EFFECTIVENESS AND POTENTIAL USEFULNESS OF DIETARY SUPPLEMENTATION WITH SAPROPEL ON DUCKLINGS AND GOSLINGS GROWTH AND QUALITY INDICES

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Abstract. The effectiveness of complex diet supplementation with organic sapropel was assayed in order to find natural, safe and native feed for young poultry. Sapropel effectiveness of appointed chemical composition was evaluated considering body mass, digestibility, development of the digestive tract and meat quality indices of duckling and gosling. Organic sapropel (pH 7.0) seems to be perspective for diet supplement due to sufficient content of organic material (86.5%), 2.06% N and 12.70% minerals in dry material (DM). Rates of nitrate (409.01 mg kg^{-1}) and noxious for health and environment heavy metals (1.72–10.01 mg kg^{-1}) did not exceed safety quotas. 7 essential, 3 conditionally essential (His, Tyr and Arg) and limiting (Lys, Trp, Met, Cys) amino acids proved the sapropel suitability for young poultry feeding. Ducklings diet supplemented with 6% of sapropel and goslings not supplemented with it (control group, CG) resulted in the most effective feed conversion rate (3.62 and 3.83 respectively). Meal-based diet supplemented with 9% of sapropel resulted in the highest body mass: 1931 and 2704 g of 40 and 50 days ducklings; 1766 and 3772 g of 20 and 60 days goslings respectively. 9% sapropel supplementation increased body mass of 50 days ducklings and 60 days goslings by 5% and 9% points respectively. Ducklings diet supplemented with 9% sapropel caused better feed assimilation with the highest meat yield (66.7%) exceeding CG by 1.6%. Also 1.7% and 1.1% increase of DM and fat, respectively, in duckling carcass meat were observed. However, the meat quality indices of goslings occurred to be better of CG than those of the 4th experimental group supplemented with 9% of sapropel; possibly due to larger body–build and nutritious needs than that of ducklings.

Keywords: sapropel, duckling, gosling, digestibility, body gain, meat quality.

SAPROPELIO PRIEDO RACIONE EFEKTYVUMAS, POTENCIALI NAUDA ANČIUKŲ IR ŽĄSIUKŲ AUGIMO BEI KOKYBĖS RODIKLIAMS

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Santrauka. Sudėtinis organinio sapropelio dietos papildų poveikis buvo tiriamas norint rasti vietinį natūralų ir saugų lesalo priedą paukščių jaunikliams. Nustatytos cheminės sudėties sapropelio veiksmingumas įvertintas atsižvelgiant į ančiukų ir žąsiukų kūno masės, virškinamumo, virškinimo trakto bei mėsos kokybės rodiklius. Organinis sapropelis (pH 7,0) – perspektyvus mitybos papildas dėl pakankamo organinių medžiagų (86,5 proc.), 2,06 proc. N ir 12,70 proc. sausosios medžiagos (SM) mineralų kiekio.

Nitratų (409,01 mg/kg^{-1}) ir kenksmingų sveikatai bei aplinkai sunkiųjų metalų (1,72–10,01 mg/kg^{-1}) kiekis neviršijo saugios normos. Septynios pakeičiamosios, trys sąlyginai pakeičiamosios (His, Tyr ir Arg) ir nepakeičiamosios (Lys, Trp, Met, Cys) aminorūgštys rodė sapropelio tinkamumą paukščių jauniklių lesalui. Ančiukų 6 proc. sapropelio mitybos priedas ir žąsiukų racionas be sapropelio (kontrolinė grupė, CG) lėmė efektyviausią lesalų konversijos normą (atitinkamai 3,62 ir 3,83). Žolės miltų pagrindu sudarytas lesalas, papildytas 9 proc. sapropelio, lėmė didžiausią kūno masę – 1931 g ir 2704 g 40 ir 50 dienų ančiukų; 1766 ir 3772 g 20 ir 60 dienų žąsiukų. 9 proc. sapropelio priedas per 50 ir 60 dienų ančiukų ir žąsiukų kūno masę padidino atitinkamai 5 proc. ir 9 proc. Ančiukų lesalas su 9 proc. sapropelio priedu lėmė geresnę lesalo asimiliacijos ir didžiausią skerdienos išeigą (66,7 proc.), 1,6 proc. viršijančią CG. Taip pat ančiukų skerdenoje nustatyta 1,7 proc. ir 1,1 proc. padaugėjusios SM ir riebalų. CG žąsiukų skerdienos kokybės rodikliai buvo geresni, nei 4 eksperimentinės grupės ančiukų, gavusių 9 proc. sapropelio priedo. Veikiausiai dėl didesnio maisto medžiagų poreikio kūno augimui.

Raktažodžiai: sapropelis, ančiukai, žąsiukai, virškinamumas, priesvoris, mėsos kokybė.

Introduction. The basic problems of poultry feeding consist not only of sufficient supply of the main feed materials (Kluth and Rodehutscord, 2006; Gous, 2010), but also of looking for safe and native food sources (Corzo et al., 2005; Brenes, Roura, 2010). Sapropel seems to be a perspective and alternative feed source. Sapropel, or the lake silt, is a unique and valuable sedimentary material accumulated in natural environment (Knicker and Hatcher, 2001; Maiorano et al., 2008; Rohling et al., 2004). It is a complex substance of organic and mineral origin, the main part of which is composed from residues of plankton, benthos, algae and others hydrophytes,

stratified with sand, clay and limestone fractions (Capozzi and Picotti, 2003). There are approximately 10 b m^3 of sapropel accumulated in lakes and marshes during thousands of years. It is deposited in 7–15 m thick layers in Lithuania and conserve the nature balanced beneficial materials (Ciūnys et al., 1994). Sapropel is organic and mineral–carbonic by origin with pH 6.0–7.5 and contains 79.80–90.80 % of organic material (OM), 2.27–3.56 % N, 0.56–1.18 % Ca, 0.9–0.15% P_2O_5, 0.055–0.20% K_2O in DM (Bakšienė and Janušienė, 2005; Katkevičius et al., 1998). Part of accumulated hydrolysable trace elements, especially Se, is found in a more effectively assimilated organic form than in an inorganic form (Endo and Nakano, 1999). For 40 years, the trace element Se has been accepted as a major component of the animals' antioxidant defence mechanism controlling the body's glutathione (GSH) pool and its major Se-containing antioxidant enzyme, glutathione peroxidase (GPX) (Mackowiak et al., 2004; Power et al., 2011). Evidence has emerged suggesting that organic selenium, natural Se-amino acids found in plants, grains and other natural recourses, maintain the antioxidant defence system more efficiently than inorganic selenium. Inorganic selenium is a pro-oxidant, whereas organic selenium possesses antioxidant properties itself and is a natural solution of multiple stress-affected problems in animal feeding (Bañuelos and Mayland, 2000; Tinggi, 2003). Various bio–active materials (vitamin, enzyme, essential amino acid, antibiotic, carbohydrate, estrogen, humic acid, lipid fractions as growth regulators, etc.) accumulated in OM confirm physiologic significance of sapropel for feeding of young poultry (Chennaiah et al., 2007; Skřivan et al., 2012; Ravindran et al., 2007; Wang and Xu, 2008). Among the diversity of bio–active materials found in sapropel, amino acids are an essential feeding material due to their high physiologic activity and their role as N, C resources, growth stimulators (Guo et al., 2008) or anti-stressors (Dai et al., 2011). As Mikulionienė et al. (1998) reports, essential amino acids compose 47–60% of total amino acids in sapropel. Zaccone et al. (2008) reports an antiseptic effect of sapropel humic acids, which improve the functionality of gastrointestinal tract and microbiologic balance due to increasing content of useful microbe. Chemical composition and bio–activity have actualized sapropel implementation as of native origin, natural and ecological, protein and vitamin rich diet supplement with pro– or pre–biotical peculiarities.

Nowadays, actualities of safe feeding and needs for search of native, natural and ecologically safe raw materials instigate investigations of sapropel efficiency in young poultry feeding (Katkevičius et al., 1998; Mikulionienė et al., 1998). Therefore the **aim of this study** was to estimate the application of assessed chemical composition sapropel for ducklings and goslings feeding, evaluating its efficiency for food digestibility accordingly to feed conversion ratio (FCR) and impact on the quality indices of gastrointestinal tract and meat.

Materials and Methods. Organic sapropel from the Kvietkinė Lake, Marijampolė Distr. was tested for ducklings and goslings feeding. The excavated sapropel was air dried to 40 % dry matter (DM) over 3 cm diameter mesh sieve, crushed up and used for feed. Chemical composition of sapropel and poultry meats was assessed at the Agronomical and Zoo technical Analysis Laboratory (Lithuanian University of Agriculture) using chemical methods: crude lipid (CL) – Soxhlet, crude protein (CP) – Kjeldahl, crude fiber (CF) – Van Soest, organic material (OM) and crude ash (CA) – burning at 500 ± 25^{o}C. The nitrogen–free extract was evaluated following Weender methods (Nauman and Bassler, 1993). The content of amino acids in DM was analyzed using analyzer T-339, the concentration of heavy metals and minerals was measured spectrometrically using atomic analyzer Perkin Elmer 603 (Official…, 1999), and vitamin status was assessed by high pressure liquid chromatograph at the Institute of Ecology of the Lithuanian Nature Research Centre.

The study of ducklings and goslings feeding was performed during 50 and 60-day period in the B. Gečas' farm (Šilalė Distr., Lithuania). A total of 150 5-days old ducklings of the *Pekin* and 150 5–day old goslings of *Vishtines* breed were individually weighed and used for forming of control (CG) and experimental groups (EG). The experiment was replicated twice. Young poultry were fed in accordance to energy and nutritious consumption of each age group. The trials were performed in accordance with LR Order n o 4-16 (1999 01 18) and EC recommendation (EC/2007/526).

The rearing was performed on deep peat litter. The poultry keeping followed the regulations for *Pekin* ducklings and *Vishtines* goslings rearing with controlled light, zoo–hygiene and feeding technological regiment. The poultry was fed with dry complete feeding mixtures, selected in accordance with nutrient requirement of age periods and DLG-standard (Bons et al., 2000; Jeroch et al., 1999). Diet energy requirement was given as metabolic energy which was corrected for nitrogen (MEn) (Jeroch and Dänicke, 2005). ? Ducklings aged 5–20 and 21–50 days were fed diets containing 17.0–12.0, and 12.0–15.0 % CP and 10.6–10.7 and 10.7–11.4 MJ ME and goslings aged 5–20 and 21–60 days were fed diets containing 22.0–13.5 and 13.5–18.0 % CP and 11.6–11.8 and 11.8–10.1 MJ MEn respectively. The complete diet contained 2.5% (21–50 d. ducklings and 21–60 d. goslings) and 5% (1–20 d. goslings) grass meal produced from fodder galega (*Galega orientalis* Lam.). In accordance with nutrition requirements (Jeroch et al., 2004), poultry in the experimental groups (2–4EG) were given diets with increased concentration of sapropel as follows: 2EG – 3 %, 3EG – 6%, 4EG – 9% and 5EG – 12% (Table 1). Besides, diet of CG poultry was not supplemented with sapropel. Sapropel was tested as mineral-bioactive supplement in ducklings and goslings diet, therefore diet of all poultry groups was iso-nutritious and iso-energetic. The effectiveness of feed conversion into body mass (BM) was estimated by calculating feed conversion ratio (FCR) estimated as feed consumption per 1 kg body mass gain (Novak et al., 2004; Wang and Xu, 2008).

Table 1. **Feeding scheme of young poultry**

Poultry species / Age group, day	Diet group		Poultry number in group (n x 2)	Sapropel supplement, %	Experiment duration, d.
	No	Code			
Ducklings / 5, 20, 40, 50	1	CG	30	0	50
	2	EG	30	3	50
	3	EG	30	6	50
	4	EG	30	9	50
	5	EG	30	12	50
Goslings / 5, 20, 60	1	CG	30	0	60
	2	EG	30	3	60
	3	EG	30	6	60
	4	EG	30	9	60
	5	EG	30	12	60

40 days aged ducklings (n=4) of average mass of CG and the 4th EG (which showed the fastest growth) were selected randomly for digestibility tests applying TiO_2 as exogenic indicator. Development of body mass (measured by individual weighing of ducklings on days 5, 20, 40 and 50 of their age and goslings on days 5, 20 and 60), feed conversion rate, and survival rate were estimated. During the experimental study, poultry health condition and mortality rate were observed as well.

For each treatment group, the six control slaughters of average mass ducklings (n=9) and goslings (n=9) were done at the end of the experiment. The slaughter quality was analyzed in accordance with the EC directives (EC/657/2002; EC/1072/2000) and National Order (LR..., 2003). Yield and structure of carcass meat, together with breast muscle quality, namely DM (LST ISO 1442:2000), protein (LST ISO 1443:2000), fat and ash were determined. Development of poultry digestible organs (small intestine, rectum, cecum and liver) was estimated by measuring the mass and length.

The confidence limits of the data were based on Student's theoretical criterion. The least significant difference (LSD_{05}) and standard error (SE) were calculated at level of statistical significance $p<0.05$. The results of sapropel effect on poultry body mass gain, digestibility and meat quality were statistically evaluated by using the statistical package STATISTICA of StatSoft for Windows standards.

Results and Discussion

The following sapropel DM chemical composition was documented: 86.50% OM, 2.06 % N and 12.70% minerals (Table 2). Low energetic value of sapropel is due to small-scale fat content (1.53%). High fibre content (24.89 %) in sapropel was found equal to that in plants at maturity stages. Furthermore, sufficient amount (2.82 and 10.89 g kg^{-1} respectively) of P and Ca substantial for forming poultry structure and functionality was accumulated in DM sapropel. Corresponding to Wang and Xu (2008), Bañuelos and Mayland (2000), the essential trace element Se increases broiler body mass and up–regulates defence mechanism by controlling concentration of anti–oxidative and Se–containing enzyme GSH-Px in blood plasma and liver. Considerable content of Se rated 0.36 mg kg^{-1} in sapropel.

Table 2. **Composition of organic sapropel** ($p<0.05$)

Constituent	Content	±SE
DM, %	86.50	1.01
CL, %	1.53	0.18
CF, %	24.89	0.97
CA, %	16.01	1.10
N, g kg^{-1}	2.06	0.07
Ca, g kg^{-1}	10.89	0.96
P, g kg^{-1}	2.82	1.14
Fe, mg kg^{-1}	578.71	73.65
Mn, mg kg^{-1}	214.01	3.12
Cu , mg kg^{-1}	12.02	0.94
Zn , mg kg^{-1}	97.01	4.47
Se, mg kg^{-1}	0.36	0.008
Heavy metal, mg kg^{-1}		
Pb	6.50	0.29
Ni	7.51	0.23
Cd	1.72	0.08
Cr	10.01	0.04
Amino acid, mg kg^{-1}		
Lys*	67.61	5.88
Met *	17.40	1.52
Thr *	59.31	5.16
Phe *	62.12	5.40
His	50.30	4.38
Leu *	97.21	8.46
Ile *	50.20	4.37
Val *	72.62	6.32
Tyr	48.40	4.21
Arg	79.31	6.90
Vitamin, mg kg^{-1}		
Cobalamine	0.52	0.014
Inozit	28.30	0.30
Biotin	0.02	0.00
Pantothenic acid	4.21	0.04
Thiamin	0.06	0.00
Pyridoxine	0.03	0.00
Niacin	6.31	0.02
p–aminobenzoic acid, PABA	0.34	0.01

*-essential amino acid

Optimal deposits of other trace elements (Zn, Cu, Mn and Fe), that are essential for increasing poultry body gains and FCR (Schrauzer, 2000; Lizama et al., 1998) were also found in sapropel. Essential, but potentially neurotoxic and involved in many metabolic functions Mn rated 214.01 mg kg^{-1} in DM sapropel. Cu and Zn influence animal growth, immune function and also sustain antioxidant and regulatory impact of Fe (Rashtchizadeh et al., 2008; Shao et al., 2010; Watt et al., 2006). Physiologically optimal content of Cu and Zn (12.02 and 97.01 mg kg^{-1} respectively) accumulated in organic sapropel increases its relevance as feed supplement. Otherwise, doses (1.71–10.01 mg kg^{-1}) of toxic heavy metals (Pb, Ni, Cd, Cr) have not exceeded safety limits assigned for animal health and environment (86/278/EEC Council Directive), therefore sapropel is found as natural and ecologically clean native supplement for healthy animal diet.Natural sapropel pH was neutral (7.0) and nitrates rate (409.0 mg kg^{-1}) have not exceeded permissible standards (500.0 mg kg^{-1}).

Kluth and Rodehutscord's (2006) appointed protein importance in poultry feed; nonetheless the share of nitric materials observed was negligible and made up to 2.06 %. Corzo et al. (2005) have pointed out the importance of amino acids composition in numerous investigations of poultry feeding. Some non-protein amino acids (Trp, Gly, Arg) contained in sapropel have important role as precursors or as limiting amino acids (Lys, Trp, Met) (Meierhenrich, 2008). As mentioned in these records, protein poor (180.0 g kg^{-1}) starter-phase diet supplement with proteinogenic amino acids increased body mass gains and N retention in organism. The presence of 7 essential, 3 conditionally essential (His, Tyr and Arg) and 3 limiting amino acids (Lys, Trp, Met) has proved relevance of sapropel as natural diet supplement for poultry. The determined content (17.40–97.21 mg kg^{-1}) of different amino acids in sapropel was smaller in comparison with other feeds. Nonetheless, the ratio of essential amino acids in sapropel protein ranged between the one in protein of vegetative and animal origin (Table 2).

The presence of vitamins, mainly B group, proves sapropel to be suitable as a poultry diet supplement (Table 2). B group vitamins are constituents of different conferment and take part in mitochondrion functionality (Depeinta et al., 2007). A sufficient content of essential for cell metabolism inozit (28,3 mg kg^{-1}), NADH, NAD, NAD+, NADP and NADPH precursor niacin (6.31 mg kg^{-1}) and pantothenic acid (4.21 mg kg^{-1}) were documented in sapropel (Combs, 2008). The content of other vitamins was negligible and insufficient for balanced diet composition. Among the mono-gastric creatures, poultry have the highest growth rate and relatively low feed input with FCR ranging between 2–4 (Livestock's ..., 2006; Novak at al., 2004; Wang et al., 2008). Ducklings diet supplementation with 3%, 6% and 9% sapropel resulted in FCR decrease (3.62–3.84) at 50–days age, but supplementation with 12% sapropel increased FCR (4.34) in comparison with the control group (Table 3). BM gains of 50–days aged ducklings from 2–4 EG increased by 2.6; 2.5 and 8.1% in comparison with BM of CG. Diet supplemented with 12% of sapropel and not supplemented predetermined the least BM of ducklings. Nonetheless, BM and FRC tendencies were different. It was observed, that sapropel supplementation stimulated food consumption, therefore ducklings diet supplementation with 9% sapropel (4 EG) resulted in statistically significant higher BM gains, while the most effective FCR (3.62) was documented in 3EG treated with 6% sapropel diet supplement. Only mechanical reasons caused ducklings mortality, which rated between 0 (CG and 3EG) and 4.0 % (5EG).

Ducklings diet supplementation with 9% of organic sapropel improved feed digestibility and intensified BM growth. Digestibility of DM, OM, CL, CF and CA was significantly higher respectively by 2.8; 2.6; 6.8 and 8.7 % points of this group (4EG) than that of control group ducklings (Table 4).

Diet supplementation with 9% sapropel (4EG) resulted in statistically significant highest carcass meat yield (66.7%), or higher by 1.6% than that in the control group (Table 5). Diet supplementation with 9% sapropel considerably improved duckling carcass meat structure and meat chemical composition, increasing its DM and fat content respectively by 1.7% and 1.1% in comparison with CG. The observed data of meat chemical composition correspond with references (Pingel, 2000).

Table 3. **Impact of sapropel diet supplement on BM gains and FCR of ducklings and goslings** (*p<0.01)

Group	Sapropel supplement, %	BM, g				FCR	Mortality rate, %
		5d.	20d.	40d.	50d./ 60d.		
Ducklings							
1 CG	0	92	655	1813	2575	3.94*	0.0
2 EG	3	92	671	1919*	2643	3.75	1.0
3 EG	6	91	708*	1919*	2652	3.62*	0.0
4 EG	9	92	663	1931*	2704*	3.84	2.0
5 EG	12	92	746*	1908*	2578	4.34*	4.0
Goslings							
1 CG	0	190	1628*	-	3460	3.83*	4.0
2 BG	3	190*	1655	-	3460	3.86*	4.0
3 BG	6	192.*	1645	-	3357*	4.02	4.4
4 BG	9	187.	1766*	-	3772*	4.26*	1.9
5 BG	12	188	1607*	-	3170*	4.05	5.0

Table 4. **Duckling feed digestibility** (%; *p<0.01)

Group	DM	OM	CP	CL	CF	NEM	CA
1 KG	79.2	81.1	92.7	70.8	42.5	88.1	50.7
4 BG	81.4*	83.2*	92.1	75.6*	47.5*	87.2	55.1*

Table 5. **Chemical composition of poultry carcass meat** (%;*p<0.**01)**

Poultry	Group	Carcass meat output	DM	Protein	Fat	Ash
Ducklings	1 CG	65.1	25.31	14.77	2.970	0.80
n=9	4 EG	66.7	27.01*	14.89*	3.080*	0.71*
Goslings	1 CG	63.1	25.12	17.24*	2.704*	0.91*
n=9	4 EG	62.4	26.78*	16.09*	2.058*	0.84*

Presented trend of goslings BM gains variation was analogous to ducklings (p<0.01), nonetheless diet supplementation with sapropel resulted in evident increase of feed conversion rates of all EG gosling. 12% sapropel diet supplementation resulted in the least BM (188–3170 kg) in all age groups of goslings (Table 3). BM of 5EG goslings aged 20 and 60 days of age decreased by 1.3 and 8.4% points respectively compared with the control group. The highest BM (respectively 1766 and 3772 g) was obtained among goslings aged 20 and 60 days fed on diet supplemented with 9% of sapropel. After 60 days, their BM increase rated 9.0% in comparison with CG. However, the least effectiveness of feed conversion was documented in 4EG (9% sapropel) and did not correspond with BM tendencies. BM rate of goslings, supplemented with 3 and 6% sapropel diet, was similar to the BM of the control group. During the whole course of feeding, the registered gosling mortality rate (4.0–5.0%) was similar in all groups, with exception of 4EG where it was the least (1.9%). Gosling diet supplementation with 9% sapropel (4EG) resulted in the same carcass meat yield, DM, protein as well as in the control group possibly due to low energetic value of sapropel supplementation (Table 5). More specifically, sapropel diet supplementation affected meat indices of goslings more negatively, supposedly due to their larger body–build and decrease of feed conversion efficiency (FCR=4.26) than that of ducklings.

Normal development of digestible organs (gizzard stomach, small intestine, bung intestine / rectum, blind intestine and liver) was documented by their mass and length of both ducklings and goslings (Table 6). Corresponding to Sklan (2001) and Uni et al. (2003), larger digestible organs, especially of small intestine, stimulate effectiveness of feed assimilation. Rate of 9% sapropel in feed stimulated development of gastrointestinal tract.

Table 6. **Development of gastrointestinal tract** (n=6)

Index	Ducklings			Goslings		
	CG	4 EG	LSD_{05}	CG	4 EG	LSD_{05}
Muscular stomach mass, g	79.8	76.1	1.02	125.8	127.9	2.07
Small intestine mass, g	73.5	77.9	1.10	112.9	140.8	2.11
Small intestine length, cm	178.9	181.6	6.11	206.9	227.9	4.13
Rectum mass, g	16.5	19.1	1.05	9.9	10.9	0.71
Rectum length, cm	14.9	14.6	0.54	14.3	15.3	0.96
Cecum mass, g	14.0	16.2	0.21	13.5	16.8	1.02
Cecum length, cm	32.5	31.7	0.92	49.8	53.6	1.31
Liver mass, g	51.8	53.9	0.89	98.9	109.8	1.42

4EG goslings and ducklings small intestine mass increased by 6 and 25 % and length – by 2 and 10 % respectively compared with the control group. Progressed gastrointestinal tract induced good food sorption, digestibility and explained maximal BM of 4EG of both treated species.

Summarising, diet supplementation with 9% sapropel could be considered as appropriate native, natural and safe component for ducklings feeding due to increased body gains, feed conversion rate, higher carcass meat yield and its quality, but sapropel is less contributing for goslings with larger body–build. The obtained data proved 6–9% organic sapropel to be suitable for duckling diet supplementation without impairment of growth ability and feed conversion under the conditions of complete diet.

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