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THERMOREGULATION AND BLOOD BIOCHEMICAL CHANGES IN MALE DROMEDARY CAMELS DURING HOT-HUMID AND HOT-DRY ENVIRONMENTS UNDER EGYPTIAN CONDITIONS

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ABSTRACT

The present study was aimed to investigate the effect of breeding and non-breeding seasons either hot-humid or hot-dry months on thermoregulation parameters, blood haematology and blood serum components of 65 clinically healthy male dromedary camels.

The obtained results showed that, rectal temperature, respiration rate and pulse rate were significantly (P<0.05) higher during non-breeding season in hot-humid months than hot-dry months and breeding season. Haemoglobin and haematocrit red blood cells were significantly (P<0.05) higher during non-breeding season either hot-humid or hot-dry months than breeding season. While, white blood cells count was significantly (P<0.05) lower during non-breeding season in hot-humid months than hot-dry months and breeding season. Total protein concentration was significantly (P<0.05) increased, while albumin and globulin concentrations were insignificantly increased in the non-breeding season in hot-humid months as compared with hot-dry months and breeding season. Sodium concentration and activities of alkaline phosphatase, alanine-aminotransferase and aspartate-aminotransferase enzymes were significantly (P<0.05) higher during non-breeding season in hot-humid months as compared with hot-dry months and breeding season. Potassium concentration was significantly (P<0.05) higher during breeding and non-breeding seasons in hot-dry months than in hot-humid months. Cholesterol, calcium, total phosphorus and testosterone hormone concentrations were significantly (P<0.05) higher during breeding season than the non-breeding season in hot-dry and hot-humid months.

Key words: Blood components, breeding season, haematology, male camel, thermoregulation,

The dromedary camels are regarded as seasonal breeders (Wilson, 1984). The impression gained is that decreasing day length is the stimulus to seasonality, but it is obvious that, in dromedary camels near the equator factors such as rainfall, nutrition and management (Wilson, 1984), may override the effect of photoperiod (Merkt *et al,* 1990) and allow breeding to occur throughout the year (Arthur *et al,* 1982).

The breeding season of camels varies geographically, since the environmental factors affect temporally the pattern of reproduction in this species (Gombe and Okelo, 1977). Daylight ratio and temperature are the 2 main climatic factors influencing the seasonal physiological and biochemical changes which, in turn affect the sexual behaviour. However, numerous investigations have shown that the most efficient climatic factors are the variation in the daylight ratio (Hafez, 2000), although the length of daylight seems to be the primary stimulus for seasonality in reproduction.

The present study aimed to investigate the effect of breeding and non-breeding seasons either hot-humid or hot-dry environments on thermoregulation parameters, blood haematology and blood components of the male dromedary camels.

Materials and Methods

The present study was conducted in the Laboratory of Physiology, Department of Animal Production, Faculty of Agriculture, Ain Shams University, Egypt. The experimental work was carried out in Private Camel Farm and Abattoris in Belbies City, Sharkiya Governorate, located in the north eastern part of the Nile Delta (30°N), during the period from June, 2007 to May, 2008.

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The present study aimed to investigate the effect of breeding season (December to May) and non-breeding season either hot-humid (June to August) months or hot-dry (September to November) months (according to Egyptian Meteorological Authority) on thermoregulation parameters (rectal temperature, respiration rate and pulse rate), blood haematology (haemoglobin, haematocrit, red blood cells and white blood cells counts) and blood serum components including total protein, albumin, globulin, cholesterol, sodium, potassium, calcium, total phosphorus, alkaline phosphatase (ALP), alanine-aminotransferase (ALT), aspartate-aminotransferase (AST) enzymes, and testosterone hormone. A total number of 65 clinically healthy male dromedary camels were used in this study. The age of these camels varied from 5 to 10 years and their live weights were approximately 500-600 kg.

Minimum and maximum values of air temperature (°C), relative humidity (%), temperature-humidity index (THI) and length of daylight (hours), during breeding and non-breeding (hot-humid and hot-dry months) seasons are shown in Table 1. The temperature–humidity index (THI) was estimated according to Livestock and Poultry Heat Stress Indices (LPHSI, 1990) as the following formula: THI=db°F-(0.55-0.55×RH/100) (db°F-58.00). Where, db°F=dry bulb temperature in Fahrenheit and RH=relative humidity. The obtained values of THI were classified as follow: less than 72 = absence of heat stress, 72 to < 74 = moderate heat stress, 74 to < 78 = severe heat stress and over 78 = very severe heat stress.

Thermoregulation parameters

Rectal temperature, respiration rate and pulse rate were measured 10 times during the period from 9.00 to 12.00 am, during breeding and non-breeding (hot-humid and hot-dry months) seasons. Rectal temperature (°C) was obtained gently by inserting the digital liquid thermometer for 15–20 cm in the rectum for two minutes. Respiration rate (breaths/min) was determined by counting the frequency of flank movement per one minute. Pulse rate (pulses/min) was determined by counting the frequency of the jugular vein pulse with hand per minute. All possible precautions were taken in consideration to avoid disturbing the animal, therefore counting the respiration breathes and pulse rates were taken just before measuring the rectal temperature.

Blood haematology

Blood samples were collected from animals in dry clean screw caped tubes and divided into 2 portions. The first portion was collected into heparinised tubes to determine haemoglobin concentration (g/dl), haematocrit (%), counts of red blood cells ($x10^6/mm^3$) and white blood cells ($x10^3/mm^3$). The second portion was collected into non-heparinised tubes and centrifuged for the separation of serum and stored at –20°C for assaying of total protein, albumin, cholesterol, sodium, potassium, calcium, total phosphorus, ALP, ALT, AST enzymes, and testosterone hormone concentrations.

Haemoglobin concentration was determined in fresh blood samples using haemoglobinometer according to Tietz (1982). Haematocrit (%) was estimated by haematocrit capillary tube and centrifuged at 3000 g for 20 minutes. Haematocrit value was read and recorded according to Wintrobe (1965). Red blood cells (RBC's) and white blood cells (WBC's) were counted in fresh blood sample using haemocytometer and counted at x40 objective of phase contrast microscope according to Hawkey and Dennett (1989).

Blood serum components

Total protein was determined colourimetrically according to Biuret method as described by Welchselbaum (1946). Albumin concentration was determined colourimetrically according to Weis (1965). Globulin level was calculated by subtraction

Table 1. Mean air temperature, relative humidity, temperature-humidity index (THI) and length of the day light during breeding and non-breeding seasons (According to Egyptian Meteorological Authority).

Seasons		Air temperature (°C)		Relative humidity (%)		(THI)		Length of the day light (hrs)
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
Breeding season		11.23^{c} ± 0.19	21.66^{c} ± 0.27	43.02 ± 0.39	58.49 ± 1.18	50.40^{c}	68.02^{c}	12.84
Non-breeding season	Hot- humid months	20.84^{a} ± 0.32	34.30^{a} ± 0.46	42.67 ± 0.62	63.66 ± 0.95	65.88^{a}	86.60^{a}	15.24
	Hot-dry months	15.43^{b} ± 0.12	28.62^{b} ± 0.42	38.83 ± 0.48	53.42 ± 1.32	59.18^{b}	76.98^{b}	13.00

^{a,b,c} Values with different superscripts within a row are significantly different (P<0.05).

of albumin content from the total protein value. Cholesterol Sodium, potassium, calcium and total phosphorus concentrations were determined colourimetrically according to the methods described by Tietz (1982), Trinder (1951), Sunderman and Sunderman (1958), Gindler (1972) and Kuttner and Liechtenstein (1930), respectively.

Alkaline phosphatase (ALP) activity was determined colourimetrically using commercial kits (Stanbio kit, Texas, USA) according to Graham and Pace (1967). Alanine-aminotransferase (ALT) and aspartate-aminotransferase (AST), activities were determined colourimetrically using QCA kit, Amposta, Spain according to Reitman and Frankle (1957). Testosterone concentration was determined in blood serum by Radioimmunoassay Technique (RIA) of Coat-Ab-Count Kits (Diagnostic Products Corporation-Los Angles, USA) according to manufacturer information.

Data were statistically analysed by one way ANOVA, using General Linear Model (GLM) procedure of SAS (Goodnight *et al,* 1986). Duncan's New Multiple Range test (Duncan, 1955) was used to detect significant differences among means.

Results and Discussion

Temperature–humidity index (THI)

The THI shown in Table (1) indicated that the experimental camel exposed to severe heat stress and very severe heat stress during hot-dry and hot-humid months, respectively. Significant changes in both air temperature and THI occurred during the experimental period. There was 12.64 and 6.96% increase in air temperature, 18.58 and 8.96 units increase in THI and 2.40 and 0.16 hours in length of the day light during hot-humid and hot-dry months, respectively, in non-breeding season when compared to values of breeding season. The THI which reflects the combined effects of both air temperature and relative-humidity showed a similar trend to air temperature.

Thermoregulation parameters

Data presented in Table (2) showed that the rectal temperature, respiration rate and pulse rate of the male dromedary camels were significantly ($P<0.05$) higher during non-breeding season in hot-humid months than hot-dry months and breeding one and values were highest ($P<0.05$) hot-humid months and the lowest ($P<0.05$) values were recorded during breeding season. However, the effect of non-breeding season during hot-dry months was an insignificant increase in the rectal temperature, respiration rate and pulse rate compared to breeding season. Abdel-Samee and Marai (1997) showed that season of the year had a significant effects on rectal temperature and respiration rate (low in winter and high in summer) of the dromedary camel. Sarwat *et al* (1998) noticed lower pulse rate (43.46 counts/minutes) for dromedary camels (*Camelus dromedarius*) during the hot summer season. These results are in agreement with those reported by Khalifa *et al* (2002). Mohammed *et al* (2007) showed also that averages rectal temperature, respiration rate and pulse rate values were significantly lower in the cold season than in the dry hot season of adult one-humped camel. Similar trends were reported by Zeidan *et al* (2008) in the female dromedary camels.

The increase in rectal temperature during the hot summer conditions may be due to minimised temperature gradient between the body and the environment that resulted in reduced body heat gain (Abdel-Samee and Marai, 1997) and this could minimise the heat-stress on animals. The increased pulse rate and respiratory rate during hot-humid season is a physiological response to increase heat dissipation.

Blood haematology

Data presented in table 3 showed that the haemoglobin and haematocrit values of the male dromedary camels were significantly ($P<0.05$) higher during non-breeding season either hot-humid or hot-dry months than breeding season. The highest

Table 2. Effects of breeding and non-breeding seasons on thermoregulation parameters in the male dromedary camels (Means ± SE).

Item	Breeding season	Non-breeding season	
		Hot-humid months	Hot-dry months
Rectal temperature (°C)	38.69 ± 0.26^{b}	39.36 ± 0.17^{a}	38.91 ± 0.18^{b}
Respiration rate (breaths/min)	13.83 ± 0.37^{b}	23.45 ± 0.38^{a}	14.15 ± 0.39^{b}
Pulse rate (pulses/min)	50.22 ± 0.67^{b}	54.73 ± 0.68^{a}	50.30 ± 0.72^{b}

[a,b] Values with different superscripts within a row are significantly different ($P<0.05$).

(P<0.05) values of the haemoglobin and haematocrit were recorded during hot-dry months and the lowest (P<0.05) values were recorded during breeding season. However, the haemoglobin and haematocrit values during non-breeding season in hot-humid months were insignificantly lower as compared with the hot-dry months. These trends are in agreement with those reported by Zeidan and Abbas (2004). The present increase of haemoglobin during non-breeding season may be due to availability of iron and copper essential for haemoglobin synthesis, since camels during breeding season lose their appetite and body condition with diarrhoea (Schalm *et al*, 1975). The present overall mean of haematocrit value during all seasons was 31.65 %, which approached that reported by Nyangao *et al* (1997) who found that mean haematocrit value was 27.1% in dromedary camel.

The red blood cells count (RBC's) was significantly (P<0.05) higher of the male dromedary camels during non-breeding season either hot-humid or hot-dry months than breeding season. The RBC's count ($x10^6/mm^3$) during non-breeding season in hot-humid months was insignificantly higher as compared to the hot-dry months. The effect of non-breeding season during hot-humid months on the white blood cells (WBC's) count ($x10^3/mm^3$) produced a significant (P<0.05) lower, while insignificant higher values were observed during breeding season as compared to hot-dry months. These results are in agreement with those reported by Kataria *et al* (2002) and Zeiden and Abbas (2004) The highest (P<0.05) values of the RBC's and WBC's were recorded during hot-humid months and breeding season, respectively. While, the lowest (P<0.05) values of the RBC's and WBC's were recorded during breeding season and hot-humid months, respectively. Similar trends were reported by Zeidan and Abbas (2004) and Amin *et al* (2007) who found that the RBC's count increased significantly during the dry season than in the green season for one–humped camels. The increase of the RBC's count may be due to haemoconcentration during the hot weather (Kaneko, 1989).

The present results disagree with that reported by Rezakhani *et al* (1997). The reduction of blood haematological parameters during breeding season may be due to reduce oxygen intake, thus reducing metabolic heat production and the increase in WBC's in the breeding season may be to enhance immunity.

Blood serum components

Data presented in Table (4) showed that the effect of non-breeding seasons (hot-humid) on total proteins concentration of the male dromedary camels was significantly (P<0.05) higher, while albumin and globulin concentrations were insignificantly higher during non-breeding season in hot-humid months than hot-dry months or breeding season. The highest values of the total protein, albumin and globulin concentrations were recorded during hot-humid months, while the lowest values of the total protein and globulin concentrations were recorded during breeding season and lowest value of albumin concentration was recorded during hot-dry months. Similarly, Amin (1993) and Ahmadi (2001) found a significant increase in total protein concentration during summer as compared to the other seasons in camels. These results are in agreement with those reported by Ahmadi (2001) and Abd El-Samee and Marai (1997). These results suggest the greater ability of camels to adapt to heat stress. Amin *et al* (2007) showed that the serum level of globulin increased significantly during the dry season than in the green season of one-humped camels.

The increase of total protein during summer may be attributed to exposure to heat stress which represented the potent stimulus for growth releasing hormones (Maxwell and Kleemon, 1980) which led to increase in plasma protein that was considered important in maintaining plasma water (Horowiz and Adler, 1983) or due to haemoconcentration during summer. Moreover, physiological hypothyroidism during summer was accompanied by protein deposit

Table 3. Effects of breeding and non-breeding seasons on blood haematology in the male dromedary camels (Means ± SE).

Item	Breeding season	Non-breeding season	
		Hot-humid months	Hot-dry months
Haemoglobin (g/dl)	9.44 ± 0.26^b	11.04 ± 0.27^a	11.75 ± 0.28^a
Haematocrit (%)	26.60 ± 1.10^b	34.89 ± 1.12^a	36.14 ± 1.14^a
Red blood cells ($\times10^6/mm^3$)	7.92 ± 0.38^b	10.07 ± 0.39^a	9.18 ± 0.41^a
White blood cells ($\times10^3/mm^3$)	12.21 ± 0.57^a	9.51 ± 0.83^b	12.03 ± 0.61^a

[a,b] Values with different superscripts within a row are significantly different (P<0.05).

for retaining plasma water (Ganong, 1979). The same latter authors stated that the effect of seasons of the year on total proteins revealed a significant increase during summer in camels.

The cholesterol concentration of the male dromedary camels was significantly (P<0.05) higher during breeding than non-breeding season either hot-dry or hot-humid months (Table 4). The highest (P<0.05) value of the cholesterol concentration was recorded during breeding season, while the lowest (P<0.05) value was recorded during hot-humid months. These results are in agreement with those reported by Khan and Kohli (1973). Nazifi and Gheisari (1999) found that the concentration of serum cholesterol was significantly higher in winter than in summer months. Sarhan (2007) and Zeidan *et al* (2008) found that the cholesterol concentration of the dromedary she-camels during breeding was significantly higher than non-breeding season in the hot-dry or hot-humid months. The seasonal variations in serum cholesterol concentration may be due to the type of feed offered during different seasons. During breeding season (winter) the green fodder was berseem since berseem is a rich source of steroids (Salem, 1980). The significant decrease of cholesterol during non- breeding season (summer) may be due to rise of environmental temperature which influence serum cholesterol level (Zeidan *et al,* 2008).

Minerals profile

The sodium concentration of the male dromedary camels was significantly (P<0.05) higher, while potassium concentration was significantly (P<0.05) lower during non-breeding season in hot-humid than hot-dry months and breeding season (Table 4). The highest (P<0.05) values of the sodium and potassium were recorded during hot-humid months and breeding season, respectively. While, the lowest (P<0.05) values in blood sodium and potassium were recorded during breeding season and hot-humid months, respectively. These results are in agreement with those obtained by Rathore (1986) and Ahmadi (2001). Amin (1993) confirmed that the normal sodium values for adult male camel were 158.10, 162.60, 139.25 and 135.20 Equiv/L during spring, summer, autumn and winter, respectively. Similar trend was reported by Zeidan and Abbas (2004). These results may be attributed to the combined effects of both absorption and reabsorption of sodium and chloride from the alimentary tract and kidney under the effect of aldosterone which had higher levels in the summer and this was accompanied by increase of plasma sodium level (Yagil and Etzion, 1979). In addition, the increase in plasma sodium concentration during the heat of summer may be necessary to maintain blood osmotic pressure.

With regard to potassium, Ahmadi (2001) reported that plasma potassium concentration of the male dromedary camels was significantly (P<0.01) higher during winter than spring, summer and autumn seasons. Similar trend was reported by El-Mougy *et al* (1984), Abd El-Samee and Marai (1997), Nazifi *et al* (1999) and Zeidan and Abbas (2004) who confirmed that the concentration of potassium in winter months was higher than summer months (P<0.05) in dromedary camels. Amin (1993) also confirmed that the average values of potassium in adult male camel were 4.48, 3.95, 4.61 and 5.22 m Equiv/L during spring, summer, autumn and winter seasons, respectively. The decrease of potassium concentration during summer may be attributed to an increase of aldosterone secretion in hot and dry climate which is enhanced by renin-angiotensin system in response to changes in effective circulating fluid volume where aldosterone balances largely plasma potassium through its effect on renal absorption of sodium in exchange for potassium and hydrogen ion (Kaneko, 1989).

The calcium and total phosphorus concentrations of the male dromedary camels were significantly (P<0.05) higher during breeding than non-breeding season either hot-dry or hot-humid months (Table 4). The highest (P<0.05) values of the calcium and total phosphorus concentrations were recorded during breeding season, while the lowest (P<0.05) values were recorded during hot-humid months. Abbas and Musa (1989) reported that there was a marked increase in calcium of the camel during spring and summer, while this increase was highly significant during spring in comparison with that during winter season. These results are in agreement with those obtained by Ahmadi (2001). Similar trend was reported by Abd El-Azim (1996), Nazifi *et al* (1999) and Zeidan and Abbas (2004). Amin *et al* (2007) found that the concentrations of serum calcium and phosphorus increased significantly during the green season than in the dry season of one–humped camels. The increase of calcium concentration during winter may be due to the high calcium values of berseem (Trifolium alexandrinum) during rutting season (Ayoub *et al,* 1972). Abd El-Azim (1996) confirmed that phosphorus level in male camel was significantly decreased in both summer and autumn, while the significant increase was in winter and spring seasons.

Enzymatic activities

The serum ALP enzyme activity of the male dromedary camels was significantly (P<0.05) higher during non-breeding season particularly in hot-humid months than hot-dry months and breeding seasons (Table 4). The highest (P<0.05) value of the serum ALP enzyme activity was recorded during hot-humid months, while the lowest (P<0.05) values were recorded during the hot-dry months. These results are in agreement with those of Sarhan (2007) and Zeidan *et al* (2008) disagree with those obtained by Ahmadi (2001).

The serum ALT and AST enzymes activities of the male dromedary camels were significantly (P<0.05) higher during non-breeding season in hot-humid months than hot-dry months and breeding season. The highest (P<0.05) values of the serum ALT and AST enzymes activities were recorded during hot-humid months, while the lowest (P<0.05) values were recorded during breeding season (Table 4). These results are in agreement with those reported by Ahmadi (2001) and Nazifi *et al* (1999) and Zeidan and Abbas (2004). However, these results disagree with those obtained by Abd El-Samee and Marai (1997) who reported that ALT in camels was 137 and 139 U/L and AST was 613 and 599 U/L in breeding and non-breeding seasons, respectively and they did not differ significant between breeding and non-breeding seasons. The liver functions may be partially affected by heat stress during non-breeding season (Abd El-Samee and Marai, 1997).

Testosterone profile

The testosterone hormone concentration of the male dromedary camels was significantly (P<0.05) higher during breeding season than non-breeding season either hot-dry or hot-humid months (Table 4). The highest (P<0.05) value of the testosterone hormone concentration was recorded during breeding, while the lowest (P<0.05) value was recorded during hot-humid months. These results are in agreement with those reported by Ahmadi (2001) who showed that plasma testosterone concentration of the male dromedary camels was significantly higher during winter than spring, summer and autumn seasons. Similarly, Abd El-Azim (1996) and El-Sherief (1997) confirmed a significant increase in testosterone level in male one-humped camel during breeding season. The increase of testosterone is parallel to the increase of sexual activity in winter and spring seasons. These reflect the fact that the high androgen in the male camel during breeding season is the direct cause of the characteristics of its sexual behaviour. In addition, the decrease of androgen production during the non-breeding season could be explained by the effect of environmental cause as photoperiod, rainfall, temperature and humidity. Zeidan and Abbas (2004) confirmed that testosterone

Table 4. Effects of breeding and non-breeding seasons on blood serum components of the male dromedary camels (Means ± SE).

Item	Breeding season	Non-breeding season	
		Hot-humid months	Hot-dry months
Blood metabolities (gm/dl)			
Total protein	6.26 ± 0.28[b]	7.13 ± 0.36[a]	6.27 ± 0.30[b]
Albumin	3.26 ± 0.14[a]	3.81 ± 0.17[a]	3.21 ± 0.12[a]
Globulin	3.00 ± 0.26[a]	3.32 ± 0.32[a]	3.06 ± 0.28[a]
Cholesterol	261.25 ± 24.18[a]	123.75 ± 28.15[c]	228.75 ± 20.17[b]
Minerals profile (mg/dl)			
Sodium	120.37 ± 6.17[b]	164.50 ±6.14[a]	129.00 ± 8.53[b]
Potassium	8.61 ± 0.18[a]	5.98 ± 0.16[b]	8.45 ± 0.16[a]
Calcium	10.61 ± 0.38[a]	9.09 ± 0.26[b]	9.12 ± 0.51[b]
Total phosphorus	8.60 ± 0.50[a]	7.39 ± 0.54[b]	7.52 ± 0.55[b]
Enzymatic activities (U/L)			
Alkaline phosphatase	43.87 ± 2.72[b]	52.125 ± 3.77[a]	43.37 ± 2.67[b]
Alanine-aminotransferase	5.75 ± 0.87[c]	11.87 ± 0.81[a]	7.87 ± 0.92[b]
Aspartate-aminotransferase	9.50 ± 0.85[c]	31.50 ± 1.15[a]	23.75 ± 1.12[b]
Hormonal profile (ng/ml)			
Testosterone	4.88 ± 0.14[a]	0.62 ± 0.12[c]	2.97 ± 0.14[b]

[a,b,c] Values with different superscripts within a row are significantly different (P<0.05).

concentration was significantly higher during the rutting compared with the non-breeding season in the male dromedary camels. Bedrak *et al* (1983) recorded significant low levels in testosterone during the non-breeding season which agree with the results of the present study and may be attributed to the low gonadotropins and high prolactin levels in the blood. At the same time, the low gonadotropins level in the non-breeding season could be explained by the inhibitory effect of prolactin secretion (Almeida and Lincoln, 1984). The seasonal rhythm of prolactin secretion is influenced by photoperiodism in which concentrations being high under long days and low under short days (Almeida and Lincoln, 1984).

In conclusion, exposure to high ambient temperature (non-breeding season) causes impairment of the metabolic biochemical functions in the male dromedary camel. The effect of heat is aggravated when heat stress in accompained with the high humidity and long day light. Exposure to elevated ambient temperature with the long day light evokes a series of drastic changes in camel biological functions, which include disturbances in total protein, minerals, enzymatic reactions, hormonal secretions and blood metabolites.

The male dromedary camels during breeding season (short day light) showed better blood haematology and components than non-breeding season either hot-dry or hot-humid months (long day light). Thermoregulation parameter was also better during breeding than the non-breeding season.

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