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The Effects of Using Turkey Meat on Qualitative Properties of Heat-Treated Sucuk

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Abstract

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The effects of using different levels of turkey meat (0, 20, and 40%) on some quality properties of heat-treated sucuk were investigated. Lactic acid bacteria, *Micrococcus*/*Staphylococcus*, and *Enterobacteriaceae* counts were determined and pH and a_w analyses were carried out, taking samples from the batter, and also after the fermentation, heat treatment, and drying stages. The sensory and volatile compounds analyses were carried out on the final product. The use of turkey meat had a very significant effect on the pH and a_w values. The stage of production also had very significant effects on the pH and a_w values as well as on the lactic acid bacteria and *Micrococcus*/*Staphylococcus* counts. Heat treatment increased the pH value of the product. In all groups, terpenes constituted a major part of the volatile compounds. The use of turkey meat affected a few volatile compounds.

Keywords: turkey meat; sucuk; pH; volatile compounds; heat treatment

Sucuk, a type of dry fermented sausage, is widely produced and consumed in Turkey. In the sucuk production, beef and/or water buffalo meats are usually used as raw material. The duration of the production process is 6 to 20 days depending on the ripening conditions. Smoking and heat treatment are not used in this process (Soyer *et al.* 2005; Kaban 2013).

Poultry meat has been used in the production of fermented sausages since 1970s. However, the use of poultry meat in dry fermented sausage without heat treatment is controversial. There are two important factors in this controversy. The first factor is the high incidence of foodborne pathogens in poultry meat. *Salmonella* and *Campylobacter jejuni* are important pathogenic microorganisms in poultry meat. These pathogens cause serious public health hazards due to the high pH value of poultry meat. Another important pathogen is *Listeria monocytogenes* that limits the development of fermented meat products produced with the use of the poultry meat. It can be usually found in slaughterhouses, poultry processing plants and all raw poultry meat. Secondly, adipose tissue of poultry meat is not suitable for textural properties of dry fermented sausage (Santchurn & Collignan 2007).

While poultry meat is not used in sucuk produced with traditional methods, it has been used in contrast, in heat treated-sucuk for 20 years. The application of the heat treatment is of great importance in terms of the product safety in this type the product. However, because of the specific production method based on the principle of fermentation and drying, these products, which are produced differently from dry fermented sausages, must be stored in the cold because of their own high moisture content. Due to these properties, heat-treated sucuk can be included in the class of semi-dry fermented sausages. There exist researches into the use of poultry meat and the products properties in dry and semi-dry fermented sausages (Anil *et al.* 1995; Deumier & Coollignan 2003; Ensoy 2004; Gülbaz 2004; Karslioğlu *et al.* 2006; Sariçoban *et al.* 2006).

In these studies, the possibilities of using poultry meat such as turkey (Ensoy 2004; Karslioğlu *et*

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al. 2006), chicken (Anil *et al.* 1995; Sariçoban *et al.* 2005), and goose (Gülbaz 2004) in sucuk or heat-treated sucuk have been investigated. No studies occur on the production of heat-treated sucuk produced by using beef and turkey meats together as raw material. In this study, the effects of using turkey meat in the production of heat-treated sucuk on some microbiological, physical, chemical, and sensory properties and volatile compounds of heat-treated sucuk were investigated.

MATERIAL AND METHODS

Production of heat-treated sucuk. In the production of the sausages, 20 g nitrite-curing salt, 10 g garlic, 3 g sucrose, 7 g red pepper, 5 g black pepper, 9 g cumin, 2.5 g pimento per kg of meat (beef and beef/turkey meat), and fat (beef meat fat) were used. A commercial starter culture preparating (*Lactobacillus sakei* + *Lactobacillus curvatus*+ *Staphylococcus carnosus*) was used in the production. The production was conducted under the factory conditions (Aytaç – Red Meat and Meat Products Factory, Çankırı/Turkey). Sucuk batters were prepared in a meat mincer (Kolbe GmbH, Elchingen, Germany). First, the control group (0% turkey meat) was prepared, and subsequently the batters including different levels of turkey meat (20 and 40 %, based on meat weight) were prepared and each batter was stuffed into collagen casing (ø38 mm; Naturin Darm, Weinheim, Germany) using a stuffing machine REX RVF 760 (REX Technology, Thalgau, Austria). In the fermentation stage, the initial temperature of 24 ± 1°C was applied, while the relative humidity was adjusted 92 ± 2% using an automatic climate unit. After 24 h, the samples were subjected to heat treatment. In the heat treatment, initial temperature applied was 50°C and was gradually increased to 72°C in the core of the samples. Then, the samples were washed for 5 min with tap water and dried at 15°C for 3 days.

Sampling procedures. For the analyses, two random samples were taken from each group at various stages (batter and also after fermentation, heat treatment, and drying stages) of the production. These samples were subjected to microbiological and chemical analyses. Sensorial and volatile analyses were carried out on the final products. The samples for the volatile compound analysis were kept under –20°C until the beginning of the analysis.

Microbiological analyses. 25 g sample was transferred into a sterile stomacher bag (Lab Stomacher Blender 400-BA 7021; Seward, Worthing, UK) and 225 ml of sterile physiological water (0.85% NaCl) were added, the mixture was homogenised for 1.5 minutes. Serial decimal dilutions were prepared in the same diluents and 0.1 ml samples of appropriate dilutions were spread in duplicate on selective agar plates. Lactic acid bacteria and *Micrococcus*/*Staphylococcus* were enumerated on de Man Rogosa Sharpe Agar (MRS) in anaerobic conditions (Anaerocult A) and on Mannitol Salt Phenol-Red Agar (MSA) (all Merck, Darmstadt, Germany) in aerobic conditions after 48 h at 30°C, respectively. *Enterobacteriaceae* count was determined on Violet Red Bile Dextrose Agar (VRBD) (Merck) in anaerobic conditions after 48 h at 30°C.

Physico-chemical analyses. The pH was measured in the homogenate of the sample with distilled water (1 : 10 w/v) using a pH meter (ATI ORION 420; Orion Research, Beverly, USA). Water activity (a_w) was determined using a TH-500 a_w sprint apparatus (Novasina, Pfäffikon, Switzerland).

Volatile compound analyses. The extraction of the headspace volatile compounds was done using a SPME device (Supelco, Bellefonte, USA), using fibres of 75 µm, carboxen/polydimethylsiloxane (CAR/PDMS). The extraction and identification of volatile compounds were made according to Kaban and Kaya (2009a). The compounds were determined by comparing the results with mass spectra from the database developed by NIST and WILEY or standards molecules (for calculation kovats indices, Supelco 44585-U; Supelco, Bellefonte, USA) and by matching their retention indices with those given in the literature. Quantification was based on the total ion chromatogram on an arbitrary scale (70 eV). Mass spectra data of the volatile compounds were acquired in the range of 30–400 amu. The results were expressed as arbitrary area units (AU × 10^{-6}) as the mean of three replicates of each sample.

Statistical analyses. The results of analyses which depend on the proportion of turkey meat (0, 20, and 40%) and production stage (batter and after fermentation, heat treatment and drying) were analysed according to a completely randomised design (two replicates). However, the samples for volatile compounds were taken from the final product. The data were tested by the variance analysis, and the differences between the means were evaluated by Duncan's multiple range test using SPSS 13 statistics software (SPSS, Tulsa, USA).

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RESULTS AND DISCUSSION

Microbiological properties. The production stage had a significant ($P < 0.01$) effect on lactic acid bacteria count (Table 1). The mean count of lactic acid bacteria was determined as 6.41 log CFU/g in the batter due to the starter culture inoculation. Lactic acid bacteria showed good growth during fermentation and their count increased to 8.20 log CFU/g. However, heat treatment caused an important reduction ($P < 0.01$) in the lactic acid bacteria count, which decreased to 4.07 log CFU/g. Similarly, Candoğan (2000) reported a reduction in lactic acid bacteria count in fermented sausage produced with the application of heat treatment. In other studies conducted on the heat treated sucuk, heat treatment showed a significant effect on lactic acid bacteria (Ercoşkun 2006; Kurt & Zorba 2010; Çakir *et al.* 2013). However, no significant change in lactic acid bacteria count was observed during the drying stage (Table 1).

The use of turkey meat caused an increase in the count of lactic acid bacteria. The lowest mean value was determined in the control group. Lactic acid bacteria count was slightly higher in the group containing turkey meat. This result can be explained by that the pH and a_w values of the batters containing turkey meat were higher than those of the control batter. However, the interaction of the turkey meat and production stage had no significant effect on lactic acid bacteria ($P > 0.05$). *Micrococcus*/*Staphylococcus* count showed a slight increase in the fermentation stage. However, the differences between the mean counts were not significant (Table 1). Similarly, Lücke (1985) and Kaban and Kaya (2009b) indicated that these acid sensitive organisms demonstrate a weak growth or no growth during fermentation. On the other hand, *Micrococcus*/*Staphylococcus* count was affected by the heat treatment, and a decrease of approx. 2.5 log unit was observed ($P < 0.05$). The researches carried out on the heat-treated sausage were also determined that the production stages had a significant effect on the catalase-positive cocci count (Ercoşkun 2006). In addition, both the use of turkey meat and the interaction of the turkey meat and production stage had no significant effect on *Micrococcus*/*Staphylococcus* count (Table 1). *Enterobacteriaceae* count was 2–3 log CFU/g in all batters. After the heat treatment, *Enterobacteriaceae* count was under the detectable level (< 2 log CFU/g) in all groups. According to these results, *Enterobacteriaceae* family was easily eliminated by the heat treatment in heat-treated sucuk. On the other hand, mold growth on the surface of both semi-dry sucuk and other fermented sausages such as Prešporská saláma and Vysočina is undesirable (Pipek *et al.* 2010).

pH and a_w values. The interaction of the turkey meat use and production stage had a significant effect ($P < 0.01$) on pH value. In contrast, the interaction

Table 1. Overall effects of using turkey meat and production stage on the microbiological counts and pH and a_w values of heat-treated sucuk

	Lactic acid bacteria	*Micrococcus*/*Staphylococcus*	pH	a_w
	(log CFU/g)			
Production stage (PS)				
Batter	6.41 ± 0.20^b	6.00 ± 0.21^a	5.84 ± 0.09^a	0.959 ± 0.002^a
Fermentation	8.20 ± 0.36^a	6.14 ± 0.07^a	4.93 ± 0.04^d	0.958 ± 0.002^a
Heat treatment	4.07 ± 0.28^c	3.63 ± 0.05^b	4.98 ± 0.04^c	0.948 ± 0.002^b
Drying	3.96 ± 0.66^c	3.53 ± 0.20^b	5.03 ± 0.05^b	0.927 ± 0.001^c
Significance	**	**	**	**
Turkey meat ratio (TM)				
Control (0%)	5.38 ± 2.08^b	4.82 ± 1.41^a	5.14 ± 0.37^c	0.946 ± 0.013^b
20%	5.81 ± 1.69^a	4.82 ± 1.26^a	5.20 ± 0.40^b	0.948 ± 0.014^a
40%	5.80 ± 1.96^a	4.84 ± 1.35^a	5.25 ± 0.43^a	0.949 ± 0.014^a
Significance	*	ns	**	**
Interaction (PS × TM)				
Significance	ns	ns	ns	ns

*$P < 0.05$; **$P < 0.01$; ns – not significant; ^{a,b}any two means in the same column having the same letters in the same section are not significantly different at $P > 0.05$

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Table 2. Volatile compounds of heat treated sucuk with or without turkey meat

Compounds	RI	KI	Turkey meat ratio		
			control (0%)	20%	40%
Aliphatic hydrocarbons					
Hexane	A	600	1.80 ± 0 .12[a]	2.18 ± 0.28[a]	1.03 ± 0.71[a]
Heptane	A	700	3.79 ± 2.33[a]	4.50 ± 0.21[a]	2.74 ± 1.92[a]
Octane	A	800	1.00 ± 0.72[a]	0.41 ± 0.34[a]	0.43 ± 0.28[a]
Undecane	A	1100	14.84 ± 14.34[a]	11.96 ± 10.92[a]	5.41 ± 4.46[a]
Dodecane	A	1200	1.81 ± 7.25[a]	12.83 ± 7.82[a]	11.69 ± 1.63[a]
Tridecane	A	1300	6.89 ± 2.24[a]	9.61 ± 3.30[a]	9.19 ± 1.20[a]
Tetradecane	A	1400	3.43 ± 0.91[b]	5.16 ± 0.59[ab]	6.38 ± 0.56[a]
Pentadecane	A	1500	1.16 ± 0.25[a]	2.32 ± 0.76[a]	2.34 ± 0.91[a]
Sulphur compounds					
Methyl thiirane	B	574	12.44 ± 1.06[a]	11.60 ± 3.45[a]	10.29 ± 0.97[a]
Allyl methyl sulfide	B	730	12.64 ± 2.84[a]	9.96 ± 1.18[ab]	6.61 ± 0.69[b]
1-Propene-3,3'-thiobis	B	888	6.39 ± 1.46[a]	7.02 ± 2.14[a]	6.85 ± 2.45[a]
Methyl-2-propenyl disulfide	B	958	2.82 ± 1.08[a]	1.56 ± 0.45[a]	3.48 ± 0.88[a]
Diallyl disulfide	B	1138	7.34 ± 2.80[a]	10.14 ± 1.42[a]	10.52 ± 1.32[a]
3-(4-methyl-3-pentenyl) thiophene	B	1332	0.00 ± 0.00[a]	0.99 ± 0.47[a]	1.75 ± 1.12[a]
Esters					
Ethyl acetate	A	648	3.27 ± 1.82[a]	3.25 ± 1.17[a]	3.29 ± 1.40[a]
Acetic acid ethenyl ester	B	743	0.39 ± 0.04[a]	0.33 ± 0.01[a]	0.00 ± 0.00[b]
Propionic acid, butyl ester	B	976	1.09 ± 0.23[ab]	2.36 ± 0.69[a]	0.00 ± 0.00[b]
Hexanoic acid, propyl ester	B	1151	1.84 ± 2.60[a]	4.40 ± 1.79[a]	4.09 ± 5.78[a]
Butanoic acid, hexyl ester	B	1221	3.17 ± 0.33[a]	3.49 ± 1.41[a]	1.86 ± 0.72[a]
Aldehydes					
Acetaldehyde	C	< 500	1.14 ± 0.35[a]	1.02 ± 0.01[a]	0.81 ± 0.01[a]
Pentanal	B	742	4.93 ± 0.48[a]	3.08 ± 0.64[a]	4.76 ± 2.48[a]
Hexanal	A	849	5.22 ± 1.16[a]	6.29 ± 3.01[a]	10.18 ± 0.31[a]
Heptanal	B	955	1.12 ± 0.42[a]	1.03 ± 0.27[a]	1.12 ± 0.19[a]
2-Methyl-3-phenyl propanal	B	1334	3.85 ± 2.22[b]	9.14 ± 3.72[ab]	13.62 ± 2.47[a]
Alcohols					
Ethanol	C	539	6.68 ± 1.32[a]	6.56 ± 1.51[a]	7.30 ± 0.85[a]
1-Propen-2-ol	C	597	2.61 ± 0.83[a]	1.51 ± 0.09[a]	0.93 ± 0.70[a]
1-Hexanol	B	935	1.46 ± 0.51[a]	2.13 ± 0.62[a]	2.64 ± 0.64[a]
3-Hexen-1-ol	C	952	0.25 ± 0.35[a]	0.43 ± 0.16[a]	0.31 ± 0.01[a]
1-Terpinen-4-ol	C	1287	1.00 ± 0.11[a]	2.53 ± 1.75[a]	2.00 ± 1.00[a]
Ketones					
2,3-Butanedione	C	678	2.33 ±1.48[a]	1.68 ± 0.47[a]	1.91 ± 0.23[a]
Acetoin	B	779	4.74 ± 0.84[a]	2.36 ± 1.71[a]	3.16 ± 0.61[a]
2-Heptanone	B	948	0.92 ± 0.21[a]	1.05 ± 0.24[a]	0.99 ± 0.23[a]
Acids					
Acetic acid	A	717	2.24 ± 1.53[a]	1.40 ± 0.60[a]	1.49 ± 0.35[a]
Furans					
Furan,2-pentyl	B	1021	0.13 ± 0.18[a]	0.44 ± 0.27[a]	0.78 ± 0.71[a]

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Table 2 to be continued

Compounds	RI	KI	Turkey meat ratio		
			control (0%)	20%	40%
Aromatic hydrocarbons					
Toluene	A	789	1.94 ± 0.48[a]	3.30 ± 1.12[a]	2.29 ± 0.69[a]
p-Xylene	B	894	1.56 ± 0.91[a]	1.38 ± 0.72[a]	1.12 ± 0.62[a]
Styrene	B	933	0.46 ± 0.06[a]	0.60 ± 0.11[a]	0.64 ± 0.23[a]
1,3-Bis(1,1-dimethylethyl)-benzene	C	1289	1.56 ± 0.54[a]	2.09 ± 0.23[a]	2.17 ± 0.60[a]
1,2-Dimethoxy-4-(2-propenyl)- benzene	B	1485	0.00 ± 0.00[b]	0.16 ± 0.23[ab]	0.57 ± 0.04[a]
Terpenes					
α-Thujene	B	944	2.02 ± 1.03 [a]	2.02 ± 1.72 [a]	2.05 ± 0.98 [a]
1R-α-pinene	B	957	4.63 ± 1.40[a]	3.84 ± 2.77[a]	2.83 ± 2.1[a]
Camphene	B	970	1.06 ± 0.64[a]	0.68 ± 0.25[a]	0.85 ± 0.51[a]
β-Pinene	B	988	47.99 ± 19.95[a]	53.27 ± 17.37[a]	57.13 ± 6.34[a]
β-Myrcene	B	1005	41.08 ± 18.71[a]	40.16 ± 12.47[a]	56.07 ± 8.55[a]
α-Phellandrene	B	1019	6.02 ± 2.06[a]	2.76 ± 3.90[a]	4.08 ± 0.64[a]
3-Carene	B	1022	22.24 ± 3.49[a]	30.54 ± 18.16[a]	22.09 ± 18.76[a]
α-Terpinene	B	1030	0.00 ± 0.00[a]	2.94 ± 0.55[a]	3.08 ± 1.58[a]
D-Limonene	B	1054	0.00 ± 0.00[a]	26.04 ± 10.42[a]	10.17 ± 14.38[a]
o-Cymene	B	1059	90.20 ± 48.7[a]	137.01 ± 40.16[a]	127.64 ± 35.10[a]
Eucalyptol	B	1064	4.92 ± 1.83[a]	3.99 ± 2.10[a]	3.04 ± 1.51[a]
γ-Terpinene	B	1079	7.55 ± 2.74[b]	22.46 ± 4.43[a]	18.33 ± 4.14[ab]
Terpinolene	C	1128	0.00 ± 0.00[b]	1.35 ± 0.05[a]	1.49 ± 0.62[a]
Linalool	B	1161	2.56 ± 0.21[a]	3.27 ± 0.18[a]	3.70± 1.39[a]
α-Cubebene	C	1453	1.22 ± 0.22[a]	1.81 ± 0.30[a]	1.71 ± 0.36[a]
Eugenol	C	1460	0.00 ± 0.00[b]	0.63 ± 0.06[a]	0.59 ± 0.06[a]
Caryophyllene	C	1490	2.00 ± 0.49[b]	4.46 ± 0.73[a]	4.27 ± 0.40[a]

Results are expressed in Arbitrary Area Units ($\times 10^{-6}$) as means of 3 replicates of each sausage; RI – Reliability of identification: A – mass spectrum and retention time identical with an authentic sample, B – mass spectrum and Kovats index from literature in accordance; C – tentative identification by mass spectrum; KI – Kovats index calculated for DB-624 capillary column (J&W Scientific: 30 m, 0.25 mm *i.d.,* 1.4 μm film tickness) installed on a gas chromatograph equipped with a mass selective detector

of the turkey meat proportion and production stage had no effect ($P > 0.05$) on pH value.

An increase in pH value was determined depending on the increasing proportion of turkey meat. The lowest mean pH value was measured in the heat treated sucuk without turkey meat. While pH value was under 5 after the fermentation stage, the heat treatment application caused an increase in pH value ($P < 0.05$), indicating that protein denaturation caused by heat-treatment resulted in an increase in pH (Ercoşkun *et al.* 2010). Similarly, an increase was observed in the drying stage. High a_w values were determined in the heat treated samples containing turkey meat in comparison with the control group. However, a_w value was under 0.93 in all groups at the end of the drying stage. As can be seen in Table 1, the mean a_w value was 0.927. According to the results, heat-treated sucuk can be named as semi-dry fermented sausage.

Volatile compounds. In this research, many volatile compounds such as aliphatic hydrocarbons, aromatic hydrocarbons, sulphur compounds, esters, ketones, alcohols, aldehydes, terpenes, acids, and furans were identified. The amounts of β-pinene, β-myrcene, 3-carene, and *o*-cymene were found significant in the groups with turkey meat and in control. In the sucuk production, the use of turkey meat had an effect on acetic acid ethenyl ester, eugenol, allyl methyl sulphide, propanoic acid, butyl ester, γ-terpinen, terpinolen, 2-methyl-3-phenyl propanal, tetrade-

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cane, 1,2-dimethoxy-4-(2-propenyl)-benzene, and caryophyllene at various levels. In all sucuk groups, terpenes constituted a major part of the volatile compounds. Acetic acid was the only acid identified and 2-penthyl furan was the only furan detected. Furans are related with the heating process. On the other hand, furan is derived from linoleic acid oxidation at 20°C (Ruiz *et al.* 1999).

Tetradecane was detected in the samples with turkey meat at a relatively higher level, but the difference between the means of the control group and 20% turkey meat added group was found as statistically not significant ($P > 0.05$). The use of turkey meat affected the occurrence of 1,2-dimethoxy-4(2 propenyl)-benzene, as this aromatic carbon compound was not detected in the control group.

At the same time, it was observed that the amount of allyl methyl sulphide decreased as the proportion of turkey meat increased, and the differences between the means of all groups were found to be statistically significant ($P < 0.05$) (Table 2).

Another volatile compound group, esters, was also detected. The highest mean of acetic acid ethenyl ester was found in the control group. Differences between the groups in terms of propionic acid butyl ester were also determined. Esters in the meat products are generally formed by esterification of carboxylic acids and alcohols (Sabio *et al.* 1998; Rotsatchakul *et al.* 2009).

Some aldehydes were detected in statistically significant amounts. The highest propanal,2-methyl-3-phenyl meat value was observed in 40% turkey meat group while the lowest value was observed in the control group. It was also stated in other studies that propanal,2-methyl-3-phenyl is an important aldehyde for sucuk (Kaban & Kaya 2009a,b, 2010). Moreover, Çakır *et al.* (2013) mentioned that heat treatment increases the amount of this compound. Aldehydes sourcing from lipid oxidation and amino acid catabolism were also detected in other fermented sausages (Mateo & Zumalacarregui 1996; Flores *et al.* 2004). Lipid oxidation also affects on the oxidation of haem pigments (Rohlík *et al*. 2010).

A significant proportion of the volatile profile of sucuk samples consists of terpenes. The lowest mean values of statistically significant terpenes, γ-terpinen and caryophyllene, were seen in the control group. However, terpinolene and eugenol compounds were not detected in the control group. It was reported that spices are the main source of terpenes while feedstuff is an important means of transfer of these compounds into the meat (Hinrichsen & Pedersen 1995; Sabio *et al.* 1998; Anserona *et al.* 2001; Ramirez & Cava 2007; Kaban 2009).

CONCLUSIONS

The use of turkey meat resulted in an increase in pH values of sucuk batters but this increase had no negative effect on fermentation. In all samples, pH value of the final product dropped below 5 while a_w value dropped below 0.930. In all groups (control, 20, and 40% turkey meat), terpenes constituted a major part of the volatile compounds. The use of turkey meat had significant effects on some volatile compounds. As a result, it can be recommended that turkey meat can be partially used in the production of heat-treated sucuk as a substitute for beef at a proportion of 20%.

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