THE EFFECTS OF *COLA NITIDA* ON THIRST PERCEPTION IN INDIVIDUALS UNDER DIFFERENT CONDITIONS

Abstract

The study investigated the influence of *Cola nitida* on thirst perception in the male and female human subjects. Sixty (60) non-obese volunteers (30 males and 30 females) and non-habitual Cola nut chewers, aged 18-28years were used for the study. They were sub-divided into three (3) subgroups: underweight (n=10), normal weight (n=10) and overweight (n=10) for each gender. Subjects with hypertension, kidney and heart-related conditions were excluded from the study. Three environmental conditions were involved: The normal chamber temperature, with a room temperature (RT) of 27^0C and a relative humidity (RH) of 70%, the raised chamber temperature, with RT of 37^0C and RH of 90%.In the aforementioned conditions, the subjects sat quietly in the sweat chamber for 20 minutes. The third condition was the normal chamber temperature with exercise, when RT and RH were maintained at 27^0C and 70% respectively and the subjects pedalled a bicycle ergometer at moderate workload of 750J/minute for 20 minutes. The three conditions were before taking *Cola nitida*. Thirst perception rating was done immediately after the 20 minutes in the sweat chamber using the visual analogue scale.0.5g/kg body weight of *Cola nitida* was administered to each subject and chewed as a bolus, under each of the three experimental conditions. After ingestion, 50ml of deionized water was given to each volunteer to flush the masticated *Cola nitida* down the gut and the subject was allowed to rest for 90 minutes before being admitted into the sweat chamber. Conclusively, *Cola nitida* significantly influenced fluid loss via the sweat glands. Consequent upon the loss of fluid and electrolytes in the sweat (especially Na^+ and Cl^-), *Cola nitida* stimulated the thirst perception as a compensatory mechanism to the fluid loss. Therefore, some caution should be applied in the consumption of *Cola nitida* by human subjects (even among those already adapted to Cola nut eating), especially under raised temperature and exercise conditions.

INTRODUCTION

Cola nitida contains caffeine (as the most active ingredient) amongst many other principles (Umoren *et al.*, 2009). Caffeine, theophylline and theobromine (all in *Cola nitida*) are naturally occurring plant alkaloids referred to as methylxanthines. Methylxanthines share the ability to relax smooth muscles, stimulate the central nervous system (CNS) and produce diuresis (Umoren *et al.*, 2009).

The ability to sense and regulate body temperature is a key feature of human survival as a deviation of $\pm3.5^{0}$C from the resting temperature of 37.0^{0}C can result in physiological impairments and fatality (Moran and Mendal, 2002).

Thermoregulation is a neural process that matches information about the external environment with the appropriate human response to maintain a more or less stable internal environment relative to external variation (Nakamura and Morrison, 2008). It involves sensation of environmental conditions and the internal thermal state of the individual, the transmission of this information to the brain via afferent neural pathways and the initiation of the response by efferent signals from the brain (Nakamura and Morrison, 2008). The thermoregulatory system interacts with body fluid regulatory and cardiovascular systems (Takamata *et al.,* 2001). The maintenance of body fluid status prevents progressive hyperthermia during exercise in a hot environment (Sawka and Montain, 2000).

Sweating is the production of a fluid that is excreted by the sweat glands in the skin of mammals (Ugwu, 2010). It is a thermoregulatory physiological adaptation associated with sweat gland function after heat exposure. The rate and sensitivity to sweating; increases with increasing environmental temperature (Armstrong and Maresh, 1991; Libert *et al.,* 1988). Sweating serves both excretory and thermoregulatory roles, especially in humans (Ugwu,2007; Blood *et al.,* 2007).The sympathetic nervous system mainly regulates sweating (Stocking and Gubili, 2004).Sweat composition is mainly dependent on the secretive and absorptive mechanisms in the sweat glands that may increase or decrease the concentration of solutes (Ugwu, 1996; Shona *et al.,* 2010).

Increased temperature causes the autonomic nervous system to stimulate the eccrine glands; to secrete fluid onto the surface of the skin (Ugwu, 2007; Wyart *et al.,* 2007). The thermoregulatory center in the hypothalamus controls body temperature by regulating eccrine sweat output and blood flow to the skin (Holzle, 2002). It responds to changes in the core body temperature, hormones, endogenous pyrogens, physical activity and emotions; via the limbic system (Holzle, 2002).Caffeine also stimulates sweating in humans. Both intracellular and extracellular fluid contains dilute solutions of electrolyte minerals that cells rely on to perform a number of functions.

Caffeine intake increases renal excretion of sodium (alongside other electrolytes) and water. This is caused by both slightly increasing the glomerular filteration rate and inhibiting the tubular reabsorption of sodium and water (Milon *et al.*, 1988; Rieg *et al.,* 2004). Because of its diuretic effects, some authorities have recommended that athletes or airline passengers avoid caffeine in order to reduce the risk of dehydration through stimulation of urinary output (Maughan *et al.*, 2003). The aim of the study was to observe the influence of *Cola nitida* on thirst perception.

MATERIALS AND METHODS

SUBJECTS

Sixty (60) non-obese volunteers (30 males and 30 females) and non-habitual Cola nut chewers (Chukwu *et al.,* 2006), aged 18-28years were used for the study. Individuals from the University of Benin were used. Their health status was assessed with the aid of questionnaires and physical examination (Ugwu, 2007; Ugwu and

Oyebola, 1996). All the subjects were active but none was athletically trained as defined by the absence of a regular physical exercise programme during the last six months before the experiment (Kokkinos *et. al.*, 1995). They were divided into three (3) subgroups of underweight (n=10), normal weight (n=10) and overweight (n=10). Informed consent was obtained from each subject before the study and permission of the ethical committee of the university was also obtained.

Three environmental conditions were involved:

- The normal chamber temperature condition, with a room temperature (RT) of 27^0C and a relative humidity (RH) of 70%.
- The raised chamber temperature condition, with RT of 37^0C and RH of 90%.
- The normal chamber temperature with exercise condition, when RT and RH were maintained at 27^0C and 70% respectively (Ugwu, 1985; Ugwu, 1996).

The Sweat Chamber

Professor (Sir) A.C. Ugwu's Sweat Chamber (situated in the University of Benin) was used for the study. It is a room with the dimension 4m x 3m (Ugwu, 1978; Ugwu and Oyebola, 1992). A heater was used in raising the room temperature and a thermometer used in measuring it. An air conditioner was used to maintain the relative humidity while a hygrometer was used to measure it at the desired level (Ugwu and Oyebola, 1992). Prior to the studies, the subject's age (years), weight (kilogram), height (metre), blood pressure (mmHg) and pulse rate (beats/minute) were recorded.

Inclusion/Exclusion Criteria

Subjects with hypertension (Artfield, 1985), kidney and heart-related conditions (Reiling, 1999; Chukwu *et al.,* 2006) were excluded from the study. Knowing that the commonly accepted body mass indices (BMI) are: underweight (under 18.5 kg/m^2), normal weight (between 18.5-25.0 kg/m^2), overweight (between 25.0-30.0 kg/m^2) and obese (over 30.0 kg/m^2) (Omorede *et al.,* 2016); only the subjects that were underweight, normal weight and overweight but not obese were so categorized and included in the study. Volunteers discontinued the experiment on reaching any one of the two criteria: 20 continuous minutes of exercise and voluntary cessation (Troy *et al.,* 2008).

Each subject was studied on different days and studies commenced without breakfast (Marriot, 1993). Thirst perception rating was done immediately after the 20 minutes in the sweat chamber using the visual analogue scale (VAS) (Takamata *et al.,* 1995; Amabebe *et al.,* 2013).

There was a separate sheet of paper for each subject with a 10cm marking, the ends of which were marked "very thirsty" and "not thirsty". Subjects were first presented with instructions for completing the VAS. They then rated how thirsty they were by a mark across each scale.

0.5g/Kg body weight of *Cola nitida* (refers to a preliminary study in which the dose of *Cola nitida* taken in the study was worked out by allowing an ad libitum intake until the subjects were satisfied. The range of the intake was between 0.39g/kg and 0.57g/kg body weight (Obika *et al.,*

1995) was administered to each subject to be chewed as a bolus) (Igwe *et al.,* 2007). After ingestion, 50ml of deionized water was given to each volunteer to flush the masticated *Cola nitida* down the gut (Igwe *et al.,* 2007). The subject was allowed to rest for 90 minutes (preliminary experiments had suggested that the effects of the nuts were observable in body tissues 90 minutes after ingestion) (Igwe *et al.,* 2007). Thereafter, the subject was admitted into the sweat chamber.

Sweat Output

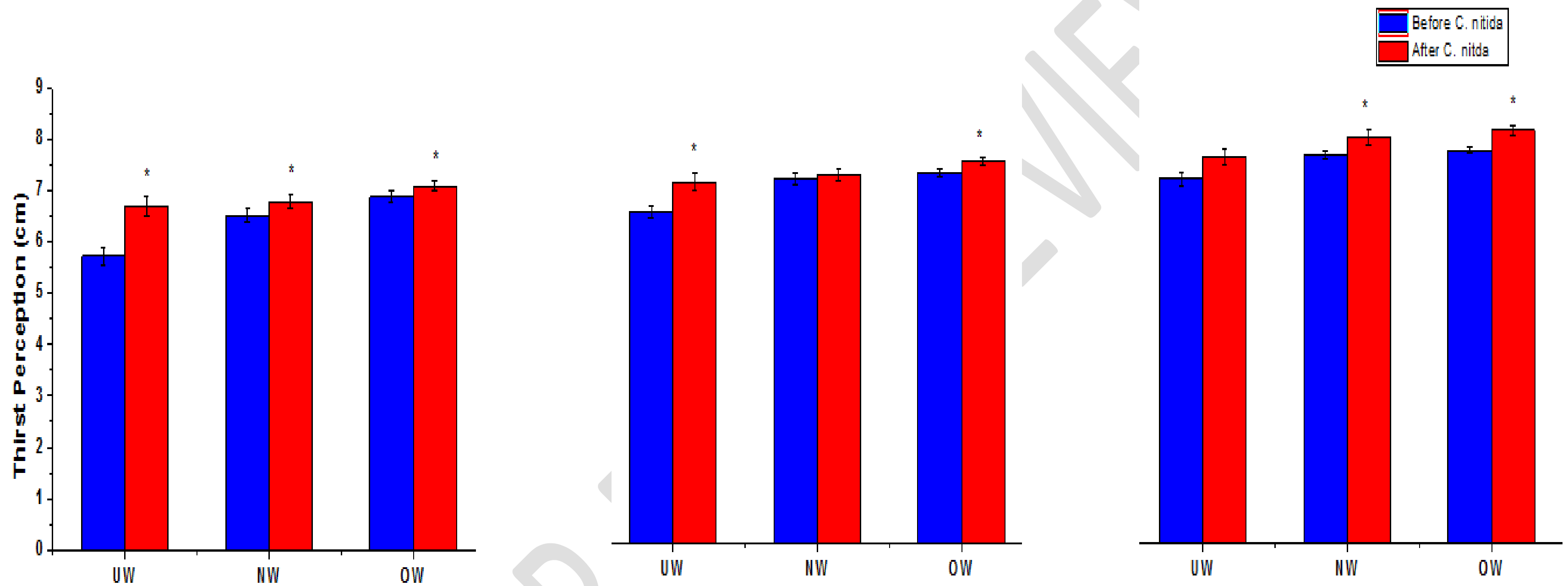
In the normal chamber temperature and raised chamber temperature conditions, the subject sat quietly in the sweat chamber for 20 minutes (Ugwu, 1986; Ugwu and Oyebola, 1996). While in the normal chamber temperature with exercise condition, the subjects pedalled a bicycle ergometer at moderate workload of 750J/minute for 20 minutes (Ugwu and Oyebola, 1992).

Data Analysis

All results were expressed by suitable tables and graphs as the Mean ± SEM. Statistical analyses were carried out using Microcal

Origin version 8.0 statistical software and the 0.05 level of probability ($P<0.05$) was regarded as significant.

RESULTS



NORMAL CHAMBER TEMPERATURE

(RT= 27^0C, RH= 70%)

RAISED TEMPERATURE

(RT= 37^0C, RH= 90%)

NORMAL TEMPERATURE WITH EXERCISE

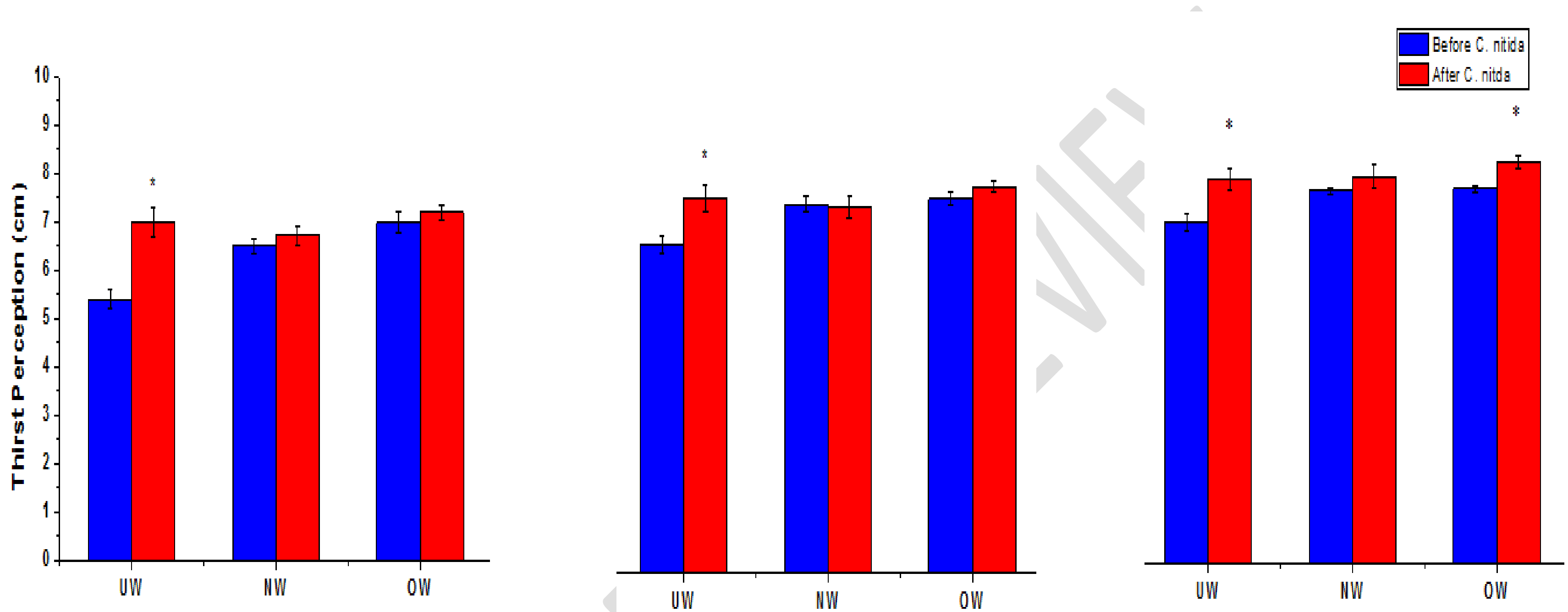
(RT= 27^0C, RH= 70%)

FIG. I: SHOWING THE ***THIRST PERCEPTION*** IN INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF *COLA NITIDA* AT DIFFERENT CONDITIONS.

*P<0.05 indicates significant difference when before ingesting is compared with after ingesting of *Cola nitida*.

$^{\alpha}$P<0.05 indicates significant difference when underweight is compared with normal and overweight.

$^{\#}$P<0.05 indicates significant difference when normal weight is compared with overweight.



NORMAL CHAMBER TEMPERATURE

(RT= 27^{0}C, RH= 70%)

RAISED TEMPERATURE

(RT= 37^{0}C, RH= 90%)

NORMAL TEMPERATURE WITH EXERCISE

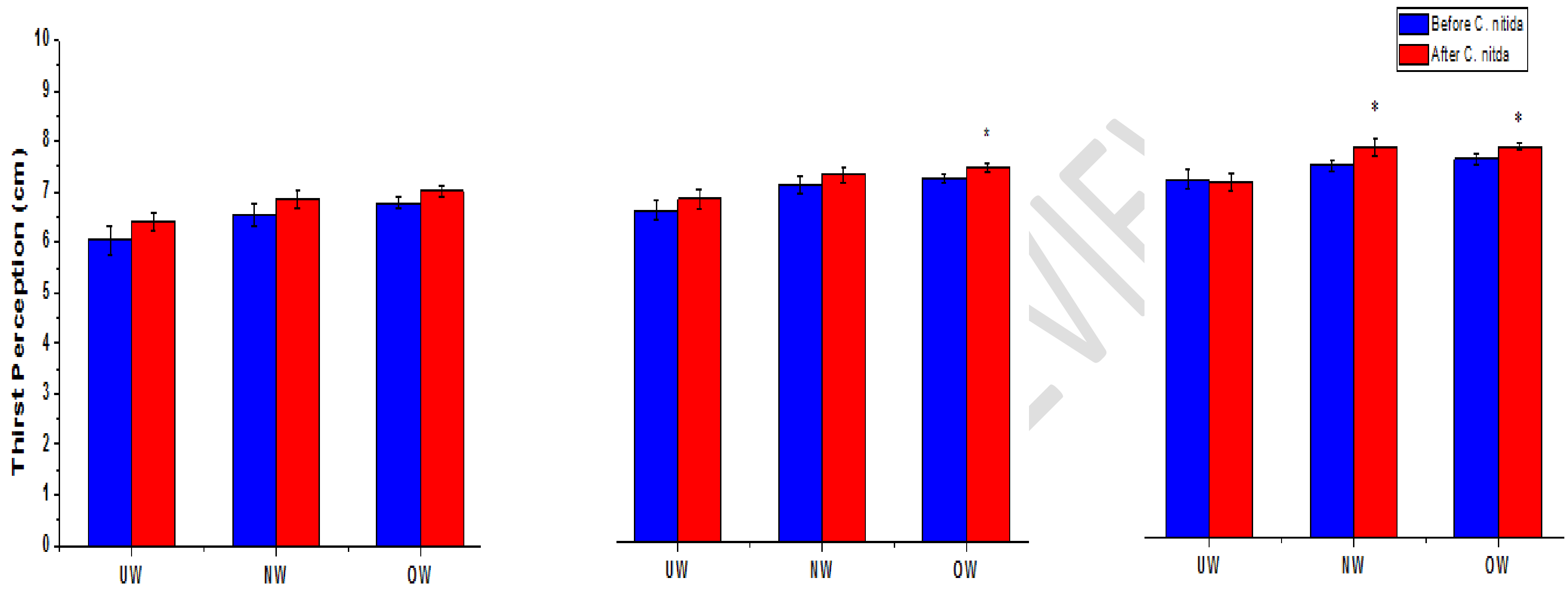
(RT= 27^{0}C, RH= 70%)

FIG. II: SHOWING THE ***THIRST PERCEPTION*** IN MALE INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF *COLA NITIDA* AT DIFFERENT CONDITIONS.

*P<0.05 indicates significant difference when before ingesting is compared with after ingesting of *Cola nitida*.

$^\alpha$P<0.05 indicates significant difference when underweight is compared with normal and overweight.

$^\#$P<0.05 indicates significant difference when normal weight is compared with overweight.



NORMAL CHAMBER TEMPERATURE

(RT= 27^{0}C, RH= 70%)

RAISED TEMPERATURE

(RT= 37^{0}C, RH= 90%)

NORMAL TEMPERATURE WITH EXERCISE

(RT= 27^{0}C, RH= 70%)

FIG. III: SHOWING THE ***THIRST PERCEPTION*** IN FEMALE INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF *COLA NITIDA* AT DIFFERENT CONDITIONS.

*P<0.05 indicates significant difference when before ingesting is compared with after ingesting of *Cola nitida*.

$^{\alpha}$P<0.05 indicates significant difference when underweight is compared with normal and overweight.

$^{\#}$P<0.05 indicates significant difference when normal weight is compared with overweight.

DISCUSSION

The results showed significant increases in thirst perception in all the subjects (under normal condition), UW and OW (under raised temperature condition) and NW and OW (under exercise condition) after ingesting *Cola nitida* compared to before (Fig. I, II and III). This could be because of hypovolemia due to dehydration following the loss of Na^+ and Cl^- to sweat which could have caused increased osmolality and tonicity of the extracellular fluid. Na^+ and Cl^- are primarily responsible for the increased plasma osmolality (Kubica *et al.,* 1983). Na^+ and Cl^- mobilise fluid from the intracellular fluid to the extracellular fluid to enable defense of plasma volume in hypohydrated persons.

Thirst sensations including dry mouth and throat increase with dehydration and decrease with rehydration (Phillips and Rolls, 2000). Dehydration stimulates physiological thirst via two main homeostatic mechanisms: i) increased cellular tonicity (cellular dehydration) detected by osmoreceptors in the central nervous system (CNS), and ii) decreased extracellular fluid volume (ECF, extracellular dehydration) sensed by baroreceptors in the large blood vessels (Kenney and Chiu, 2001). Central and peripheral osmoreceptors detect the degree of dehydration/hypertonicity and signal the hypothalamus to generate several thirst-associated homeostatic mechanisms.

Drinking patterns are influenced by plasma levels of certain hormones involved in hydromineral metabolism such as angiotensin II (A-II), arginine vasopressin (AVP), oxytocin, atrial natriuretic peptide (ANP), relaxin and aldosterone (Antunes-Rodrigues *et al.,* 2004; Amabebe *et al.,* 2017; Begg, 2017). Concurrent loss of NaCl (the major solute of the ECF) and water results in proportionately more ECF depletion than water loss alone. Several adaptive regulatory responses are employed during volume depletion of either the ICF or ECF. These responses which include activation of the renin-angiotensin system (RAS), AVP release, sympathetic activation and increased renal sodium and water reabsorption, have the adaptive tendency of curtailing alterations in volume and composition of body fluid (Amabebe *et al.* 2017; Begg, 2017; McKinley and Johnson, 2004; Stachenfeld, 2014).

Cumulatively, this could have resulted in the stimulation of the osmoreceptors located in the organum vasculosum of the lamina terminalis; with the end results of the following cascade of events being increased thirst and antidiuretic hormone secretion (Ciura *et al.,* 2011; Mckinley *et al.,* 2004). This is in agreement with the findings of Obika *et al.* (2009) that stated that dehydrated subjects have higher thirst perception than their euhydrate counterparts. According to Obika *et al.* (1996), *Cola nitida* stimulates drinking and increases thirst perception. Thirst perception also increased with increasing body mass index because of the subject's higher fluid and electrolyte loss during exercise (Osayande *et al.,* 2016).

Hypovolemic thirst involves a more complex mechanism (double feedback loop). It involves both volume detectors (baroreceptors) in the vascular compartment, which are activated with decreased blood volume; and renal mechanisms that stimulate the renin-angiotensin aldosterone system (RAAS) in response to decreased renal perfusion and NaCl concentration at the macula densa. Hypovolemia only develops into a crucial thirst stimulus during severe dehydration (Fitzsimons, 1991; Fitzsimons, 1998; Rolls and

Phillips, 1990). Stimulation of central osmoreceptors produces impulses that are transmitted to the cerebral cortex resulting in thirst and water-seeking behavior (Palevsky, 1998).

CONCLUSION

Cola nitida significantly increased thirst perception. It was most pronounced for the overweight subjects and under the exercise experimental condition. Therefore, to avoid possible over-stretching of the thirst mechanism in any of these conditions, Cola nitida consumption should either be avoided or minimized.

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