Multi-plant *(Phoenix dactylifera and Cyperus esculentus)* Effects on Regulating Diet Induced-hypercholesterolemia in Female Sprague-Dawley Rats

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Hypercholesterolemia also known as amplified blood cholesterol represent other forms of hyperlipidemia secondary to atherosclerosis is rising fast in our society. Natural remedies without potential harmful effects are increasing as well. It is against this backdrop that we investigated combined effects of *Phoenix dactylifera* and *Cyperus esculentus* against diet induced hypercholesterolemia in rats. In-bred, healthy non-pregnant female Sprague-Dawley rats (11-17weeks, 153-177g) were grouped and orally administered (A1, B1, and C1 =300mg/kg b.w.; A2, B2, and C2 =600mg/kg b.w.; A3, B3, and C3 =900mg/kg b.w.; A4, B4, and C4 =1200mg/kg b.w. and D = untreated, n=3) daily for 45days by oral intubation. Polypropylene cages in a sanitized aerated facility, bedded with sawdust housed all animals. They observed 7days adaptation to environmental temperature (25±5ºC), humidity (45±5%), and photoperiod (12:12 hr. day/night). Rats consumed high fat-dietary cholesterol diet to induce hypercholesterolemia and water provided *ad libitum*. Sera were used for lipid profiling (before, during, and after) following varying treatments plan. Lipid profile: TC (total cholesterol), ST (serum triglycerides), LDLC (low-density lipoprotein cholesterol), HDLC (high-density lipoprotein cholesterol) were abnormal in pre-experimental phases (both test and control). Values were regulated after treatment particularly in 1200mg/kg b.w in rats administered *P. dactylifera*: TC50.17±2.7/dL, ST27.7±0.6mg/dL, LDLC23.5±2.5mg/dL, HDLC89.1 ±3.9/dL; *C. esculentus*: TC41.03±2.3mg/dL, ST27.4±2.9mg/dL, LDLC27.1±2.1mg/dL, HDLC94.3±1.8mg/dL; and mix: TC32.77±3.8mg/dL, ST23.5±2.4mg/dL, LDLC21.3±2.9mg/dL, HDLC97.8±3.9mg/dL, excluding control: TC92.62±0.3mg/dL, ST71.3±1.9mg/dL, LDLC64.0±0.2mg/dL, and HDLC93.1±1.1mg/dL (p < 0.05). Therefore, synergy of *P. dactylifera* and *C. esculentus* regulate hypercholesterolemia in rats while *C. esculentus* particularly is the super active constituent in the mix.

**Keywords:** *C. esculentus*, *P. dactylifera*, lipid profile, hyperlipidemia, medicinal crops, experimental rats

1. **Introduction**

Hypercholesterolemia is also known as high cholesterol content in blood (Durrington, 2003). Hypercholesterolemia is another form of hyperlipidemia, which indicates the onset of abnormal lipid metabolism secondary to manifestation and progression of atherosclerosis (Sinha and Gosh, 2018). Death rate resulting from coronary heart disease has been globally reported, and epidemiologists suggest that there is a link to hypercholesterolemia being a major predisposing factor (Saryono et al., 2017). Increased level of cholesterol results to atherosclerosis due to an elevated atherogenic index leading to poor blood circulation and subsequent to untimely death of heart muscles (Ghuge and Zine, 2012). A rise in total cholesterol level and low density lipoprotein (LDL) increases the risk of coronary heart disease and has been linked to high intake of saturated fatty meals, low intensity of physical activities including unhealthy lifestyle in humans (Madamanchi et al., 2005). The use of herbs in regulating high cholesterol in blood or abnormal lipid parameters subsequent to hyperlipidemia has been useful with improved activities through regulation of varying mechanisms of action (Sinha and Gosh, 2018). A high consumption of fruits and vegetables is beneficial to human health by preventing chronic diseases like: atherosclerosis, cancer, cardiovascular,
diabetes, and neurodegenerative diseases (Saryono et al., 2016). The antioxidant content in fruits and vegetables may decrease the risk of chronic diseases and protect human health (Saryono et al., 2016). Nonetheless, natural remedies are increasingly used to resolve complicated health issues believing that nature has no potential harmful effects to humans. Among the numerous medicinal plants are P. dactylifera popularly called date palm fruit and C. esculentus known globally as tiger nut. Date palm fruit belongs to the family Arecaceae, while the component parts have anticancer, antioxidant, hepatoprotective, anti-diabetic, anti-inflammatory, antibacterial, antifungal and antiviral activities (Lim, 2012).

P. dactylifera is an important traditional crop in Iraq, Arabia, North Africa and Morocco where it is reportedly used in treating various illnesses including atherosclerosis and coronary heart disease (Saryono et al., 2017). Phytochemicals of P. dactylifera suggest that it is rich in antioxidants, vitamins, steroids, flavonoid, saponins, and simple sugars (Ezeh et al., 2014). On the other hand, C. esculentus from Cyperaceae family propagated by rhizome, basal bulb, and tuber is a pleasurable and exciting crop to taste (Ogeyemhe et al., 2018). The crop is commonly known by several names like chufa, earth almond, and tiger nut in English considered as one of the earliest food sources known to humanity (Ezeh et al., 2014). Tiger nut juice has been reportedly used in preventing arteriosclerosis, since its consumption can help to prevent heart problems and thrombosis and activate blood circulation mainly because it contained unsaturated fatty acid, which is similar to olive oil (Chukwuma et al. 2010). There is a clear distinction in the individual use of the plant as against the mix, which is yet to be harnessed for regulating lipid parameters either in animals or humans. This is a novel study as far as we are aware being that most literature we came across focused solely on either P. dactylifera or C. esculentus against other ailments. It is against this backdrop that we investigated the multi-plant effects of P. dactylifera and C. esculentus mix against diet induced hypercholesterolemia toxicity in rat’s model.

2. Materials and Methods

2.1 Collection of Plant Materials
Six hundred and twelve grams of P. dactylifera and seven hundred and eighty-two grams of C. esculentus were purchased from Hausa quarters at Aduwawa cattle market in Benin City, Nigeria. Plant materials were identified and authenticated by an expert taxonomist at the Department of Plant and Biotechnology, University of Benin, Nigeria. Plants were assigned voucher referencing UBH191 and UBH192 respectively.

2.2 Preparation and Extraction Process
Plant materials were washed in a basket under running tap water and left to drain dry in the laboratory, shaded from direct sunlight for 24 hours and oven dried thereafter. Extracts of P. dactylifera and C. esculentus were obtained by pulverizing samples of each plant with an electric blender (Kenwood 1.6L, BL480 Prestons, Australia) repeatedly till it achieved a smooth powdery substance following the methods of extraction earlier published (Ogeyemhe et al. 2018; Ogeyemhe et al., 2019). Multi-plant extract was obtained by mixing extracts of P. dactylifera and C. esculentus in equal proportion (Ogeyemhe et al., 2019).

2.3 Experimental animals
In-bred and healthy non-pregnant female Sprague Daley rats of about 11-17 weeks, weighing 153-177g were obtained from the animal facility of the Department of Animal and Environmental Biology, University of Benin, Nigeria after obtaining ethics approval for the study. Males were excluded to minimize physiological interactions in female rats resulting from animal mating. Rats were handled in line with international best practices for animal experimentation (NRC, 2011); and maintaining the rights of animals updated in the committee’s guides for the care and usage of experimental rat’s gazette (2011). Rats were housed in a sanitized environment were animals are nursed from birth. Aerated cages were designed with polypropylene and bedded with wood-dust, which are often cleaned mornings and evenings to maintain same sanitary condition from start to finish. Rats observed 14 days adaptation to environmental temperature (25±5°C), humidity (45±5%) and photoperiod (12:12 hr. day/night). Rats had unrestricted access to specially arranged animal fat containing feeds and water at ease.

2.4 Hypercholesterolemia in rats
Animal feeds contained huge proportion of fat constituents (saturated and trans fats) including extremely high dietary cholesterol, specifically demanded from Livestock Feeds PLC, Lagos. Feeds were fed to experimental rats throughout the experiment to sustain hypercholesterolemia.

2.5 Experimental Design and Conduct
Due to the large number of groups in this study (13 cages), n=3 rats were utilized to minimize the use of experimental animals according to lay down regulations (NRC, 2011). Hence, Rats were grouped and administered extract for 45 days by oral intubation in the following order: Group D - untreated group serving as control
Hypercholesterolemia associated lipid disorders are considered to cause atherosclerotic cardiovascular diseases ranked as one of the risk factors contributing to prevalence and severity of coronary heart diseases (Niharika, 2017). It is characterized by elevated serum total cholesterol, low density lipoprotein cholesterol (LDLC), very low density lipoprotein cholesterol (VLDLC), and decreased high density lipoprotein cholesterol (HDLC) respectively (Mushtaq et al., 2017). Cholesterol is abundant in the liver, adrenal glands as well as the brain and the nervous system, but the liver has the capability of synthesizing sufficient amount of cholesterol for conducting at room temperature and stored at -20°C until it was needed for lipid profile testing. Enzymatic end point method was used to evaluate the lipid profile: serum triglycerides (ST), total cholesterol (TC), high density lipoproteins cholesterol (HDLC) and low density lipoproteins cholesterol (LDLC).  

2.5.4 Estimation of Lipid Profile  
Sera for fasting blood was obtained by centrifuging clotted blood as described earlier. Chemical analyzer (Erba Chem 5X Analyzer) based on spectrophotometric principle was applied for lipid analysis: serum triglycerides (ST), total cholesterol (TC), high density lipoproteins cholesterol (HDLC) and low density lipoproteins cholesterol (LDLC). Commercialized kits (Solana Health Inc. USA) were used with a wavelength of 546 nm and an optical path of 1cm respectively.

2.5.5 Histopathology  
Organs like liver, kidney, pancreas and heart, said to be associated with hyperlipidemia disorder (Csonka et al., 2017) were excised and grossed accordingly. About 3-5mm thickness of tissues were cut and processed histologically. Five microns of serial sections were cut with a rotatory microtome (Hestion ERM 4000 Germany). Sections were deparaffinized and stained according to H&E method, and viewed with a light Binocular microscope®.

2.5.6 Data processing and analysis  
Result expressions are presented as means ± S.E.M. Data are analyzed using Instat Statistic Package version 3. Analyses ANOVA was used to compare the mean differences between and within the groups. Dunneth’s post hoc test compared the means within experimental groups and against varying controls including before, during and after experimentation. Variants within the groups were considered statistically significant at P ≤ 0.05.

3. Results and Discussion  
Hyperlipidemia associated lipid disorders are considered to cause atherosclerotic cardiovascular diseases ranked as one of the risk factors contributing to prevalence and severity of coronary heart diseases (Niharika, 2017). It is characterized by elevated serum total cholesterol, low density lipoprotein cholesterol (LDLC), very low density lipoprotein cholesterol (VLDLC) and decreased high density lipoprotein cholesterol (HDLC) respectively (Mushtaq et al., 2017). Cholesterol is abundant in the liver, adrenal glands as well as the brain and the nervous system, but the liver has the capability of synthesizing sufficient amount of cholesterol for...
normal body functions carried in the blood as lipoprotein while streaming in the body (Osmund, 2000). This may suggest partly why histopathology of liver, kidneys, pancreas and heart in this study did not show pathological concerns as against the report that these organs are often affected in end-stage hyperlipidemia through metabolic and biologic activities (Csonka et al., 2017). Considering that hypercholesterolemia was induced with diet, we suggest that exerted impacts may be insufficient to cause any pathological effects. There were no observable toxicological signs in experimental animals, no morbidity and mortality before, during and after experimentation while mixed extract was found to have a wide safety margin.

P. dactylifera treated rats showed remarkable weight gain in all treatment groups while C. esculentus showed slight gain in body weight only in animals that consumed low doses of extract which suggests that C. esculentus may support weight loss if included in diet plans in large quantity. This observation is strongly supported by Ogeyemhe et al., (2019) in which similar weight losses were reported. Though negligible weight gain was demonstrated in rats treated with mixture of extracts (Table 1), which may translate to both plants being competitively antagonizing one another (Ogeyemhe et al., 2020).

### Table 1: Empirical and Physical Measurement of Experimental Rats

| EXTRACT                  | Groups | Dosages (mg/kg) b.w. | Initial Average Weight (g) | Final Weight (g) | Average Physical Activities |
|--------------------------|--------|----------------------|----------------------------|------------------|----------------------------|
| Distilled water          | D      | 0                    | 153.21±1.9                 | 237.28±3.6       | ±                          |
| P. dactylifera A1        | 300    | 159.32±2.7           | 173.24±2.8                | ++               |
| P. dactylifera A2        | 600    | 161.17±1.8           | 174.12±3.5                | ++               |
| P. dactylifera A3        | 900    | 172.25±2.6           | 184.33±1.4                | ++               |
| P. dactylifera A4        | 1200   | 181.16±2.4           | 192.72±2.7                | ++               |
| C. esculentus B1         | 300    | 155.77±1.9           | 163.66±2.8                | +                |
| C. esculentus B2         | 600    | 163.22±3.3           | 170.86±3.7                | +                |
| C. esculentus B3         | 900    | 168.02±1.3           | 173.74±1.5                | ++               |
| C. esculentus B4         | 1200   | 176.29±3.8           | 181.62±1.9                | ++               |
| Combined extract C1      | 300    | 161.15±1.3           | 166.11±2.6                | ++               |
| Combined extract C2      | 600    | 162.62±1.1           | 166.83±2.7                | ++               |
| Combined extract C3      | 900    | 170.03±3.9           | 175.11±1.1                | ++               |
| Combined extract C4      | 1200   | 176.83±4.5           | 180.02±1.8                | ++               |

All values expressed as mean ± standard error of the mean, while 0mg/kg = control.
Combined extract = P. dactylifera + C. esculentus; body weight = b.w.

### Table 2: Serum Lipid Panels of Experimental Animals Before Administration

| Grouping                | TC mg/dL | ST mg/dL | LDLC mg/dL | HDLC mg/dL |
|-------------------------|----------|----------|------------|------------|
| 0mg/ kg                 | 61.61±0.3| 47.3±1.9 | 41.0±0.2   | 33.0±2.1   |
| P. dactylifera 300mg/ kg b.w./ day | 65.14±3.02 | 45.7±2.8 | 43.9±4.1   | 35.2±4.5   |
| P. dactylifera 600mg/ kg b.w./ day | 54.22±1.05 | 49.8±0.8 | 40.8±3.1   | 32.7±3.6   |
| P. dactylifera 900mg/ kg b.w./ day | 57.96±1.33 | 51.1±2.7 | 47.2±3.9   | 30.6±2.5   |
| P. dactylifera 1200mg/ kg b.w./ day | 61.77±3.48 | 48.2±5.6 | 47.9±3.7   | 29.4±1.3   |
| C. esculentus 300mg/ kg b.w./ day | 63.01±2.4 | 49.1±4.4 | 40.2±2.8   | 34.6±1.5   |
| C. esculentus 600mg/ kg b.w./ day | 63.17±2.7 | 47.3±1.3 | 43.75±0.1  | 33.9±3.1   |
| C. esculentus 900mg/ kg b.w./ day | 64.82±3.6 | 47.4±1.3 | 48.77±3.5  | 31.3±1.5   |
| C. esculentus 1200mg/ kg b.w./ day | 62.53±2.8 | 49.5±2.6 | 46.88±1.7  | 36.3±2.2   |
| Mixed extract 300mg/ kg b.w./ day | 61.83±3.9 | 49.5±6.0 | 43.5±2.7   | 33.8±2.9   |
| Mixed extract 600mg/ kg b.w./ day | 61.62±2.3 | 46.7±4.1 | 51.07±2.2  | 34.4±1.3   |
| Mixed extract 900mg/ kg b.w./ day | 59.13±1.8 | 48.1±2.2 | 45.2±4.4   | 29.8±2.5   |
| Mixed extract 1200mg/ kg b.w./ day | 63.77±3.8 | 49.7±1.2 | 44.8±2.8   | 36.3±1.1   |

Values are expressed as mean ± standard error of the mean, while 0mg/kg = control.
Values are not statistically significantly at P ≥ 0.05 (one-way ANOVA) before treatment options.
Note: Lipid profile was calculated in mg/dL in all the parameters. TC = total cholesterol; ST = triglycerides; LDLC= low density lipoprotein; HDLC= High density lipoprotein
Mixed Extract (P. dactylifera + C. esculentus ) in equal proportion.
Table 3: Serum Lipid Panels of Experimental Animals Midline (During) Administration

| Grouping         | TC mg/dL      | ST mg/dL      | LDLC mg/dL   | HDLC mg/dL   |
|------------------|---------------|---------------|--------------|--------------|
| 0mg/ kg          | 79.17 ± 0.3   | 57.3 ± 1.9    | 49.0 ± 0.2   | 27 ± 2.1     |
| P. dactylifera   |               |               |              |              |
| 300mg/ kg b.w. / day | 62.03 ± 3.15 | 41.0 ± 3.3    | 39.3 ± 2.2   | 42.1 ± 3.3   |
| 600mg/ kg b.w. / day | 51.98 ± 0.33 | 44.3 ± 2.1    | 31.3 ± 2.9   | 59.9 ± 2.4   |
| 900mg/ kg b.w. / day | 56.13 ± 2.11 | 44.1 ± 2.2    | 33.7 ± 0.6   | 62.8 ± 3.2   |
| 1200mg/ kg b.w. / day | 60.05 ± 2.03 | 43.8 ± 1.2    | 34.6 ± 9.1   | 66.3 ± 3.4   |
| P-value          | 0.053         | 0.011         | 0.146        | 0.051        |
| C. esculentus    |               |               |              |              |
| 300mg/ kg b.w. / day | 50.56 ± 3.13 | 46.6 ± 2.1    | 41.36 ± 0.3  | 53.4 ± 2.3   |
| 600mg/ kg b.w. / day | 46.03 ± 1.18 | 41.2 ± 2.4    | 39.3 ± 2.2   | 57.7 ± 3.9   |
| 900mg/ kg b.w. / day | 53.21 ± 2.32 | 41.1 ± 0.1    | 33.6 ± 1.7*  | 71.7 ± 2.2*  |
| 1200mg/ kg b.w. / day | 51.82 ± 3.49 | 42.1 ± 2.7    | 31.28 ± 2.5* | 71.9 ± 2.5*  |
| P-value          | 0.157         | 0.111         | 0.025        | 0.053        |
| Mixed extract    |               |               |              |              |
| 300mg/ kg b.w. / day | 56.58 ± 1.1  | 43.0 ± 3.7    | 36.0 ± 0.3   | 60.8 ± 4.9   |
| 600mg/ kg b.w. / day | 53.04 ± 3.5  | 40.5 ± 1.8    | 40.28 ± 0.2  | 63.2 ± 4.1   |
| 900mg/ kg b.w. / day | 46.05 ± 0.1* | 41.9 ± 0.8    | 36.2 ± 1.4   | 67.1 ± 3.9*  |
| 1200mg/ kg b.w. / day | 42.29 ± 2.7* | 44.4 ± 2.3    | 33.8 ± 1.4*  | 74.2 ± 2.8*  |
| P-value          | 0.011         | 0.065         | 0.076        | 0.004        |

Values are expressed as mean ± standard error of the mean, while 0mg/kg = control
*Significantly different from values midway to treatment and control groups at p ≤ 0.05
Note: Lipid profile was calculated in mg/dL in all the parameters. TC = total cholesterol; ST = triglycerides; LDL = low density lipoprotein; HDL = High density lipoprotein
Mixed Extract (P. dactylifera + C. esculentus) in equal proportion

Table 4: Serum Lipid Panels of Experimental Animals After Administration

| Grouping         | TC mg/dL      | ST mg/dL      | LDLC mg/dL   | HDLC mg/dL   |
|------------------|---------------|---------------|--------------|--------------|
| 0mg/ kg          | 92.23 ± 1.3   | 71.3 ± 1.9    | 64.0 ± 0.2   | 21.3 ± 1.1   |
| P. dactylifera   |               |               |              |              |
| 300mg/ kg b.w. / day | 55.93 ± 2.6  | 33.8 ± 1.5    | 28.7 ± 1.3   | 68.3 ± 2.8   |
| 600mg/ kg b.w. / day | 47.58 ± 2.5  | 31.6 ± 0.3*   | 22.4 ± 1.1*  | 69.8 ± 3.6*  |
| 900mg/ kg b.w. / day | 48.48 ± 1.4* | 32.3 ± 3.5*   | 24.8 ± 2.4   | 76.7 ± 2.5*  |
| 1200mg/ kg b.w. / day | 50.17 ± 2.7* | 27.7 ± 0.6*   | 23.2 ± 2.5*  | 89.1 ± 3.9*  |
| P-value          | 0.041         | 0.028         | 0.036        | 0.001        |
| C. esculentus    |               |               |              |              |
| 300mg/ kg b.w. / day | 47.11 ± 1.6  | 31.1 ± 1.4    | 29.2 ± 0.1   | 71.9 ± 3.7*  |
| 600mg/ kg b.w. / day | 41.17 ± 1.1  | 35.2 ± 2.2    | 31.0 ± 1.2   | 74.6 ± 1.6*  |
| 900mg/ kg b.w. / day | 42.99 ± 2.9* | 26.7 ± 0.1*   | 29.1 ± 1.2*  | 83.9 ± 0.2*  |
| 1200mg/ kg b.w. / day | 41.03 ± 2.3* | 27.4 ± 2.9*   | 27.1 ± 1.3*  | 94.3 ± 1.8*  |
| P-value          | 0.001         | 0.003         | 0.134        | 0.001        |
| Mixed extract    |               |               |              |              |
| 300mg/ kg b.w. / day | 41.62 ± 1.3* | 31.6 ± 0.4    | 25.4 ± 2.9   | 75.5 ± 2.6*  |
| 600mg/ kg b.w. / day | 44.45 ± 2.6  | 29.3 ± 1.9*   | 27.3 ± 1.1   | 79.5 ± 2.2*  |
| 900mg/ kg b.w. / day | 33.13 ± 3.8* | 38.3 ± 1.5    | 25.2 ± 1.2   | 87.1 ± 1.3*  |
| 1200mg/ kg b.w. / day | 32.77 ± 2.4* | 23.5 ± 2.4*   | 21.3 ± 2.9*  | 97.8 ± 3.9*  |
| P-value          | 0.004         | 0.001         | 0.016        | 0.001        |

Values are expressed as mean ± standard error of the mean, while 0mg/kg = control
*Significantly different from values midway to treatment and control groups at p ≤ 0.05
Note: Lipid profile was calculated in mg/dL in all the parameters. TC = total cholesterol; ST = triglycerides; LDL = low density lipoprotein; HDL = High density lipoprotein
Mixed Extract (P. dactylifera + C. esculentus) in equal proportion
Lipid profile of rats were fully regulated after treatment with *P. dactylifera* extracts compared with results before treatment, midway to experimentation, and controls in this study. We suggest that *P. dactylifera* fruit extract exerts a long term effect rather than short as the overall result was laudable after 45 days treatment. This observation is comparable with reports on capability of *P. dactylifera* fruit to improve serum lipids in rat’s model (Saafi *et al.* 2011; Arshad *et al.* 2015; Gunay *et al.* 2016). In a randomized controlled study, it was reported that serum HDLC increased while LDLC, triglycerides and total cholesterol significantly decreased after investigation (Mushtaq *et al.*, 2017). Reductions in serum LDLC and elevated HDLC values after treatment were reported to be due partly to free radical scavenging activities of *P. dactylifera* fruit (Chaiera *et al.*, 2007). In another report, atherogenic index with LDLC / HDLC ratio in plasma has been found to be a good prognostic factor for cardiovascular risk in the presence of co-morbid situations as reported (Gunay *et al.*, 2016). Regulation of lipid profile by *P. dactylifera* extract may also be traced to some active components in the plant like flavonoids and polyphones (antioxidants), and has been confirmed to exist richly in *P. dactylifera* fruit as against other component parts of the plant (Arshad *et al.*, 2015). *P. dactylifera* fruit fiber content is relatively high and has been reported to captivate dietary fats which in-turn help in regulating lipid profiles (Juhaimei *et al.* 2012; Osman, 2014).

All parameters after treatment with high dose *C. esculentus* extract indicated a statistical significance (p ≤ 0.05) compared with those obtained before treatment / control animals. This observation suggests that the extract performs better after a prolonged administration, and embraces the report of Hassan (2007), which suggests that *C. esculentus* extract has varying health benefits that are yet to be harnessed. It appeared that *C. esculentus* assists in inducing the good lipid (elevation of HDL-cholesterol levels) in animals via inhibition of biosynthesis of cholesterol concentration (Zommara and Imaizumi, 2017). Elevation of HDL-C / reduction in LDL-C during treatment with *C. esculentus* may have resulted from high amount of mono unsaturated fatty acids such as oleic acid content of the plant. This acid (oleic acid) is largely available in *C. esculentus* leading to increasing levels of HDL / reduced LDL-C in rats primarily by delaying the clearance of HDL apo A-I from plasma compartment (Brousseau *et al.*, 1995). On the other hand, poly unsaturated fatty acids (linoleic acid), which is abundantly available in *C. esculentus* oil was found to decrease LDL-C and VLDL in rats and has been reported to signify an inhibitory effect on hepatic synthesis including secretion of triglyceride-rich VLDL in blood (Nenster *et al.* 1992; Rustan *et al.*, 1993).

Effects of high dose multi-plant extract on lipid parameters revealed that all values were markedly controlled during investigation (Table 3) while further regulation of parameters were observed after treatment (Table 4) compared to controls. The results of this study indicate that *P. dactylifera* and *C. esculentus* are potential sources of health benefits and may be used as a dietary supplement to improve health and reduce the risk of cardiovascular diseases.
with values before administration / controls and were statistically significant (p ≤ 0.05). This report is strongly suggestive of an anti-hypercholesterolemia action, which means that the effect may be due to synergy between P. dactylifera / C. esculentus including individual actions of the plant. It was observed that the mix may possess therapeutic, regulatory, and anti-hyperlipidemia properties than individual extracts going by the quick healing exhibited in animals after sample collections from marginal ear lobe followed by treatment with multi-plant extract compared with control animals. But the mechanism of this act has not been well understood in the present work. Notwithstanding, the action buttresses earlier reports on multiple plant’s extracts functioning effectively than individual components (Mahunnah et al. 2006; Oti et al., 2008). Thus justifying reports that combination of plants of similar actions has more curative potentials compared with its individual actions (Ogeyemhe et al., 2019).

4. Conclusion

Multi-plant extracts regulate hypercholesterolemia in rats while C. esculentus appeared to be the major active anti-hypercholesterolemia component in the mix. The present combined extracts may just be a welcome development in the management of hypercholesterolemia.

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Conflict of interest

The authors declare no conflict of interest.

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