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Sporting aptitudes in rat as affected by *Solanum aethiopicum* Shum fruits consumption

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ABSTRACT

The consumption of performance-enhancing substances is not a novel practice. In Southern Cameroon, *Solanum aethiopicum* Shum fruit is consumed as ergogenic aid product. Animal experiment was carried out to evaluate the effect of the *S. aethiopicum* Shum fruit on physical performance in rat using rotating rod. The study showed a significantly higher water and food intakes in rats fed with *S. aethiopicum* Shum fruit during training period, while lower body weight was observed in these animals. Sporting abilities (speed and endurance) significantly increased, while tiredness decreased in rats fed diet containing *S. aethiopicum* Shum fruit compared to the control. The mass of faeces decreased during exercise in rats fed diet containing *S. aethiopicum* Shum fruits in comparison with control, indicating the improvement of their psychological state. Therefore, the results of this study suggest that the consumption of *S. aethiopicum* Shum fruits might have a beneficial effect on physical performance.

KEYWORDS

Solanum aethiopicum fruits;
Consumption;
Benefit;
Physical performance;
Rats.

INTRODUCTION

Physical performance is important in all daily activities of animal or human. Physical activity is helpful to satisfy essential necessities such as: locomotion, food, reproduction and globally welfare. In addition, physical performance is fundamental in sport events. The work of sportsmen and sports judges needs sporting capabilities. Consequently, several ergogenic aids are used to increase physical performance including physical training, drugs and the food supplements[1, 2, 3, 4]. Life being a sequence of challenges that need physical and mental strength, the performance-enhancing substances are used widely, despite of their serious adverse effects[5, 6]. These substances are ranged from soft to hard drugs, and can damage organs such as: brain, heart, kidney, liver, muscles, bones, testicles, ovaries and lungs[7, 8, 9]. The use of performance-enhancing substances is a real public health problem; the major mean of prevention is to provide alternatives[10]. However, the use of ergogenic aid depends on the diet habits of each people, its geographic area, biodiversity, culture and technological develop-

ment[11]. In Central and West Africa fruits of *Solanum aethiopicum* Shum (mock tomato) are consumed as performance-enhancing product by "*Bantous*" people.

Mock tomato is annual subtropical plant belongs to Solanaceae family, *Solanum* gender, species *Solanum aethiopicum* and group Shum[12]. It is a woody herb with a solid erect stem, black or green in colour, about 150 to 180 cm high. This plant can grow easily in extreme ecological conditions[13]. The leaves are alternate and pale green in colour. Its fruit is round, 1 to 1.5 cm diameter, grouped in clusters on the stem or branch; green in colour when unripe, yellow and orange are intermediate colour. At full ripeness, the fruit turns red, and its taste is bitter[12]. Scientific evidence has shown that they are rich in substances such as: glycoalkaloïds, high phenolic and vitamin C[13]. These phytochemicals only cannot justify folkloric performance-enhancing virtues attributed to *S. aethiopicum* Shum fruit. Phytochemical screening of *S. aethiopicum* Shum fruit will be necessary to know the pharmacological substances that it contains. In southerner Cameroon, the robustness and longevity of those people are associated with the consumption of traditional beverage made using *S. aethiopicum* Shum fruit as basic ingredient, called "*mindim me zon*". In form of beverage or raw, *S. aethiopicum* Shum fruits are consumed to remain vigorous all day long. However, we noticed the lack of scientific evidence related to improvement sporting abilities by the consumption of *S. aethiopicum* Shum fruits.

In this paper, we reported that follows: phytochemical screening of *S. aethiopicum* Shum fruit; the effect of *S. aethiopicum* Shum fruit consumption on the diet behaviour in rats during physical training period; finally, the effect of *S. aethiopicum* Shum fruit consumption on various parameters of physical performance such as endurance and speed in rats using rotarod.

EXPERIMENTAL

Phytochemical screening of *Solanum aethiopicum* Shum fruits

The fruit material was collected from *S. aethiopicum* Shum plant, in the month of October, growing on the locality of Ngaoundere, Adamawa Region, Cameroon, altitude 3,640 feet, located at 7°24'.730N and 13°33'.001E(GPS, Garmin version 2.11). A voucher specimen (N°HNC/14610 dated 25-08-2009) has been deposited at the National Herbarium of Research Institute of Agricultural Development, Yaounde, Cameroon. The fruits were sorted (1–1.5 cm of diameter), washed (tap water), disinfected (2% sodium hypochlorite), rinsed (distilled water), cut, dried (40°C/24 h, vegetable dryer) and ground (vegetable grinder, particle of 1 mm). Resulting fruits powder has been used for experimental diet, as well as to identify the pharmacological substances.

Phytochemical tests were performed on the extracts samples obtained with solvents such as: water, methanol, ethanol and hexane using standard procedures[14, 15, 16]. The presence of each substance in *S. aethiopicum* Shum fruits was appreciated by changes observed in the reaction medium (colouration and foam). Reaction intensity was used to categorize each constituent of *S. aethiopicum* Shum fruits into very abundant, moderately abundant, slight and absent.

Animals and diet

A total of twelve Wistar male rats, eight weeks old were used in the experiment, following instructions of Committee for the Update of the Guide for the Care and Use of Laboratory Animals. The rats were divided into two different groups of six. They were randomly housed with six in each plastic cage, under controlled conditions of temperature, humidity and light (12-h light–dark cycle, 23°C ambient temperature and 60% humidity). The first group (control) was fed with basal diet. The second group (test) was fed with diet containing fruits powder of *S. aethiopicum* Shum. The composition of the diets consumed by animals over the 20 days of study period is shown in TABLE 1.

Rotarod test

Rats have been trained during five days on the Rotarod, in order to reduce the anxiety levels prior to testing. The rats were placed on the roller lane of the Rotarod with diameter of 7 cm set at 16 revolu-

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TABLE 1 : Composition of the experimental diets fed to rats over the 20 day study period

	Diets	
Ingredients (%)	Control	Test
Fish powder	15	15
Maize flour	40	35
Bran	19	19
Palm oil	20	20
Minerals	5	5
S. aethiopicum Shum fruits	-	5
Salt	1	1

tions per min (model PBS 12V DC 81/WW, Harvard apparatus, from Panlab) for four animals, and the timer was started. When the animal drops safely into its own lane, the time latency to fall (minutes and seconds) as indicated in Figure 1. Rats that were able to continuously walk on the rotating rod for at least 3 min (180 s) were selected for the physical exercise test[17].

During the assay, animals walk for a maximum of 10 min four times weekly in the evening on a horizontal rotating rod set at 25 revolutions per min. When the animal dropped safely or changing direction on the roller lane, it was repositioned immediately to follow the walk, until the time of falls or direction changes become brief (each five seconds). At that moment, the time spent on the Rotarod was recorded. Every five days, the parameters associated with physical activity such as: number of falls, time spent and speed on rotating rod, and number of direction changes. Parameters of stress during the physical effort including defecation have been recorded. On the other hand, the changes in body weight and diet behaviour (food and water intakes) during 20 days training period have been evaluated.

Statistical analysis

The collected data regarding animals were analysed using Statgraphics Plus version 5.1. The difference between the control and treated values were established by analysis of variance (ANOVA). P-values < 0.05 were taken to be significant. Results were expressed as mean ± SD (standard deviation) and presented as figure using Sigmaplot software version 11.0.

Figure 1 : Rotarod showing three rats walking on the horizontal rotating rod and one falling into its own lane

RESULTS

Phytochemical study of *solanum aethiopicum* shum fruits

As shown in TABLE 2, the fruits of *S. aethiopicum* Shum were rich in many pharmacological substances such as: alkaloids, phlobatannins, flavonoids, anthraquinones, glycosides, tannins, saponins, steroids, Terpenoids and phytosterols. Alkaloids, saponins, flavonoids and phytosterols were very abundant; there was slightly presence of triterpens and anthraquinones; moderate abundance of glycosides, tannins, steroids.

Diet behaviour and body mass in rats during physical training

The body weight of rats and the parameters of diet behaviour such as: water and food intakes in rats were measured every five days during training period on rotarod. As presented in Figure 2, there was a tendency for both water and food intakes to be higher in rats fed diet containing *S. aethiopicum* Shum fruits in comparison with control. The greatest increase of food and water intakes was observed

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TABLE 2 : Determination of phytochemicals in *S. aethiopicum* Shum fruits

Phytochemicals	Extract				
	Aqueous	Methanolic	Ethanolic	Hydroethanolic	Hexanic
Alkaloids	+++	++	++	+++	-
Phlobatannins	+	-	++	++	-
Flavonoids	++	+	+	+++	-
Anthraquinones	+	-	+	+	-
Glycosides	++	+	++	++	-
Tannins	+	+	++	++	-
Saponins	+++	+	+	++	-
Steroids	++	-	+	++	+
Terpenoids	-	-	+	+	-
phytosterols	+++	++	++	+++	+

+++ (very abundant), ++ (moderately abundant), + (trace), – (absent)

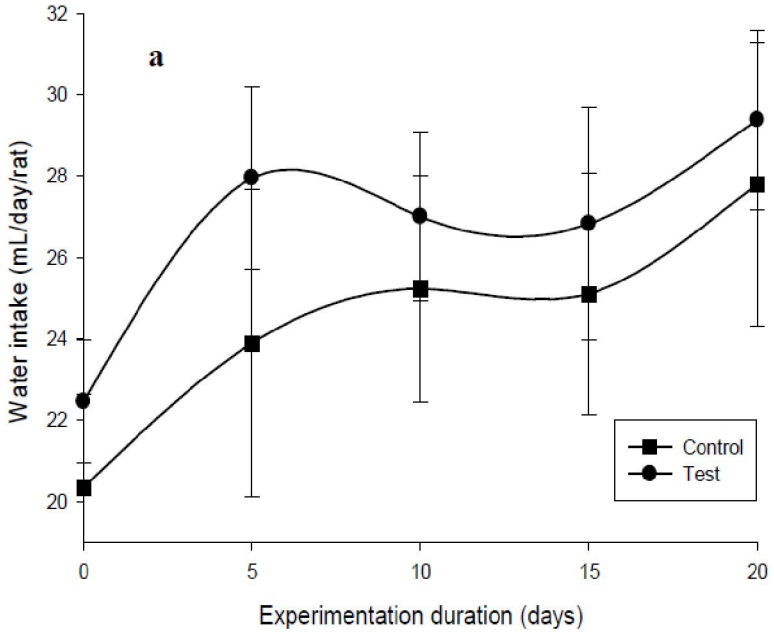

Figure 2a : Changes in the water intake of rat trained on rotarod, Rats were fed with diet containing *S. aethiopicum* Shum fruits and control diet, Values are shown as means ± SD of six animals

at five days after the start of animals training. The higher intakes were statistically throughout the training period in rats fed with *S. aethiopicum* Shum fruits ($p < 0.05$). However, the body weight had a tendency to be lower (Figure 3) in rats fed diet containing *S. aethiopicum* Shum fruits compared to control. The decrease in body weight became statistically significant at ten days after the initiation of the training, in comparison with control ($P < 0.05$).

Physical performance

Endurance and speed

The parameters of the physical performance such as: exercise endurance and speed were evaluated every five days of the rats training period on rotarod and presented in Figure 4. The exercise endurance increased linearly as function of training period. The increase of the exercise endurance was significant in rats fed diet containing *S. aethiopicum* Shum fruits in comparison with control ($p < 0.05$). The speed of rats on rotarod had also a tendency to increase linearly during the training period. It was higher in rats fed diet containing *S. aethiopicum* Shum fruits at 5, 10 and 20 days after the start of training ($p < 0.05$). There was no significant difference between treated rats and control in terms of rat speed on rotarod at

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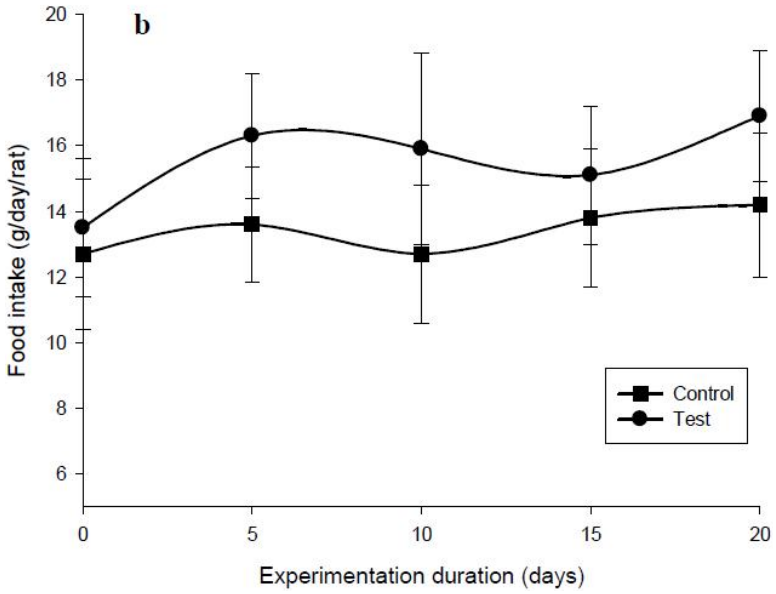

Figure 2b : Changes in the food intake of rat trained on rotarod, Rats were fed with diet containing *S. aethiopicum* Shum fruits and control diet, Values are shown as means ± SD of six animals

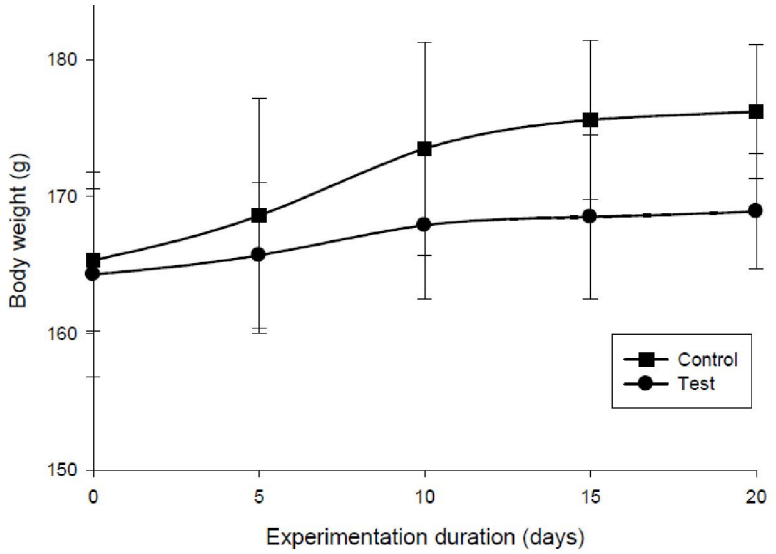

Figure 3 : Changes in the body weight of rat trained on rotarod, Rats were fed with diet containing *S. aethiopicum* Shum fruits and control diet, Values are shown as means ± SD of six animals

15 days after the initiation of training ($p > 0.05$).

Parameters of tiredness in rats

The effect of *S. aethiopicum* Shum fruits consumption on the parameters of the tiredness (numbers of falls from rotating rod and direction change of walking) in rats was presented in Figure 5. There was a tendency for both numbers of falls from the rotating rod and direction change to decrease as a function of experimentation period in rats fed with diet containing *S. aethiopicum* Shum fruits in comparison with control ($p < 0.05$). The lower numbers of falls and direction change were observed at 20 days after the initiation of training.

Faeces mass on rotating rod as stress factor in rats during physical training

The effect of *S. aethiopicum* Shum fruit consumption on the stress factor as defecation during effort on the trained rats was shown in Figure 6. There was a significant difference between treated and control rats ($p < 0.05$). The faeces mass in rats fed with diet containing *S. aethiopicum* Shum fruits was lower than control throughout the training period.

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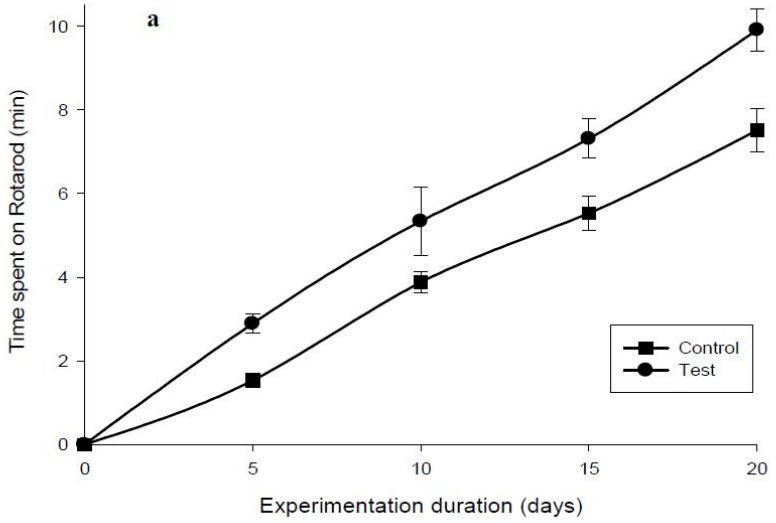

Figure 4a : Changes in the effort volume of rat trained on rotarod, Rats were fed with diet containing *S. aethiopicum* Shum fruits and control diet, Values are shown as means ± SD of six animals

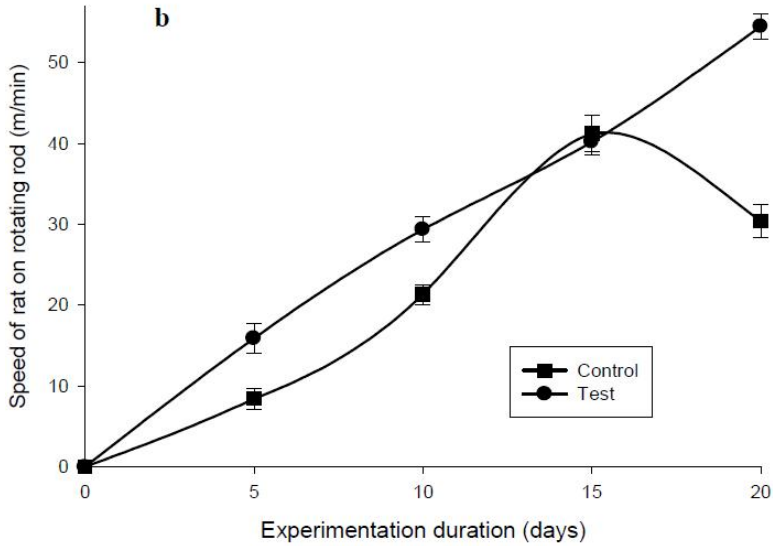

Figure 4b : Changes in the speed of rat trained on rotarod, Rats were fed with diet containing *S. aethiopicum* Shum fruits and control diet, Values are shown as means ± SD of six animals

The lowest of faeces mass were observed at ten and 20 days after the start of experimentation, while the highest were obtained at 5 days after the beginning of experimentation.

DISCUSSION

Traditional use of *S. aethiopicum* Shum fruits as ergogenic aid may be explained by individual or synergetic action of their phytochemicals. Several *Solanum* species have antiviral, anticancer, anticonvulsant and anti-infective, hypoglycaemic, hypolipidemic, antioxidant, analgesic and anti-inflammatory effects[13, 18]. These properties procure global well-being, but their performance-enhancing effects are not reported. This study revealed that *S. aethiopicum* Shum fruit can be an interesting source of phytochemicals which can directly or indirectly affect physical and mental performance[18, 19, 20].

The consumption of *S. aethiopicum* Shum fruits improved water replenishment in rats. Water is considered as first ergogenic aid[22], due to the fact that it plays essential role in circulatory function, bioenergetics reaction, elimination of waste products, maintenance of the body temperature and plasma volume[4]. The functioning of the body's vital organs, such as the kidneys, brain and heart, is limited without a certain amount of water. So, water replenish-

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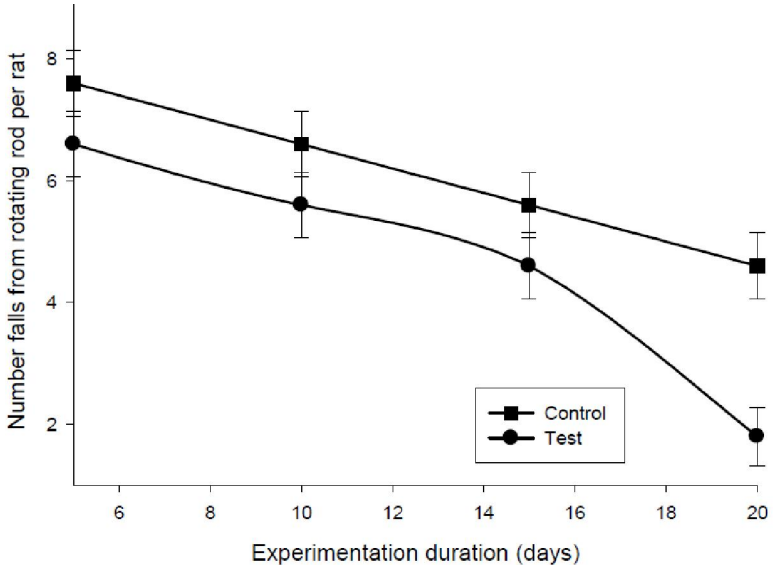

Figure 5a : Variation in the rat falls on rotarod, Rats were fed with diet containing *S.aethiopicum* Shum fruits and control diet, Values are shown as means ± SD of six animals

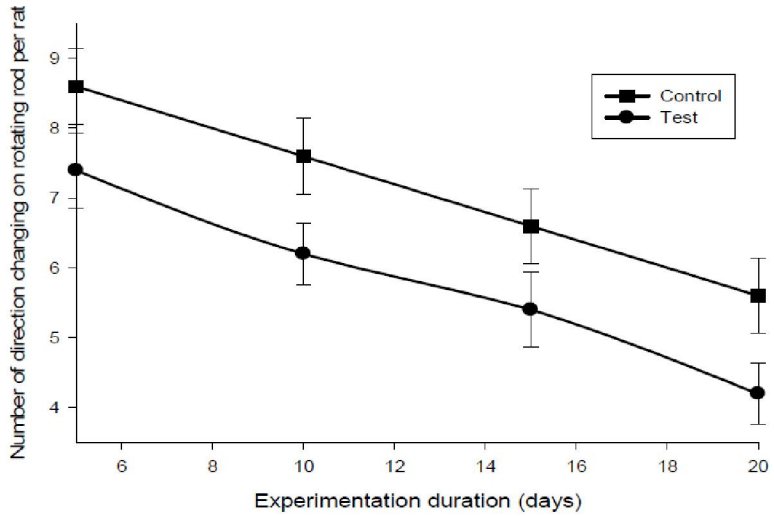

Figure 5b : Variation in the rat changing direction on rotarod, Rats were fed with diet containing *S.aethiopicum* Shum fruits and control diet, Values are shown as means ± SD of six animals

ment is an extremely important aspect of optimal performance. For instance, Oakes[23] indicated that losing as little as 2 to 4 % of body weight in water can lead to decreases in maximum speed and endurance. This suggested that *S. aethiopicum* Shum fruit indirectly acts to enhance physical performance through water intake. Food intake increased as response to the elevation of energy metabolism to maintain homeostasis. The consumption of *S. aethiopicum* Shum fruit have beneficial effects on food intake, then the availability of food factors such as carbohydrates, proteins, vitamins and minerals required to sustain physical effort and to avoid homeostasis disturbance[4]. This suggests that *S. aethiopicum* Shum fruit may indirectly affect the physical performance through the availability of food factors necessary for exercise. The decrease of body weight confirms the elevation of energy metabolism with the predominance of catabolism and wastes elimination. The consumption of *S. aethiopicum* Shum fruit combined to physical work can be used for weight management.

The consumption of *S. aethiopicum* Shum fruit beneficially affected speed and exercise-endurance on rotating rod in rats. The effect of *S. aethiopicum* Shum fruit on physical performance can be explained

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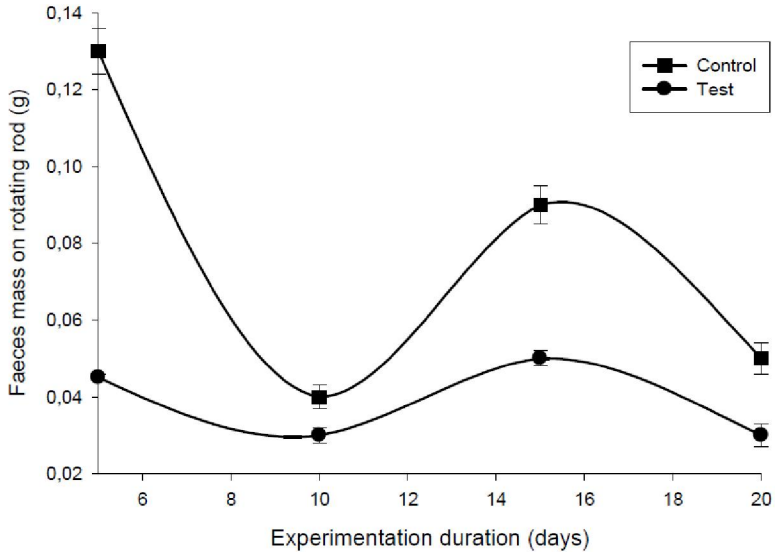

Figure 6 : Changes in the rat faeces mass on the rotating rod, Rats were fed with diet containing *S. aethiopicum* Shum fruits and control diet, Values are shown as means ± SD of six animals

by its pharmacological substances such as: alkaloids, saponins and flavonoids. As other alkaloids, these of *S. aethiopicum* Shum fruit can be a potent central nervous system stimulator. This could be due to the fact that alkaloids from *S. aethiopicum* Shum fruit enhance the release of norepinephrine from sympathetic neurons[24]. These alkaloids could also increase heart rate, myocardial strength, bronchodilatation and vasodilatation in skeletal muscle[25]. Similar effect can be observed with saponins from *S. aethiopicum* Shum fruit. Known as antioxidant component, recent study suggested beneficial effect of flavonoids on endurance capacity[26]. However, it demonstrated that some alkaloids do not individually increase physical performance, but the synergetic effect with other pharmacological substances is beneficial for endurance[11]. In addition, *S. aethiopicum* Shum fruit can increase bioavailability of substrate as free fatty acids, an interesting source of energy. This suggests that the consumption of *S. aethiopicum* Shum fruit can be associated with decreasing of tiredness, time of reaction and recovery duration after physical effort; and improving of endurance and speed. These hypotheses might substantiate the virtues of vitality, health and longevity attributed to *S. aethiopicum* Shum fruit by "*Bantous*" people. However, more studies need to be carried out to check individual and synergetic effects of pharmacological substances from *S. aethiopicum* Shum fruit as ergogenic aid.

Management of stress is an important factor during physical effort, because one must adapt to too many demands, which modifies homeostasis and affects physical performance. In response to this stressor, autonomic nervous system and the hypothalamic-pituitary-adrenal axis are known to react and to participate in the maintenance of homeostasis, with elevation of hormones such as: cortisol and catecholamine[27]. In this study, rats reacted by defecation during exercise on rotating rod. The decrease of defecation during effort may suggest beneficial effect of *S. aethiopicum* Shum fruit on psychological state in rats. The substances that improve mental alertness and mood, and exhibit anxiolytic properties have a positive effect on stress[11]. However, more works need to evaluate the effect *S. aethiopicum* Shum fruit on psychological state and determine if this effect is associated with a concomitant enhancement in physical performance.

Thus, the results of study suggest that *S. aethiopicum* Shum fruit directly improves physiological variables associated with exercise performance, or removes subjective restraints which may limit physiological and psychological capacities.

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