Hy-D IN SOW FEED INCREASES LITTER WEIGHT AT WEANING BY 3.6 KG

TRIAL REPORT NO. 1062

The addition of Hy-D to sow feed increased the number of pigs weaned and litter weight at weaning. It also doubled the vitamin D_3 content in the blood of the sows in the trial.

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Abstract

The effect of adding 47.5 µg Hy-D per feed unit (roughly 1,900 IU vitamin D_3) to sow feed was compared to the effect of adding 1,145 IU vitamin D_3 which corresponds to the content of conventional commercial sow diets in Denmark.

The investigation was made in a commercial herd and demonstrated the following results

- The 25(OH)D_3 content was significantly doubled during lactation in sows given Hy-D throughout the reproductive cycle. This effect is not expected in sows given 2,000 IU vitamin D_3 per feed unit.
- Litter weight was significantly higher (P=0.003) when litters were standardised to 14 piglets after birth and litter weight was 3.6 kg higher at weaning in the Hy-D group. The difference in litter weight was significant (P=0.022) and may partially be explained by the fact that the piglets were heavier at birth. The greatest effect was observed among young sows (1-2 parity).
- The number of pigs weaned increased significantly by 0.3 in the Hy-D group.

- Post-weaning there was no effect on daily gain and mortality regardless whether the pigs were born and reared by a sow given Hy-D when the pigs were standardised to the same start weight. Previous research confirmed that weaning weight is important to the subsequent weaner productivity and the fact that Hy-D pigs were heavier at weaning will therefore positively affect weaner productivity.

The energy evaluation in Denmark is based on:
1. Chemical analyses of water, ash, crude protein and crude fat
2. In vitro digestibilities at ileal level and faecal level
3. Energy values of nutrients based on "potential physiological values".

The protein evaluation system is based on the standardised ileal digestibility of each amino acid.

Energy content per kg diet of a normal complete diet:				
	Feed unit	MJ ME	MJ NE	MJ physiological energy
Lactation diets	1.06 FUsow	13.3	9.6	7.9
Gestation diets	0.99 FUsow	12.6	8.8	7.4

Background

Vitamin D_3 is a fat-soluble vitamin that is essential to pigs' intake and absorption of calcium and phosphorus. It also regulates the deposition and excretion of calcium and phosphorus from bones and the excretion of calcium and phosphorus from the kidneys [1]. The standard level for vitamin D_3 in sow feed is 800 IU per feed unit (FUsow) and must not exceed 2,000 IU per FUsow according to EU legislation. Vitamin D_3 can be added to feed and ingredients in feed also contribute a small amount through vitamin D_2, which is equivalent to vitamin D_3. In addition, vitamin D_3 may synthesize in the skin when animals are exposed to sunlight. Vitamin D_2 is of vegetable origin and exists only in plants exposed to sunlight. Synthetic vitamin D (cholecalciferol) transforms into an absorbable substance in the liver. The product Hy-D is produced by DSM Nutritional Products A/S and corresponds to the first metabolite that is transformed in the liver during metabolism of vitamin D_3. One microgram Hy-D corresponds to 40 IU vitamin D_3 [1]. This may be added to feed and will be absorbed more easily by pigs than conventional vitamin D_3.

Although vitamin D is toxic at high concentrations, the presumed maximal safe level of vitamin D_3 for long-term feeding conditions (more than 60 days) is four to ten times the dietary requirement. So, in practical conditions, vitamin D toxicosis for pigs would only be expected as a result of feed mixing errors and then over a relatively long period. Symptoms of vitamin D deficiency include convulsions and osteomalacia and osteopsathyrosis in adult pigs, while growing pigs develop soft and deform bones. It takes four to six months for pigs to develop signs of vitamin D deficiency.

A trial investigated the effect of adding vitamin D_3 in the form of 100% Hy-D, 50% Hy-D and 50% vitamin D_3, or 100% vitamin D_3 in weaner and finisher feed. Results revealed no differences between the finishers in productivity and health or bone strength. The inclusion rate in all groups corresponded to 2,000 IU per feed unit in weaner feed and 1,200 IU per feed unit in finisher feed [3]. A study of different inclusions of vitamin D_3 and Hy-D revealed only small differences in productivity, reproductive performance and bone status markers in gilts and sows given vitamin D_3 and Hy-D, but results did reveal an impact on the percentage of stillborn pigs per litter [4]. It was therefore recommended to add 1,400 IU vitamin D_3 per FUsow, and the study concluded that Hy-D may be considered as an alternative source of vitamin D due to its high bioavailability. The differences observed in stillbirths per litter were based on relatively few litters and was not found in a subsequent Danish study with 700 litters per group where either 800 or 1,600 IU vitamin D_3 was added to feed for gestating sows [5].

A study with gilts revealed that the maternal as well as the foetal vitamin D_3 status may be increased by adding Hy-D rather than vitamin D_3 to gestation feed. Records reveal a higher vitamin D_3 concentration in 90-day old foetuses and a 9.3% increase in foetuses' total number of muscle fibre. Furthermore, litters were larger and litter weight higher when gilts were given Hy-D [6]. A study comparing vitamin D_3 with Hy-D for weaners weaned on day 18 demonstrated no effect on daily gain. However, Hy-D was seen to significantly impact cellular immune parameters; the amount of granulocytes, survival of leukocytes and the phagocytic capacity was higher [7].

A study of different concentrations of vitamin D_3 during gestation demonstrated a correlation between the vitamin D_3 status of sow and piglets. A higher concentration of metabolites was observed in piglets of sows given a high concentration of vitamin D_3, ie. treatment with vitamin D_3 pre-farrowing improved the vitamin D_3 status of the piglets. Ten days after birth this effect was also observed in the piglets born of sows given vitamin D_3 treatment [8].

Vitamin D_3 is cheap, and Danish pig feed typically contains 1,100-1,400 IU vitamin D3 per FUsow, which is significantly more vitamin D_3 than advised in the standards. Hy-D is more expensive, and it must therefore improve sow productivity to be a profitable alternative to vitamin D_3. A Danish investigation made in 2010 demonstrated a limited increase in $25(OH)D_3$ in sows' blood when the vitamin D_3 content was raised from 800 to 2,000 IU per FUsow [9]. It was therefore planned to apply the current Danish minimum standard of 800 IU vitamin D_3 per FUsow in the control group, while the trial feed contained the amount of 50 µg Hy-D per FUsow recommended by DSM Nutritional Products for sow feed.

The aim of this trial was to determine whether the inclusion of 50 µg Hy-D per FUsow (corresponding to 2,000 IU = maximum inclusion allowed) compared with the inclusion of 800 IU vitamin D_3 per FUsow in feed for sows in the entire gestation period might improve litter weaning weight. It would furthermore be documented if daily gain and mortality were positively affected in weaners born and reared by sows given Hy-D during gestation.

The Danish feed evaluation system

The Danish feed evaluation system, revised in 2002, is based on the physiological energy value of nutrients and on the standardised digestibility of these nutrients. In 2002, the old feed unit was replaced by two new feed units: FUgp (feed units for weaners, growers and finishers) and FUsow (feed units for sows).

In practice, energy evaluation in Denmark is based on:
1. Chemical analyses of water, ash, crude protein and crude fat
2. In vitro digestibilities at ileal level and faecal level
3. Energy values of nutrients based on "potential physiological values".

The protein evaluation system is based on the standardised ileal digestibility of each amino acid.

Energy content per kg diet of a normal complete diet:				
	Feed unit	MJ ME	MJ NE	MJ physiological energy
Lactation diets	1.06 FUsow	13.3	9.6	7.9
Gestation diets	0.99 FUsow	12.6	8.8	7.4
Weaner diets, 6-9 kg	1.18 FUgp	14.4	10.5	8.7
Weaner diets, 9-30 kg	1.17 FUgp	14.1	10.4	8.6

Material and methods

The trial was conducted in a commercial herd where sows were fed dry feed (Electronic Sow Feeding) during gestation and lactation. The farrowing unit had conventional farrowing pens and pigs were weaned after four weeks. There was a total of eight sections with a total of 181 farrowing pens. Post-weaning, weaned pigs were accommodated in sectioned weaner units in pens holding 36 pigs each.

The herd included 650 sows/year and sows and weaners were fed home-mixed feed. However, the smallest weaned pigs were given a compound diet.

Groups

At the beginning of the trial, sows were assigned to one of two groups according to ear tag ID: sows with uneven numbers were assigned to the CONTROL group (vitamin D_3) and sows with even numbers were assigned to the TRIAL group (Hy-D). This ensured that sows in all groups were identical in age.

Feed

Both the control diet and the trial diet complied with the current standards for amino acids and minerals, and were representative of Danish sow diets. The only difference between the diets was the planned content of Hy-D (50µg in the trial feed) and vitamin D_3 (800 IU in the control feed). The diets were analysed, and the results are shown in appendix 2. The weaned pigs were fed identical diets that did not contain Hy-D.

The difference between the control diet and the trial diet in vitamin D content was achieved through the mineral premixes used in the diets. These were produced and verified by DSM Nutritional Products A/S.

Appendix 1 provides an outline of the nutrient content and the composition of the diets. In the insemination unit, all gilts and sows were fed the control lactation diet.

Feeding

Pre-insemination

From weaning until insemination, all sows – trial as well as control - were given approx. 4.5 FUsow a day of the control diet for lactating sows.

Gestation

At transfer to the gestation unit, all gilts/sows were placed on a feed curve corresponding to their body condition. Curves 1-4 were applied in the control feed and curves 5-8 in the trial feed. The curves for each category of pigs were identical. Corrections were made for summer/winter feeding, and this was handled identically for all curves. The curves rise/fall gradually.

Table 1. Feed curves for gilts and gestating sows in all groups (control as well as trial), FUsow a day

Days from insemination	Gilts	Thin sows	Medium sows	Fat sows
Feed curve no.	4 + 8	2 + 6	1 + 5	3 + 7
1	2.5	3.6	2.6	2.4
28	2.5	3.6	2.6	2.4
33	2.6	3.4	2.6	2.3
83	2.6	3.4	2.6	2.3
88	3.5	4.0	3.8	3.5
114	3.6	4.0	3.8	3.5

Three days before expected farrowing, the feed was lowered to 2.5 FUsow per day for sows and 2.0 FUsow per day for gilts.

Lactation

Both the control sows and the trial sows were fed according to the same guidelines in the farrowing unit based on approximate appetite with the following minimum amounts:

- Until day 7 post-farrowing: Minimum 2.0 FUsow + 0.2 FUsow per pig per day
- From day 7 to day 14: Minimum 2.0 FUsow + 0.3 FUsow per pig per day
- From day 14 until weaning: Minimum 2.0 FUsow + 0.4 FUsow per pig per day

Weaners

All weaners were fed according to approximate appetite in both groups.

Verification of feeding

In order to verify that all sows received the correct amounts of feed, the volume of the feed in the farrowing unit and the gestation unit was routinely checked, and the settings of the feeders would be adjusted correspondingly.

Blood sampling

The sows were blood sampled at transfer to the farrowing unit to be able to determine for how long Hy-D would be required during gestation to be able to record an increase in blood values at transfer to the farrowing unit. Blood samples were collected from two batches of 18 sows (nine control sows and nine trial sows, identical parity): the first batch at transfer to the farrowing unit two weeks after trial start and the second batch seven weeks after trial start when all trial sows were given trial feed from the same date.

Blood samples were also collected from control and trial sows to confirm the expected vitamin D concentration in the blood. These blood samples were taken from four week batches: nine sows were selected from each group that, in pairs, were identical in parity. Blood samples were taken at transfer to the farrowing unit, approx. four days post-farrowing and at weaning.

Blood samples were collected in heparin tubes and immediately centrifuged for roughly two minutes. 3 ml of blood plasma was pipetted and stored in small plastic tubes at ÷20°C. The samples were subsequently analysed by Søren Krogh Jensen, Aarhus University (Department of Animal Science, Foulum) applying high-performance liquid chromatography (HPLC) following saponification with potassium hydroxide in ethanol and extraction with heptane [10].

Recordings

Four control sows and four trial sows from each week batch were randomly selected to rear standardised litters that were established according to the below method:

- Litter size was standardised to 14 piglets per litter and cross-fostering was allowed only with the group and within the first 24 hours. Sows with fewer than 14 liveborn piglets were given averagesized piglets from the same group during the establishing of the standardised litters. For sows with more than 14 liveborn piglets the smallest piglets were moved when the standardised litters were established.

- Upon standardisation of litters and at weaning, litters were weighed and litter gain was used as an indicator of the milk production of the sows.
- Piglet mortality and cause of death in the standardised litters during lactation were recorded.
- At weaning, pigs in the standardised litters were assigned to two groups – control and trial. Thirty-six uniform pigs from each group were transferred to a pen in the weaner unit. The pigs were weighed and the weight was identical within each pen. Dead and culled pigs were recorded (date and cause), and the pigs in each pen were weighed again seven weeks later and gain was determined.

The production control performed in the herd was supplemented by records of culling for all sows that were culled during the trial. Recordings were made of date and cause for all sows that were moved out of the gestation pens, but not transferred to the farrowing unit. Sows that stayed for a brief period in a hospital pen and then returned to the gestation were not recorded. Performance of obstetric aid was recorded. These were all recorded as secondary data (see appendix 3).

Feed analyses

Feed samples were collected weekly and stored in a freezer. Once every quarter two pooled samples were made per diet – divided according to the TOS principles. One sample was submitted to the Eurofins Steins laboratory for analysis (FUsow, crude protein, crude fat, ash, water, calcium, phosphorus, lysine, methionine, cystine and threonine). The other sample was submitted to DSM Nutritional Products A/S for analysis of Hy-D and vitamin D_3.

Statistics

The primary parameters were weaning weight of pigs in standardised litters, and gain and mortality rates of weaners from weaning until approx. 30 kg.

Litter weight and the number of pigs weaned in fixed litters with maximum three dead pigs were subject to analysis in SAS with the proc mixed procedure with the factors “group”, “parity” and “number of pigs weaned” as fixed effects. “Batch” was included as random effect per design. Adjustment was made for start weight upon standardisation and the number of lactation days as co-variates. Each individual litter was assumed independent. In case of significant effect of “group”, comparisons in pairs are reported from “LSmeans statement”.

For analysis of gain and mortality in the weaner unit, logistic regression was made in proc glimmix in SAS with “group” as fixed effect. “Batch” was included as random effect per design. In case of significant effect of “group”, comparisons in pairs are reported from “LSmeans statement” as odds ratio.

Secondary parameters included totalborn piglets per litter, stillbirths per litter, farrowing rates and culling (cause and code).

Results and discussion

Feed analyses

The results of the feed analyses shown in appendix 2 reveal a fair agreement with the planned nutrient content. The control feed was planned to include 800 IU vitamin D_3 per FUsow, but analyses revealed an actual content of 1,060 IU per FUsow in the gestation feed and 1,304 IU per FUsow in the lactation feed. Assuming that a sow gets 35% lactation feed and 65% gestation feed in a reproductive cycle, the control sows got an average of 1,145 IU vitamin D_3 per FUsow. Analyses revealed a Hy-D content of 47.5 µg, which corresponds to roughly 1,900 IU vitamin D_3 per FUsow which is slightly less than planned.

Production results

Table 2 shows the results for all standardised litters in the lactation period. The results only include sows given Hy-D for minimum 50 days before farrowing. Table 2 also shows the results for young sows (1-2 parity) and older sows (3-7 parity).

Table 2. Litter results, standardised litters in the farrowing unit

Group	Vitamin D_3			Hy-D			P-value – All litters
Litter no.	1-2	3-7	All	1-2	3-7	All	
Litters weaned	44	101	**145**	42	104	**146**	
Average parity			**3.2**			**3.2**	
Totalborn piglets/litter	17.7	18.7	**18.4**	17.8	19.1	**18.6**	
Standardised litter size	14.0	14.0	**14.0**	14.0	14.0	**14.0**	
Litter weight at standardisation, kg	18.3	19.1	**18.8**	19.2	19.9	**19.8**	**0.003**
Lactation period, days	25.8	25.7	**25.7**	25.7	25.7	**25.7**	
Litters with max 3 dead pigs							
Litters weaned	40	95	**135**	39	97	**136**	
Pigs weaned per litter	12.7	12.7	**12.7**	13.0	13.0	**13.0**	**0.03**
Litter weight at weaning, kg	79.8	87.5	**85.0**	87.9	88.9	**88.6**	**0.022**
Litter weight at weaning, adjusted for start weight, kg	81.3	88.1	**86.1**	87.3	88.3	**88.0**	**0.19**

Statistical analyses were made for all litters with parity as fixed effect. The results relating to weaning weight and pigs weaned per litter include only litters with up to three dead pigs in the lactation period to eliminate effect of disease in sows or piglets. More than three dead piglets in a sow's litter during lactation are often connected to factors other than feed – such as disease.

The sows that reared standardised litters were randomly picked during gestation and procedures for cross-fostering were identical in both control and trial groups. Nevertheless, litter weight in the standardised litters was significantly higher in the Hy-D group. This cannot be explained by differences in the number of pigs moved when standardised litters were established as the number of pigs moved to and from the standardised litters did not differ significantly. To determine whether the pigs in the trial group were in fact heavier at birth than the control pigs all pigs in the litter should have been weighed at birth, which they were not – only the 14 pigs included in the standardised litter were weighed. The litter weight was 3.6 kg higher at weaning, which is significant, and part of this effect may be explained by the fact that pigs were heavier at birth. A higher number of pigs were weaned in the Hy-D group, which may in combination with heavier pigs at weaning explain the higher litter weaning weight. The results shown in table 2 indicate that the effect of Hy-D is highest among young sows.

Weaning weight is very important to daily gain in the weaner period, and the effect of Hy-D was therefore "reset" by standardising the litters again so that each pen had the same average weight within group and week batch. Post-weaning, all weaned pigs were given the same feed with no Hy-D. Daily gain, mortality and cullings were recorded at pen level. As shown in table 3, there were no differences between the groups and there was therefore no additional effect on weaner productivity whether they were born and reared by sows given Hy-D or not.

Table 3. Weaners – daily gain, mortality and culled pigs

Group	Vitamin D_3	Hy-D
Pens	30	30
Pigs transferred per pen	35.7	35.8
Weight at transfer, per pig, kg	7.3	7.3
Daily gain until 30 kg, g	460	460
Mortality, weaners	0.4	0.5
Culled weaners, %	0.8	0.7

The results of the blood samples are shown in tables 4 and 5. Table 4 shows the effect of the treatment period on blood plasma content of $25(OH)D_3$.

Table 4. Effect of treatment period on blood content of 25-OH vitamin D_3

Group	Vitamin D_3	Hy-D
Sows	18	18
After 2 weeks, ng/ml	15.7	35.8
After 7 weeks, ng/ml	14.4	46.7

Results demonstrate that sows given Hy-D for two weeks had a 25(OH)D_3 concentration in the blood at the time of farrowing that was 2.3 times higher compared with sows given regular vitamin D_3. After seven weeks, blood plasma of Hy-D sows contained 3.2 times more 25(OH)D_3 than the control sows. This corresponded to the level observed when the sows had been given Hy-D throughout the entire reproductive cycle (table 5).

The content of 25(OH)D_3 in blood plasma at farrowing, approx. four days post-farrowing and at weaning had roughly doubled and the average was significantly higher for sows given Hy-D. A Danish investigation of increasing inclusion of vitamin D_3 and Hy-D in feed for lactation sows [9] demonstrated that blood plasma of sows given 2,000 IU vitamin D_3 (maximum inclusion allowed) contained around 30 ng/ml 25(OH)D_3. Therefore it is expected that the concentration of 25(OH)D_3 observed in this study with lactating sows given Hy-D cannot be achieved by adding up to 2,000 IU vitamin D_3 to sow feed.

Table 5. Effect of treatment on blood content of 25(OH)D_3 during lactation.

Group	Vitamin D_3	Hy-D	P-value
Sows	36	36	
25(OH)D_3 in blood at farrowing, ng/ml	19.7	43.6	-
25(OH)D_3 in blood approx. 4 days post-farrowing, ng/ml	20.3	40.4	-
25(OH)D_3 in blood at weaning, ng/ml	31.4	75.5	-
25(OH)D_3 in blood, average of 3 samples per sow, ng/ml	23.6	52.7	0.0001

Conclusion

The blood content of 25(OH)D_3 during lactation was significantly doubled when sows were given an average of 47.5 µg Hy-D per feed unit (corresponding to 1,894 IU vitamin D_3) throughout the entire reproductive cycle compared with 1,145 IU vitamin D_3 per feed unit. This effect is not expected in pigs given 2,000 IU vitamin D_3 per feed unit [9].

When sows were given Hy-D in the entire cycle, litter weight at standardization of litters was significantly higher than in the group given vitamin D_3. The entire litter was not weighed in this trial and therefore there is no evidence that the use of Hy-D overall improves birth weight. However, another study did demonstrate an increase in birth weight when sows were fed Hy-D [6].

At weaning, litter weight was 3.6 kg higher in the group given Hy-D, which was significant. This effect may partly be explained by the fact that the pigs were heavier at birth and more pigs were weaned in these litters. This also indicates that the effect of Hy-D is highest among young sows (1^{st} and 2^{nd} parity).

Post-weaning, there are no indications that daily gain and mortality of weaners are affected by the fact that they were born and reared by sows given Hy-D or not. The fact that the pigs weighed more at weaning will naturally have a positive impact on the subsequent weaner productivity, but this effect was offset when the pigs were standardized to identical weight at transfer to the weaner unit.

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Trial no.1320

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Appendix 1

Gestation diet

Ingredients, %	Control/Trial
Barley	44.8
Wheat	44.8
Soy bean meal, dehulled	7.3
Soy oil	0.5
Mineral mix	2.6

Lactation diet

Ingredients, %	Control/Trial
Barley	40,1
Wheat	40,1
Soy bean meal, dehulled	14,2
Soy oil	2,0
Mineral mix	3,6

Appendix 2

Feed analyses

Gestation feed				
Diet	Control		Trial	
	Declared	Analysed	Declared	Analysed
Samples analysed		6		6
Crude protein, %	11.7	11.6	11.7	11.7
Crude fat, %	3.0	3.4	3.0	3.4
Ash, %	4.5	4.3	4.5	4.4
Water, %		13.0		13.1
FUsow per 100 kg	106	108	106	108
Calcium, g/FUsow	6.5	6.7	6.5	6.6
Phosphorus, g/FUsow	3.5	3.7	3.5	3.6
Lysine, g/FUsow	4.6	4.8	4.6	4.7
Methionine, g/FUsow	1.9	2.0	1.9	2.0
Methionine + Cystine, g/FUsow	4.2	4.3	4.2	4.3
Threonine, g/FUsow	3.8	3.8	3.8	3.9
Vitamin D_3, IU per FUsow	800	1,060		
Hy-D, µg per FUsow			50	48.6

Lactation feed				
Diet	Control		Trial	
	Declared	Analysed	Declared	Analysed
Samples analysed		5		5
Crude protein, %	14.3	14.8	14.3	14.9
CRude fat, %	4.4	4.1	4.4	4.2
Ash, %	5.3	5.4	5.3	5.5
Water, %		12.6		12.8
FUsow per 100 kg	109	109	109	109
Calcium, g/FUsow	7.5	7.6	7.5	7.7
Phosphorus, g/FUsow	4.5	4.5	4.5	4.6
Lysine, g/FUsow	7.6	8.0	7.6	8.1
Methionine, g/FUsow	2.4	2.5	2.4	2.5
Methionine + Cystine, g/FUsow	4.8	5.1	4.8	5.0
Threonine, g/FUsow	5.2	5.3	5.2	5.3
Vitamin D_3, IU per FUsow	800	1,304		
Hy-D, µg per FUsow			50	45.05

Appendix 3

Culling of sows – primary causes

Group	Vitamin D_3	Hy-D
Slaughtered	69	62
Dead	7	6
Destroyed	7	6

Explanatory causes of culling

Group	Vitamin D_3	Hy-D
Maternal traits, %	30	30
Absence of heat, %	2	7
Not gestating, %	0	3
Lame, %	4	4
Age, %	46	35
Gas blower, %	0	3
Farrowing problems, %	4	3
Prolapse, %	0	1
Other, %	14	14

Obstetric aid and reproduction results

Group	Vitamin D_3	Hy-D
Inseminations performed	544	582
Average parity	3.8	3.7
Farrowing rate after 1st insemination, %	93.6	93.8
Totalborn piglets per litter	18.0	18.0
Stillborn per litter	1.4	1.3
Obstetric aid, %	8	10

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