Effect of *Mbuja* Oil Consumption Compare to Palm Olein and Corn Oils on Lipid Parameters in Rats

Doumta Charles Falang[1, *], Bebbe Fadimatou[2], Ghomdim Nzali Horliane[3], Ngangoum Eric Serge[4]

[1]Department of Biomedical Sciences, Faculty of Health Sciences (FHS), University of Buea, Buea, Cameroun

[2]Department of Biochemistry, University of Yaounde I, Yaounde, Cameroon

[3]Department of Food Process and Quality Control, University Institute of Technology (IUT), University of Ngaoundere, Ngaoundere, Cameroon

[4]School of Agriculture and Natural Resources, Catholic University Institute of Buea, Buea, Cameroon

Email address:
cfdoumta@yahoo.fr (Doumta Charles Falang), horlianeg@yahoo.fr (Bebbe Fadimatou), bebbefa@yahoo.fr (Ghomdim Nzali Horliane), ericngangoum@gmail.com (Ngangoum Eric Serge)
[*]Corresponding author

Abstract: *Mbuja* (*Bikalga; dawadawa botso; datou; Furundu*) is a food condiment obtained by a traditional uncontrolled fermentation of *Hibiscus sabdariffa* seeds in African countries (Burkina Faso, Mali, Niger, Nigeria, Cameroon and Sudan). This condiment is known for its nutritive values and for its health properties. In spite of its nutritional and healthy properties the consumption of *Mbuja* is less appreciated in urban areas. This is due to its strong smell, to its bad condition of manufacturing practices which leads to the rapid alteration of nutritive values. The main problem now is how to lead people to consume *Mbuja* which nevertheless contains bioactive molecules, which can help in the treatment or in the prevention of some cardiovascular diseases and hypertension. In order to valorize its nutraceutic property, a study on physicochemical characterization and on nutraceutic value of its oil were carried out. *Mbuja* was purchased in Mokolo market (Far-North, Cameroon); oil extracted from it was assessed on its various components by using classical methods. Nutraceutic aspect was conducted after feeding male rats with different diets containing *Mbuja*, corn and palm oils for 50 days. The results had shown that the main constituent of *Mbuja* oil was polyunsaturates fatty acids (C18:2). Feeding rats with this oil had shown good hypocholesterolemic activities in their blood compared to corn and palm oils. Which is characterized by reduction of triglyceride, total cholesterol, LDL cholesterol and increasing of HDL cholesterol. Consumption of *Mbuja* oil need to be encouraged and can be adviced as nutraceutic and therapeutic diet to persons suffering from hypertension.

Keywords: *Mbuja*, Oil, Nutraceutic Activities, Hypocholesterolemic, Hypertension

1. Introduction

Mbuja (*Bikalga; dawadawa botso; datou; Furundu*) is a food condiment obtained by a traditional uncontrolled fermentation of *Hibiscus sabdariffa* seeds in African countries, including Burkina Faso, Mali, Niger, Nigeria, Cameroon and Sudan among others. This condiment is known for his nutritive values and for his health properties [1, 2]. *H. sabdariffa* is an herbaceous plant in the Malvaceae family also known as karkade, roselle, graines d'oseille and guinean sorrel. It is considered to be a tropical plant that grows annually or perennially. This plant is used for medicinal purposes, especially in alternative medicine. It is a folk remedy for abscesses, cancer, cough, debility, dyspepsia, dysuria, fever, hangover, diuretic, mild laxative, heart ailments, neurosis, scurvy and strangury [3]. *Hibiscus sabdariffa* has been reported to have antiseptic, aphrodisiac, astringent, cholagogue, demulcent, digestive, diuretic,

emollient, purgative, refrigerant, sedative, stomachic and tonic activities. *Hibiscus sabdariffa* and its fermented seeds (*Mbuja*) are used in the treatment of hypertension, hypocholesterolemic, anti-oxidative and hepatoprotective effects in animals [2]. *Mbuja* is mainly produced by women and constitute an economical source for the producers. This condiment is the most popular food condiments in Mokolo (Far-North, Cameroon); it is used as meat replacement mainly by low-income population. *Mbuja* is also used in traditional medicine to cure high blood pressure, diarrhoea, and cardiovascular diseases or is used as an antiseptic.

In spite of its nutritional and healthy properties the consumption of *Mbuja* is less appreciated in urban areas. This is due to its strong smell, to its bad condition of manufacturing practices which leads to the rapid alteration of nutritive values. The main problem now is how to lead people to consume *Mbuja* which nevertheless contains bioactive molecules, which can help in the treatment or in the prevention of some cardiovascular diseases [3]. Among those bioactive molecules, the lipidic profile is one of the main element which has an impact on hypertension. No scientific study on the impact of the used of *Mbuja* oil in the treatment of some chronic diseases was found in literature review. For this reason the goal of this study target its nutraceutic valorization. The present study was undertaken essentially to investigate the potential effects of *Mbuja* oil on lipid profile compare to corn and palm oils in rats fed until 50 days of growth. To overcome this, the composition of different oils on dietary fatty acid compounds, theirs influence on lipidic parameters on male rats were assessed.

2. Material and Methods

2.1. Oil Sampling and Proximate Composition

The *Mbuja* was purchased from various sellers from the Mokolo market in Far-North (Cameroon). The lipid composition was determined by exhaustively extracting a known weight of sample with hexane using a Soxhlet apparatus [4]. Corn and Palm olein oils were obtained commercially. Fatty acids were assessed using gas chromatographic method [5].

2.2. Animals and Diets

7 month old weaned male albinos Sprague Dawley rats (Harlan, France) weighing 260 ± 20 g were housed in polycarbonate cages in a controlled environment with a temperature of 25 ± 2°C, relative humidity (40–60%), with a 12-h light–dark cycle (12h/12h: 7 – 19 h light and 19 – 7h dark) [6]. During an acclimatization period of 1 week, the rats received tap water and a commercial rat diet *ad libitu* [7]. At the end of this period, the rats were weighed and randomly assigned to one of the three groups (n = 6 / group) according to diet composition. For 50 days, each group was fed a diet containing one of the following: *Mbuja* oil (MO group), corn oil (Lesieur France) (CO group) and palm olein oil (Palm'Or, Maya, Douala-Cameroun) (PO). Oil represented 5% of the composition of the diet as prescribed by American Institute of

Nutrition [8]. The diet was reconstituted by using an alipidic diet (moisture content 8.53%, proteins 21.48%, dextrose 32.00%, starch 26.42%, cellulose 6.35%, mineral mix 4.58%, vitamins mix 0.64%). Animals had free access to water and food. Food was given each week and water twice per week.

2.3. Experimental Procedure

At the end of the feeding period (50 days), the rats fasted overnight (12 hours), then were weighed, anaesthetized under chloroform vapor and sacrificed. Blood samples were immediately collected from the heart by cardiac puncture in two tubes to obtain serum and plasma (heparin tubes). Serum was separated by centrifugation at 3000 rpm for 5 min (4°C) and plasma was separated by centrifugation at 1500 rpm for 10 min (4°C). Serum was used for total cholesterol, LDL-cholesterol, HDL-cholesterol, triglycerides.

The serum triglycerides (Human SU-TRIMR 10720P), total cholesterol (Cholestérol liquicolor SU-CHOL 10017 (Biochemica und Diagnostica mbH)) and HDL cholesterol (Human SU-HDLDD 10084) were analyzed using respective enzymatic kits supplied from Human (Germany). LDL-cholesterol was done using enzymatic kit (BioMérieux 61534, France).

2.4. Statistical Analysis

Results were expressed as means ± standard deviation. For each group, the result obtained was the mean for 6 rats. All results were analyzed using a one-way analysis of variance. Duncan's Multiple Range test was performed to evaluate differences between groups. Differences between means were considered to be significant at $p < 0.05$.

3. Results and Discussion

3.1. Fatty Acids Composition of Oils

Compositions of different oils used are presented in table 1.

Table 1. Fatty acids composition of different oils used.

Fatty Acids	CO	PO	MO
C14:0	0.22	0.70	0.05
C16.0	16.95	42.18	11.07
C18.0	2.55	5. 45	09.12
C18.1$c9$	19.05	40.01	15.06
C18.2$c9c12$	54.61	09.86	57.97
C20.0	0.54	0.43	3.19
C18.3$c9c12c15$	6.07	0.43	3.82
Satured Fatty Acids (SFA) (%)	20.26	48.76	23.43
Monounsatured Fatty Acids (MUFA) (%)	19.05	40.01	15.06
Polyunsatured Fatty Acids (PUFA) (%)	60.68	10.29	61.79
PUFA/SFA	2.99	0.21	2.63
$\omega - 6 / \omega - 3$	9.00	22.93	15.17

MO: *Mbuja* oil; CO: Corn oil; PO: Palm oil

From this Table, it is noted that palm oil is highly concentrated on saturated fatty acids (48.76% of total fatty acids) and monounsaturated acids (40.01% of Total fatty acids). Palmitic acid (42.18% of total fatty acids) and oleic acid (40.01% of total

fatty acids) are the main fatty acids present in PO. However, corn oil (60.01%) and *Mbuja* oil (61.79%) are riches on polyunsaturated with a high quantity of linoleic acid 54.61 and 57.97% respectively. Total PUFA, MUFA and SFA values of MO are close to those obtained in CO but they are different to PO contents. The smallness PUFA/SFA ratio (0.21) was noted with PO. The nutritive ratio (ω-6/ω–3) of all the oil used are higher than the normal recommendation (between 3:1 and 4:1) [9].

3.2. Evaluation of Body Weight

Body weight is evaluated to witness acceptability of food submitted for each regimen. Table 2 shows the variation of body weight and gain after 50 days.

Table 2. *Variation of body weight and gain after 50 days.*

Samples	Initial Mass (g)	Final Mass (g)	Body Gain (%)
To	255.47±14.51[ab]	288.79±7.42[ab]	12.84±1.16[b]
MO	271.26±21.24[b]	293.08±2.56[ab]	8.41±2.21[a]
CO	237.17±12.70[a]	267.29±3.47[a]	12.69±1.07[b]
PO	265.54±13.60[ab]	298.86±5.91[b]	16.34±1.54[c]

All results are means of six replicate experiments; values in the same column followed by the same letter are not significantly different at p ≤ 0.05. T0: Control; PO: Palm oil; MO: Mbuja; oil CO: Corn oil. N= 6 rats per group.

The body weight increased in each group after 50 days. Compared to control group (T0) (12.84±1.16%), and CO (22±3%) the body weight gain on MO (8.41±2.21%) has shown less value, while in PO (16.34±1.54%) the increase is very important. This increase of body weight observed can be a witness of acceptability of regime submitted.

3.3. Blood Lipidic Parameters

Assessment Blood lipidic parameters is conducted to show the benefic effects of *Mbuja* oil on management of hypertension, inflammatory and cardiovascular diseases which can be linked to the blood lipdic parameters [10]. Base on traditional used, *Mbuja* has an effect on cardiovascular diseases and hypertension. It is well known that lipid profile has an influence on blood lipidic parameters with incidence on vascular risks. The markers of the cardiovascular diseases risks are triglyceride, total cholesterol and LDL-cholesterol. HDL-cholesterol is the anti-risk marker [11].

3.3.1. Evaluation of Triglycerides (TG) in Blood of Different Groups

The amount of TG constitutes a checkup lipidic parameter in relation with the cardiovascular risk. It can be provided from food or from endogen synthesis. In the clinical view, the determination of TG amount is used in the classification of lipoproteins metabolic troubles and in the evaluation arteriosclerosis risk factors and coronary diseases [12]. The increase of TG in blood is not a risk factor of arteriosclerosis but associate with cholesterol it constitutes a major risk factor. Figure 1 shows the variation of TG according to different regimens after 50 days of feeding.
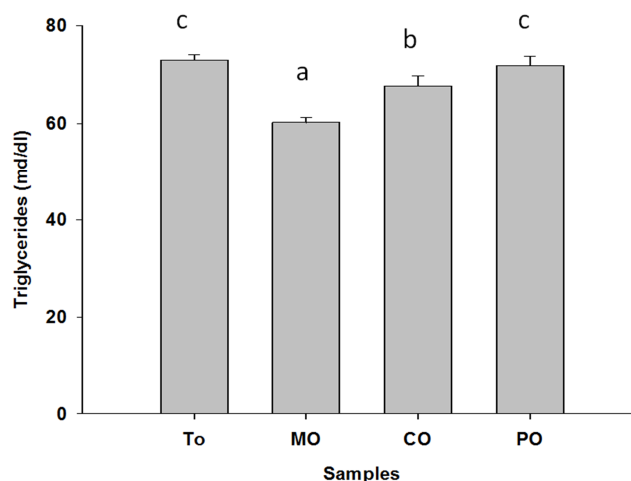

Figure 1. *Variation of TG according to different regimens after 50 days of feeding.*

T0: Control; PO: Palm oil; MO: Mbuja; oil CO: Corn oil. N= 6 rats per group.

Serum TG level for MO (60.19±1.00 mg/dl), CO (67.62±2.1 mg/dl) and PO (71.86±2.57 mg/dl) groups were lower than T0 group (73.00±2.98 mg/dl). According to Duncan test, the lowest quantity of TG obtained with MO is significantly different (p<0.05) to those assessed with CO, PO and T0. This means that Mbuja oil can contribute to reduce TG in blood.

3.3.2. Evaluation of HDLC in Blood of Different Groups

HDL-cholesterol (HDLC) was measured because it constitutes one of the balance checkup lipidic factors implicated in the definition of vascular risk. Plus HDLC is high less is the risk of cardiovascular diseases. HDLC is an element of appreciation of athermanous risk when exist a disequilibria of TC/HDLC or LDLC/HDLC ratios [13]. Figure 2 shows the variation of HDL Cholesterol according to different regimens after 50 days of feeding.
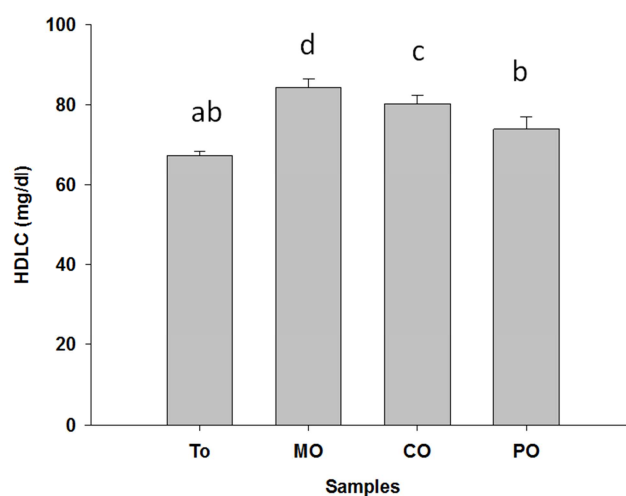

Figure 2. *Variation of HDL-Cholesterol (HDLC) according to different regimens after 50 days of feeding.*

T0: Control; PO: Palm oil; MO: Mbuja; oil CO: Corn oil. N= 6 rats per group.

From this figure, the results show that HDLC increases with the regimen used passing from 67.50±0.95 mg/dl (group T0) to 74.50±3.09 mg/dl; 80.34±2.05 and 84.41±2.52 mg/dl respectively for groups PO, CO and MO. *Mbuja* oil regimen presents the highest value of HDLC, this value is significantly different ($p < 0.05$) to those obtained with T0; CO and PO when the Duncan's test is concerned.

3.3.3. Evaluation of Total Cholesterol (TC) in Blood of Different Groups

Figure 3 presents the variation of Total cholesterol (TC)) according to different regimens after 50 days of feeding.
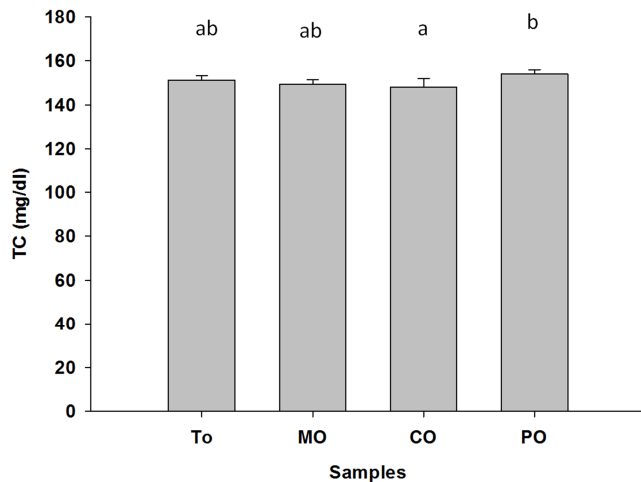

Figure 3. *Variation of Total-Cholesterol (TC) according to different regimens after 50 days of feeding.*

T0: Control; PO: Palm oil; MO: Mbuja; oil CO: Corn oil. N= 6 rats per group.

Serum total-cholesterol (TC) levels were not significantly different ($p < 0.05$) for T0; MO and CO. Mean values of different groups were 151.21±2.9 mg/dl (T0); 149.40±2.02 mg/dl (MO); 147.98±4.02 mg/dl (CO) and 153.96±2.68 mg/dl (PO).

3.3.4. Evaluation of LDL-cholesterol (LDLC) in Blood of Different Groups

LDL-cholesterol (LDLC) constitutes the lipidic checkup risk balance parameter of cardiovascular diseases. LDLC is well known more atherogenous lipoprotein of plasma because it is responsible to the lipidic accumulation in artery. Figure 4 presents the variation of LDL-Cholesterol (LDLC) according to different regimens after 50 days of feeding.

The experimental study realized on rat aging seven month shows reduction quantity of LDLC in the different regime. Significant difference was observed between the values obtained with MO (34.56±2.52 mg/dl) and others groups CO (39.95±1.54 mg/dl); PO (40.18±2.3 mg/dl) T0 (55.27±1.4 mg/dl).
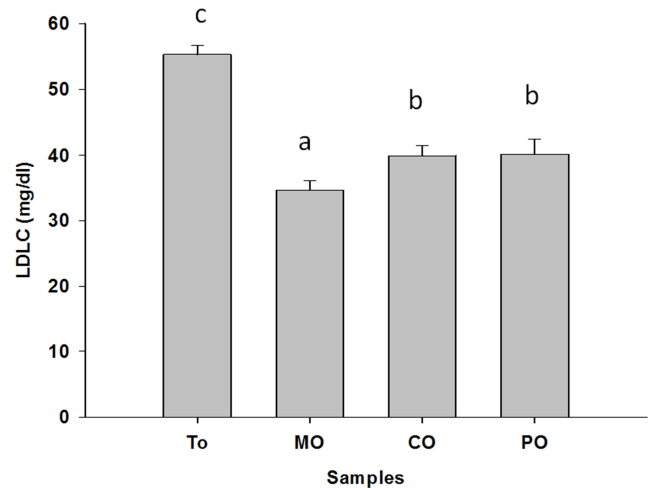

Figure 4. *Variation of LDL-Cholesterol (LDLC) according to different regimens after 50 days of feeding.*

T0: Control; PO: Palm oil; MO: Mbuja; oil CO: Corn oil. N= 6 rats per group.

3.3.5. Evaluation of LDLC/HDLC Ratio in Blood of Different Groups

Reduction of LDLC and TC are not sufficient to identify or minimize the cardiovascular disease risks. The best markers are TC/HDLC and LDLC/HDLC ratios [14].

The food lipid contents are the principal cholesterol determinant of serum, of LDLC/HDLC ratio and of lipoprotein, important factors for cardiovascular diseases [15] Plus the LDLC/HDLC ratio is high, plus the cardiovascular risk is high [14]. This ratio defines the predisposition of a subject to get arteriosclerosis. Figure 5 presents the variation of LDLC/HDLC of different regimens after 50 days of feeding.
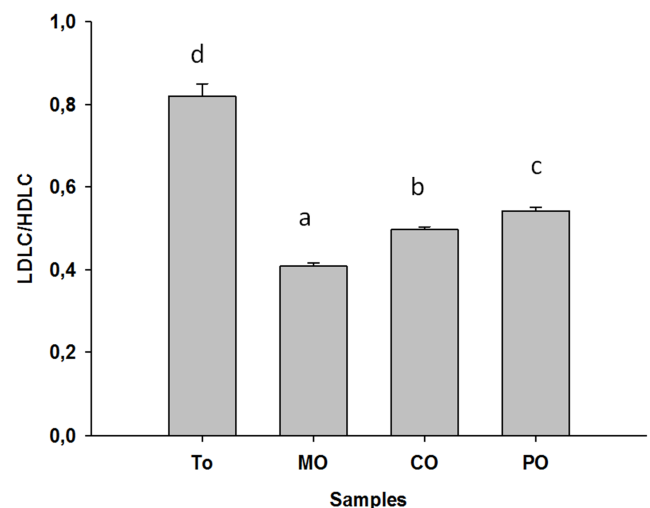

Figure 5. *Variation of LDLC/HDLC ratio of different regimens after 50 days of feeding.*

T0: Control; PO: Palm oil; MO: Mbuja; oil CO: Corn oil. N= 6 rats per group.

The calculated ratio of different experimental groups

showed significant difference between the values obtained with MO (0.41±0.08); CO (0.50±0.06); PO (0.54±0.09) and T0 (0.82±0.02). These values are under 3.55 which is the value favorable for arteriosclerosis.

3.3.6. Evaluation of TC/HDLC Ratio in Blood of Different Groups

Figure 6 presents the variation of TC/HDLC ratio according to different regimens after 50 days of feeding.
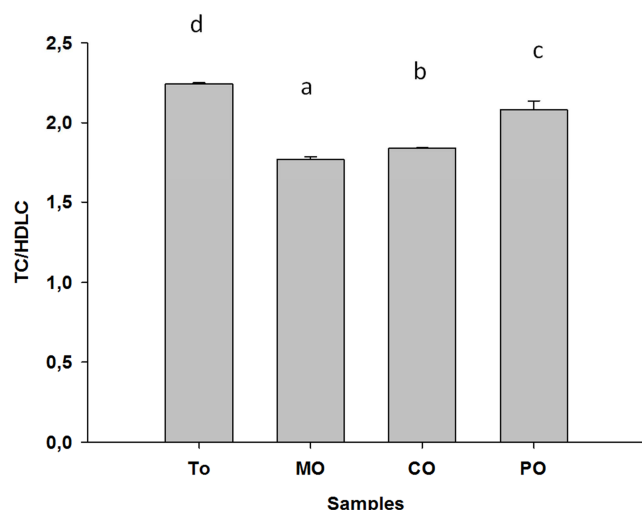

Figure 6. *Variation of TC/HDLC ratio of different regimens after 50 days of feeding.*

T0: Control; PO: Palm oil; MO: Mbuja; oil CO: Corn oil. N= 6 rats per group.

The calculated ratio of different experimental groups showed significant difference between the values obtained with MO (1.77±0.02); CO (1.84±0.03); PO (2.08±0.09) and T0 (2.24±0.05). These TC/HDLC ratio are under 4.5 which is favorable to the reduction of cardiovascular diseases risk [16]. For this reason, MO contribute to the decrease of the cardiovascular risk compared to others groups.

4. Discussion

This comparative study was carried out to investigate the effects of diet containing *Mbuja* oil, palm oil (olein), corn oil on lipid profile. The results showed that after 50 days under sedentary conditions, *ad libitum* feeding with MO, CO, PO were significant difference (P ≤ 0.05) in the body weight gain while CO groups was within the normal range compared to the control group (T0). Consumption of MO can have beneficial or neutral effects on controlling body weight. Analysis of the distribution of oil contents and the effects observed in rat blood allows saying that the modification of blood lipidic parameters of MO, CO and PO regimens are linked to presence of MUFA and PUFA. It is well known that the presence of unsaturated fatty acids in food can impact the biochemistry parameters [17; 18; 19; 20]. Meanwhile, consumption of these natural antioxidants of *Mbuja* oil can affect the oxidative stress and nutritive

properties. In fact this parameter is affected by the quality of fatty acids. Assessment of *Mbuja* oil has shown the good quality of oil (riches on PUFA, ω-6: 57.37%). These constituents could be responsible for the increasing of HDLC and decreasing of TG, TC, LDLC in rat blood and could contribute also to eradicate free radicals in cell [17]. This result corroborates to Lecerf's [18] and Doumta & Tchiegang [21] observations who estimated that PUFA decrease the TG, TC, LDLC and increase the level of HDLC in blood. The results show that tested oils facilitate the synthesis of HDLC in rat body. The fact that TC, TG and LDLC decrease in PO regimen can be linked to the transformation of SFA or MUFA into the PUFA in presence of some enzymes like desaturase in rat body [19]. Plus PUFA/SFA ratio increases plus the susceptibility to the oxidation increases [7]. High quantity of PUFA in MO has induced this reduction of TG by retarding the catabolism of lipoprotein which are rich in TG (by competitive effect at the level of LDL receptor) and has initiated apparition of small LDL which are more oxydable [20]. Base on this result it is possible to say that MO has hypotriglyceridemia property. Since the cardiovascular risk increases proportional with LDLC/HDLC ratio [14], low value of this ratio obtained with MO (0.41) is under 3.55 which is the value favorable for arteriosclerosis, means MO can help to fight again cardiovascular diseases. This assertion is confirmed by the low MO (1.77) value of TC/HDLC ratio which is under 4.5 (value of cardiovascular diseases risk) [16]. For this reason, MO can contribute to decrease the cardiovascular risk. These different interactions confirm that MO can help to treat or to prevent cardiovascular diseases and hypertension. These results are in agreement with the traditional medicine in which *Mbuja* is used to treat and to prevent hypertension, inflammatory and cardiovascular diseases [22].

5. Conclusion

The results of this study indicate that *Mbuja* oil concentrate may be a dietary supplement with the potential properties of improving antioxidant and lipid status. Its consumption by rats reduces; triglyceride, total cholesterol, LDL cholesterol and increases HDL cholesterol concentration. *Mbuja* could be considered as an affordable food with health benefits particularly for low income earners in developing countries such as Cameroon. This condiment provides some beneficial attributes to its consumers by providing bioactive components that ensure vital function and prevent or treat chronic diseases (hypertension, inflammatory and cardiovascular diseases) due to oxidative stress.

Abbreviations

T0: Control;
PO: Palm oil;
MO: *Mbuja* oil;

CO: Corn oil;
MUFA: Mono-unsatured fatty acids;
PUFA; polyunsatured fatty acids;
SFA: Satured fatty acids;
TG: Triglycerides;
TC: Total cholesterol;
HDLC: HDL cholesterol;
LDLC: LDL cholesterol.

References

[1] Doumta CF, Tchiégang C. Standardized Process to Soften African Locus Beans Seeds (*Parkia biglobosa* Benth.) by a Traditional Method. *Food* 2012, 6 (1): 33-37.

[2] Parkouda Charles, Bréhima Diawara and Labia Irène Ivette Ouoba, Technology and physico-chemical characteristics of *Bikalga*, alkaline fermented seeds of *Hibiscus sabdariffa, African Journal of Biotechnology* 2008, 7 (7): 916-922.

[3] Lin, HH; Chen, JH; Wang, CJ. "Chemopreventive properties and molecular mechanisms of the bioactive compounds in Hibiscus sabdariffa Linne". *Current medicinal chemistry* 2011, 18 (8): 1245–54.

[4] AOAC (1995). Official Methods of Analysis. Association of Official Analytical Chemists Washington DC, USA.

[5] Lepage G, Roy CC. Direct transesterification of all classes of lipids in a one-step reaction. *Journal of Lipids Research,* 1986, 27: 114-120.

[6] Gaíva MH, Couto RC, Oyama LM, Couto GEC, Sikveira VLF, Ribeiro EL & Nascimento CMO. Diets Rich in Polyunsaturated Fatty Acids: Effect on Hepatic Metabolism in Rats. *Nutrition,* 2003, 19: 144-149.

[7] Baba NH, Ghossoub Z & Habbal Z Differencial effects of dietary oils on plasma lipids, lipids peroxidation and tissue lipoprotein lipase activity in rats. *Nutrition Research*, 2000, 2 (8): 1113-1123.

[8] AIN (American Institute of Nutrition) Report on the AIN ad hoc committee on standards for nutrition studies. *Journal of Nutrition.* 1977, 107: 1340-1348.

[9] British Nutrition Foundation, Recommandations for intakes of unsaturated fatty acids. In: *Anonymous, The report of British Nutrition Foundation's Task* 1992.

[10] Betteridge DJ. What is oxidative stress? *Metabolism* 2000, 49 (Suppl 1): S3–S8.

[11] Jacotot B. Aspects cliniques et Expérimentaux: « in » *Manuel des Corps Gras*. Karleskind A., Wolff J-P. & Guthmann J-F. (Eds.), Tec. & Doc., Paris (France), 1992, 787 p.

[12] Reisen WF Use and assessment of clinical laboratory results: *in* Clinical laboratory diagnostics. Thomas L. (Ed.). Frankfurt/Main: TH-Books Verlagsgesellschaft, 1998, 167-171.

[13] Funes A, Cado S, Cuvelier B, Fléchet B, Hamida F, Huguet C, Lacroix I, Lewin P, Marachly G, Olichon D, Sainte-Laudy J, Ulrich G & Wolf N Guide des analyses spécialisées. 3e édition, Laboratoire CERBA, Val-d'Oise (France) 1995.

[14] Natarajan S., Glick H., Criqui M., Horowitz D., Lipsitz S. R. & Kinosian B. Cholesterol Measures to Identify and Treat Individuals at Risk for Coronary Heart Disease. *American Journal of Respiratory and Critical Care Medicine,* 2003, 25 (1): 51-55.

[15] Gilani GS., Ratnayaka WMN., Brooks SPJ., Botting HG., Plouffe LJ. & Lampi B. J. Effects of dietary protein and fat on cholesterol and fat metabolism in rats. *Nutrition Research,* 2002, 22: 297-311.

[16] Anonyme (Dossier spécial du «Figaro Magazine») Le métabolisme complexe explique les mesures diététiques. *Le Quotidien du médecin*. 2000, 6651: 30-33.

[17] Legrand P. les acides gras: structure, fonctions, apports nutritionnels conseillés, Huiles et santé, Société Française de Nutrition, *Cahiers de Nutrition et de Diététique,* 2007, 42 (1) 1S7-1S12.

[18] Lecerf JM. Lipides et Santé. *Cah. Nutr. Diét.*, 2007, 42. Hors série I. 24-33.

[19] Kritchesky D, Tepper SA & Klurfield DM.. Serum and liver lipids in rats fed mixtures of corn and palm oils ± cholesterol. *Nutrition Research*, 2001, 21: 191-197.

[20] Kratz M, Cullen P & Wahrburg U. The impact of dietary mono-and poly-unsaturated fatty acids on risk factors for atherosclerosis in humans. *European Journal* of Lipid *Science* and *Technology,* 2002, 104: 300-311.

[21] Doumta CF, Tchiégang C (2016). *Amélioration des procédés traditionnels de production du daddawa: influence sur ses propriétés physicochimiques et nutritionnelle* Presse Académique Française ISSN 978-3-8416-3960-8.

[22] Bricas N. & Cheyns E. Incertitude et procédure de qualification des consommateurs urbains au Burkina; le cas d'un condiment traditionnel: le soumbala. In Sylvander B et Allaire G (Eds), 1995. Qualification des Produits et des Territoires; Actes du Séminaire de Toulouse, 2-3 Oct. 1995. Toulouse, INRA-ESR-ETIQ. 1995, p 19.