puffed barley grits formulation remained the same with the exception that 10% of monoglycerides was added to the oil to retard seeping of the oil from the grits when exposed to the hot sun during and after application to the plots. With the exception of the corncob grits formulation, the Kepone concentration in each bait was maintained at 0.25% of the weight of the oil. The data in table 2 show that all of the baits, including the standard as formulated in this experiment, gave complete control of the ants.

About the time the previous test was completed, another bait toxicant was found which was extremely effective against imported fire ants. The preliminary results with this toxicant, mirex[3] (dodecachlorooctahydro-1,3,4-metheno-2*H*-cyclobuta[cd]pentalene), were reported by Lofgren et al. (1962). It was decided to shift emphasis to this compound because mirex was: (1) less toxic to mammals than Kepone, (2) not repellent to ants at high concentrations in the bait, and (3) a little more toxic than Kepone, but with good delayed toxic action.

Experiment 4 was started to determine the effectiveness of mirex in the soybean oil-corncob grits bait. Concentrations of 0.25% and 0.5% in the oil were tested. The results (table 2) show that, as with Kepone in the previous experiment, complete control was obtained in 2 weeks at the 0.5% concentration. At the 0.25% toxicant level, complete control was attained also; however, the kill was very much delayed and the maximum reduction was not reached until after 8 weeks.

Experiment 5 was initiated to (1) evaluate sawdust as a carrier, (2) retest the corncob grits formulation which had worked so well in the previous experiments, and (3) determine the effectiveness of a corncob grits-soybean oil formulation where the oiliness which occurred at oil levels above 15% was overcome by coating the impregnated granules with gelatin. Two levels of mirex in soybean oil (0.25% and 0.5%) were tested with the sawdust carrier. The source of the sundried pine sawdust was an abandoned millsite near Gulfport, Miss. It was sieved through $\frac{1}{8}$-inch-mesh hardware cloth before formulation. The corncob grits-gelatin formulation was prepared by pouring a hot 10% gelatin-water solution over the oil impregnated grits as they were tumbled in the mixer. The amount of gelatin solution added was 12½% by weight of the corncob grits and oil. The concentration of mirex in the oil on both the corncob grits formulations was 0.5%.

After 16 weeks, the control obtained (table 2) with the sawdust formulations was 100% with the 0.25% mirex concentration and 97% with the 0.5%. The corncob grits formulation with the gelatin coating gave slightly better control than the formulation without gelatin (100% vs. 97% at 4 weeks).

In evaluating the four carriers tested on the basis of the criteria listed in the introduction, it was evident that the corncob grits formulations were the most satisfactory with regard to cost, formulation, ease of handling, and ease of application with various types of conventional application equipment. For this reason, this bait was selected for more extensive testing.

Table 3.—The effectiveness of a bait composed of corncob grits (85%) impregnated with soybean oil (14.925%) and mirex (0.075%) when applied at different rates per acre. September 1961.

Dosage (lbs./acre)	Grams of Mirex per Acre	Average Pretreatment Count of Active Ant Mounds	Per Cent Reduction in Active Ant Mounds After Weeks Shown			
			2	4	8	16
2.5	0.85	36	10	11	13	52
5.0	1.70	21	31	52	87	100
7.5	2.55	17	73	88	98	100
10.0	3.40	18	63	91	94	100
15.0	5.11	13	98	98	100	100
Check	—	29	0	1	2	5

Three experiments (6, 7, and 8) were conducted to: (1) determine the effectiveness of different rates of application, (2) determine the effect of short term aging of the bait on control, and (3) evaluate other cheap fats or oils as substitutes for soybean oil. In all three experiments, the percentage of fat or oil on the corncob grits was kept at 15% by weight of total formulation and the mirex concentration at 0.5% by weight of the oil, or 0.075% by weight of total formulation. At this concentration a 10-lb.-per-acre bait application rate is an actual insecticide application rate of 3.4 gms. per acre.

The results of Experiment 6 are presented in table 3. After 16 weeks complete control had been attained when the bait was applied at rates of 5 pounds per acre and higher. Fair control resulted from the 2½ pounds per acre rate (52%). The remaining active colonies on this plot had been affected. Only two of the colonies contained brood when they were examined in the spring of 1962 while the colonies in the check plots contained an abundance of brood. The ant infestation in the pasture selected for the test ranged from 13 to 36 mounds per acre. This number is about normal for southern Mississippi. It is possible that higher numbers of colonies per acre might have affected the degree of control at the 5 or 7½ pounds-per-acre rates. Other tests have definitely shown that 10 to 15 lbs./acre of bait is sufficient to control infestations of normal size colonies as high as 100 mounds per acre.

In Experiment 7, corncob grits-soybean oil-mirex formulations were aged for periods of 1, 15, 34, and 48 days. During the aging period (August 23 to October 10, 1961), the formulations were held in steel barrels in a quonset shed and exposed to the temperatures normal for that time of the year. The application rate on the plots was 12½ pounds per acre. The results are recorded in table 4. The aging of the bait did not affect the ultimate control obtained. Complete control was obtained with all except the 48-day old formulation, which gave a 98% reduction of colonies; the remaining colonies on the plot treated with this formulation were all located in one corner of a subplot. It will be noted that the pretreatment count of ant mounds on this plot was extremely high (260

[3] Mirex is the common name assigned to this compound. It was formerly referred to by the Allied Chemical Corporation, General Chemical Division Code No. GC-1283.

Table 4.—The effect of aging corncob grits-soybean oil bait containing 0.075% mirex on its control of imported fire ants. October 1961.

Days of Aging	Average Number of Active Mounds Before Treatment	Per Cent Reduction of Active Ant Mounds After Weeks Shown			
		2	4	8	16
48	260	0	46	84	98
34	50	43	54	93	100
15	41	26	56	93	100
1	57	29	48	82	100
Check	34	9	26	14	6

per acre). This was an incipient infestation with most of the mounds being only 3 to 4 inches in diameter. For this reason, it was impossible to determine if the remaining mounds on the plot were part of the original infestation or a reinfestation. The infestations in the other plots which were in the same field were comprised almost entirely of mature colonies with normal mounds about 12 to 18 inches in diameter. The results obtained indicate that under the conditions of this test the soybean oil did not become rancid, since rancid oil is much less attractive to the ants.

Experiment 8 was initiated to compare peanut oil, tallow, tallow oil, yellow grease, and grease oil with soybean oil as food attractants when impregnated on corncob grits. The formulations were applied at the rate of 10 pounds per acre. The results are listed in table 5. After 16 weeks, all of the baits had given 100% control except the formulation with yellow grease, which gave 97% control.

Discussion.—Very effective imported fire ant toxic baits can be compounded by impregnating wheat bran, puffed barley grits, corncob grits, or sawdust, with animal or vegetable fats or oils containing mirex, or Kepone. Of the four carriers, the corncob grits best fit the essential requirements needed for a practical bait in the Imported Fire Ant Eradication Program. The other three carriers are more difficult to formulate and distribute and are more expensive. Existing granular insecticide equipment can be used to formulate or distribute the bait. Extreme caution must be taken, however, to prevent contamination of the oil with other insecticides. Quantities as low as 0.01% to 0.001% of some of the common insecticides can be harmful. They either make the bait unattractive, or start to kill the ants before the bait has been distributed throughout the colony.

Table 5.—A comparison of five fats or oils with soybean oil as food attractants in 0.075% mirex-corncob grits-imported fire ant baits.

Fat or Oil	Average Pre-treatment Count of Active Mounds	Per Cent Reduction in Active Mounds After Weeks Shown			
		2	4	8	16
Soybean oil	13	100	100	97	100
Tallow oil[a]	10	100	97	100	100
Tallow[b]	10	100	100	93	100
Yellow grease[c]	12	97	97	97	97
Grease oil[d]	13	86	100	100	100
Peanut oil	33	66	93	97	100
Check	12	0	0	0	3

[a] Obtained from inedible tallow "stearine" by graining and pressing.
[b] Inedible No. 1 grade.
[c] An inedible fat obtained by rendering the darker-colored parts of the hog.
[d] The lower melting fats obtained from grease.

Microscopic examination of the oil-impregnated grits has shown that a considerable quantity of the oil clings to the rough outer surface of the grits. Since the ants do not ordinarily macerate the grits, they probably ingest only this oil on the surface. Laboratory tests have shown that the ants can remove approximately 60% of the oil from the grits.

The effect of rainfall on the corncob grits bait, after it has been applied, has not been thoroughly evaluated.

The foraging worker ants begin to pick up the bait immediately after it is applied. Bait collecting activity is the greatest during the first several hours after application, and appears to be negligible after 24 hours. When feeding activity is high, large quantities of the bait can be found stored in the tunnels of the mound. With the corncob grits bait, the ants begin to carry the grits out and pile them around the base of the mound 24 to 48 hours later. Apparently they have removed all of the oil from the grits and are discarding them.

In most instances, the first evidence of the effect of the toxic bait on a colony of ants is the formation of piles of dead ants around the base of the mound. Depending upon the quantity of bait taken and the posttreatment temperature, the first toxic effects may be noticed within 2 days, or as late as 3 to 6 weeks. A colony may be killed out within a week, or it may take longer than 16 weeks for the entire colony to die. Colonies which are not killed out quickly often move out of the original mound and build one to several new mounds. Almost invariably these colonies die out. The sequence of death of the various forms in the colonies does not always follow a definite pattern. As mentioned previously, worker ants are the first to start dying, the last ants to die are usually the major workers; however, in some instances the alate forms are the last to die. The brood dies shortly after the first dead workers are noticed. Since the fertile queen is rarely seen in the mound, it is not known how quickly she is killed. Presumably, since brood in the mound disappears rather quickly, the queen must be one of the first to be killed, or affected in some manner so that egg production is stopped.

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