

Studies from *Hibiscus sabdariffa* (Hibiscus) Plant for Blood Cholesterol Levels Reduction

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Abstract

The species *Hibiscus sabdariffa* L. is originally from Africa. It has been distributed all over the world as an ornamental plant and it is consumed in several ways as infusion, salad dressings, marmalades, etc. However, its medical benefits are rarely studied. In this paper we present results from a clinical assay demonstrating the influence of hibiscus effects, presented as dry extracts in gel caps, on a general blood lipidic profile (LDL and HDL Cholesterol and triglycerides). We recruited 20 volunteers, 45 to 64 years old with the compromise of not changing food habits. They were divided into two groups; one of them received two 500 mg hibiscus dry gel caps treatment, three times a day for two months and the other group received same doses of placebo (Fructose) for the same period. Results showed a blood lipidic concentration reduction in those patients under hibiscus treatment statistically different ($p < 0.05$) as compared to control patients.

Keywords

Medicinal Plants, Jamaica, Cholesterol Control, Triglycerides

1. Introduction

Hibiscus plant (roselle) comes originally from Africa. It was introduced to the Indies back in the 18th century where it was grown, at the beginning, mainly as an ornamental plant to obtain fiber from its resistant stem to substitute jute [1].

The main hibiscus plant producers in the world are China and Thailand, and in a minor scale: Mexico, Egypt, Senegal, Sudan, although in a smaller amount, where its red calyx has been mostly used. As in other parts of the world in Mexico it is used to make infusion flavored water [2]. In Africa a sugared tea is made from it called “carcade” and it is also used to make marmalades, sauces, and

wines. It has also been used as a food colorant. In Argentina it is known as “ro-sella” and it is also used to make marmalades by boiling the fresh calyxes with sugar [3].

Hibiscus plant belongs to Malvaceae family and it was introduced to Mexico back in the colonial period; from there on it has been grown in hot regions in this country, the main ones being the States of Guerrero, Oaxaca, Colima, and Campeche [4]; it is known as “jamaica”.

1) Problem to Solve

In Mexico there is a high incidence, among population, to have high blood cholesterol levels which causes a great deal of derived atherosclerosis complaints, heart strokes, apoplexy, vasculopathy, ischaemia, and vascular brain accidents, which are considered the first mortality cause. In some patients a decrease in saturated oils food decreases blood lipids; however it does not work in many people, which forces them to take statins and other less indicated drugs such as: cholestyramine, colestipol, and fibrates. However, their high costs and side effects in poor people limit their purchasing power. For these reasons we decided to study and develop a plant medication as hard gel caps using a purified dry extract derived from this plant as an active ingredient to administrate it to volunteers with high cholesterol blood levels and comparing its effects vs a placebo to be able to offer an alternate treatment for all the above mentioned diseases for people with low income [5].

2) Research Justification

Obesity and overweight are chronic conditions characterized by fat excess in individuals. Recently both conditions have alarmingly increased worldwide which represents a serious public health problem. *Hibiscus sabdariffa* has shown effects on reducing liver fat in hamsters [6], using both, calyx and seeds [7] [8]; also it has been used as an antioxidant [2] [9]. It has been generally accepted that overweight and obesity are a result of an imbalance between energy uptake and its use. These conditions have a high impact on metabolic systems resulting in heart problems, cancer, arthritis, hypertension, hyperlipidemia, and type II diabetics [10], along with insulin resistance. The hypercholesterolemia is a result of metabolic changes in an individual's cholesterol blood levels and it is the main cause of cardiovascular problems [11]. Low density triglycerides (OX-LDL) play an important role in humans. Some natural extracts from *H. sabdariffa* have shown effects on some of these symptoms such as high blood pressure [12].

Plant origin sterols are those agents used to lower blood cholesterol levels, which have been applied in medicine [9]. Intestine is the target organ for these compounds, where they exert their hypocholesterolemic effect blocking cholesterol absorption in the intestinal gut or through their interference with bile acids. It has been reported that tea leaves catechins, sesamin from sesame seeds, and guar gum, among others, lower cholesterol blood levels [13] [14] [15] [16].

Hibiscus sabdariffa extract inhibits low density lipoproteins (LDL) *in vitro* oxidation lowering cholesterol stream levels in rats and rabbits submitted to a rich-in-cholesterol diet [11] [17]. Medications used nowadays are statins which

work inhibiting the HMG-CoA reductase, an enzyme that controls cholesterol production speed in the body; thus, it inhibits cholesterol levels, besides increasing the liver ability to remove LDL from the blood stream; statins lower cholesterol up to a 30% [16] [18]. In reviewed clinical studies it was found that an intake of an *Hibiscus sabdariffa* infusion could lower cholesterol blood levels in an 11% - 15% after four weeks [19] [20] and, although the infusion effects are not better than the etofibrate we suppose that the extract hypocholesterolemic activity could be enhanced making a better plant active metabolites purification and separation, besides it would not result as expensive as other pharmaceuticals. The documented dosage for *Hibiscus sabdariffa* (hibiscus flower) uses 1.5 g/150 ml (one cup) 5 - 10 times a day [15].

2. Hypothesis

Hibiscus sabdariffa (hibiscus) purified and separated active metabolites dry extract dispensed as gel caps lower cholesterol blood levels and can be used as a cheaper alternative to assist this ailment.

3. General Objective

To develop a plant medication in gel caps using a *Hibiscus sabdariffa* (hibiscus) dry extract as the active principle and to make clinical studies in high cholesterol patients to prove if it decreases.

4. Specific Objectives

- To establish a *Hibiscus sabdariffa* L. (hibiscus) active metabolites extraction and purification.
- To make batches to stabilize the extraction variables.
- To analyze the obtained dry extract.
- To make hard gel caps with the dry extract.
- To make a clinical study.

5. Theoretical Frame

Phytochemical studies in hibiscus plant have found the presence of phytosterols, flavonoids, saponins, and other glycosides. It has also been found the presence of carbohydrates, ascorbic acid and a mixture of citric and malic acids, as well as pigments, such as hibiscina, gosypetrin, quercetin, miracetina, hibiscetina, hibiscetrina and sabedaretina, the main pigments of the plant being anthocyanins, such as cyanidine-3-glycoside, and delphinidin-3-glycoside, which have antioxidant properties and do not exhibit toxic or mutagenic activities unless, as in all types of food and drinks cases, an individual shows allergic terrain and specific sensitivity to any of these compounds (Figure 1) [21]. These natural pigments extracted from hibiscus dry flower show antioxidant activity which has shown to reduce the atherosclerotic heart disease [22] [23] and are used in ophthalmology, in diverse circulatory disorder treatments, in inflammatory diseases, while

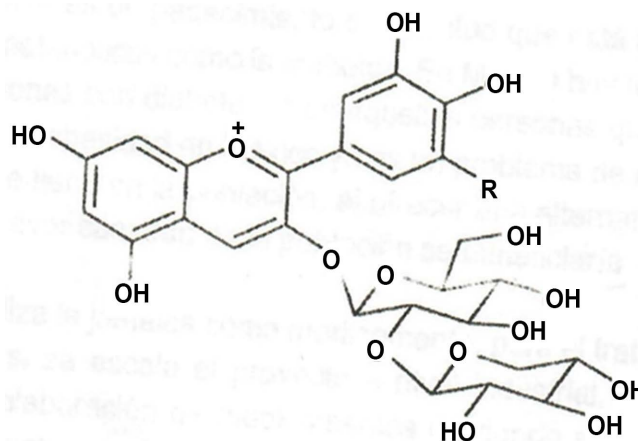


Figure 1. Identified anthocyanin molecule from a *Hibiscus sabdariffa* L. (hibiscus) extract.

hibiscus acid exhibits a high inhibitory activity on pancreatic enzymes 17). Leaves are usually used as diuretic and sedative, fruits serve to fight off scurvy; calyx infusion is used as a diuretic, intestinal antiseptic and a soft laxative, also in neurological and heart diseases, high blood pressure and arteries calcification [14].

6. Experimental Part

Hibiscus sabdariffa L. plant was bought at Mercado de Sonora in Mexico City. Ten kg of fresh plant were taken, separating its calyx. One sample of the fresh plant was pressed into a wooden and cardboard press and it was taken to the Autonomous Metropolitan University herbarium (MEXU) for its botanical identification. Its registration number was 67 and it was identified by Botanical Jorge Santana C. who gave us an identification certification, *Hibiscus sabdariffa* L., Malvaceae family, and its complete official registration number is UAMIZ67365.

6.1. Extraction Process

Once the plant was identified it was dried in a drying stove with air re-circulation. Plant calyxes were placed on drying pans with porous paper at 60°C - 70°C for a week, moving them frequently to obtain a homogeneous drying. After this, calyxes were milled by means of a Wiley type knife mill until a thick powder could pass through a No. 6 mesh.

One kg of thick powder was set in a 20 L Pyrex glass container, hexane was added to degrease the plant and it was set under maceration for two weeks after which it was filtered through a gauze fabric to separate the plant. The residue was set in a 20 L glass container, adding an alcohol/water mixture (20/80) until all powder was covered by the liquid mixture (14 L) and it was left under maceration at room temperature for 21 days (moving the mixture daily and adjusting the extraction liquid, making sure it would always cover the whole powder).

After 21 days of maceration at room temperature the mixture was filtered,

using first, a gauze fabric to separate the plant powder and then by vacuum filtration through a Büchner and a vacuum flask through a Whatman No. 42 filter, using Celite-545 as a filtering aid. The resulting filtered sample was collected in a glass container. Then it was cold evaporated, using a gas nitrogen stream over the liquid surface, set on a 22 cm diameter crystallizer until a viscous concentrate was obtained which finally was dried in a vacuum chamber, produced by means of a 1/2 HP bomb for 48 hours at 40°C until a brown-reddish dry powder was obtained. This powder was sieved through a No. 20 mesh to homogenize it; then it was kept in a suitable container.

The dry extract purification obtained from the *Hibiscus sabdariffa* L. plant extraction was made by solving the brown-yellowish powder in distilled water, adding a 6% powdered carbon active and letting the mixture shake for 2 hours after which the solution was vacuum filtered using a Büchner and a vacuum flask, through a No. 42 Whatman paper with a Celite-545 bed, obtaining a light yellow colored solution which, upon drying in a 60°C air-recirculating stove for 4 hours, resulted in a yellowish powder which was sieved through a No. 20 mesh and was kept in an amber glass bottle [24].

Ten, 1 kg each, hibiscus extraction batches were formed, and the average yielding was determined.

Extraction Results are shown in **Table 1**.

6.2. Product Analysis

Dry extract humidity was determined from each of the batches by means of a moisture balance technique which consists of setting one exactly weighed gram of the obtained dry extract on the balance plate and irradiating it with an infrared lamp for the necessary time until no decrease in weight was observed in the balance screen for three consecutive readings. After this process percent of weight loss was determined, resulting in a 0.69% average (see **Table 1**).

6.3. Dry Gel Caps Filling Method

We filled the No. zero hard gel caps with the obtained dry extract, with an average weight of 500 mg, using a Bonapace® type, semi-automatic caps filling machine as follows: gel caps were set in the machine organizer and the lower plate, which has a 100 caps capacity was filled. This plate is set in the machine holder and the caps bodies are fastened by means of a lateral lever, then the upper plate is removed which has the caps lids. This plate is momentarily set on the holder indicated for that, while it is filled with the hibiscus dry extract into the caps bodies, it is made to vibrate to compact the extract and the powder excess is removed from the plate; then the plate with its lids is set on the upper plate with the bodies and pressure is made from down to up by means of a lever which makes the bodies fit. The upper plate is removed with the already closed caps and then it is emptied. This process was repeated until the caps filling was finished (**Figure 2**).

Table 1. Yield and humidity results. The extractions yield results obtained were as follows.

Batch Number	Amount of Plant Used (kg)	Amount of Obtained Extract (g)	Average Yield (%)	Humidity (%)
1	1	148.17	14.81	1.1
2	1	134.05	13.40	1.0
3	1	142.61	14.26	0.6
4	1	153.82	15.38	0.8
5	1	152.68	15.26	0.4
6	1	150.26	15.02	0.5
7	1	146.40	14.64	0.5
8	1	149.05	14.90	0.6
9	1	136.22	13.62	0.7
10	1	148.01	14.80	0.7
Total	10 kg	1461.2 g	14.60%	0.69%

**Figure 2.** Hibiscus dry gel caps.

6.4. Plant Medication Standardization

The following analytical assays were made to the obtained caps (**Table 2** and **Table 3**) (attachment 1):

- 1) Appearance;
- 2) Weight variation;
- 3) Des-integration;
- 4) Dissolution time;
- 5) Hardness;
- 6) Friability;
- 7) Heavy metals;
- 8) Arsenic determination;
- 9) Microbial limits;
- 10) Thin layer standardization;
- 11) Secondary metabolites.

Table 2. Powder analysis results.

	TEST	REPORTED	OBTAINED
1	Appearance	Brown-yellowish powder	Brown-yellowish powder
2	Weight variation	Less than 5%	3.6%
3	Des-integration	Less than 15 minutes	14 min
4	Dissolution time	80% in 20 minutes	86%
5	Hardness	3 - 6 kg/cm ²	6 kg/cm ²
6	Friability	Less than 0.6%	0.2%
7	Heavy metals	Less than 100 ppm	20 ppm
8	Arsenic	Negative	Negative
9	Microbial limits	Less than 100 UA	Less than 100
10	CCF identity	Positive	Positive

Source: Farmacopea de los Estados Unidos Mexicanos (F.E.U.M.), 2012. Método General de Análisis para Tabletas y Cápsulas. Secretaría de Salud, 9^a. Ed. México.

Table 3. Secondary metabolite identification.

METABOLITE	TEST
Carbohydrates	Positive
Glycosides	Positive
Flavonoids	Positive
Saponins	Positive
Alkaloids	Negative
Tannins	Positive
Cardiotonic Heterosidos	Negative

6.5. Clinical Study

A clinical study was made on high blood cholesterol levels patients. It is a prospective, experimental, comparative study. The laboratory analysis was the lipidic profile which consists in total blood cholesterol levels (TC), low density lipoproteins (LDL), high density lipoproteins (HL), and triglycerides (TGCS) determination. Normal ranges were:

a) Total cholesterol (TC):

Ideal or desirable: 140 - 200 mg/dl. Higher limit: 200 - 239 mg/dl. High: more than 240 mg/dl.

b) Low density lipoproteins (LDL):

Desirable: less than 130 mg/dl. Higher limit: 130 - 159 mg/dl. High: more than 160 mg/dl.

c) High density lipoproteins (HL):

Men: 30 - 70 mg/dl; women: 30 - 80 mg/dl.

d) Triglycerides (TGCS):

Desirable: 40 - 150 mg/dl.

Source: Norma Oficial Mexicana NOM-037-SSA2-2012 para la prevención, tratamiento y control de las dislipidemias.

6.6. Patients Selection Criterion

Patients with a lipidic profile, with higher lipid levels than those established as high limits, no matter the base disease. Ages were within the range of 45 - 65 years old.

6.7. Name Sampling Criteria

1) Gender

Indifferent but with high or clear readiness to participate in the project.

With the commitment of not modifying their usual diet during the study. With the commitment of not modifying their basis treatment.

2) Exclusion Criterion

Patients who were receiving a lipid levels lowering treatment.

3) Elimination Criterion

Lack of commitment to the treatment. Voluntarily giving up. Usual diet modification during treatment. The beginning of some lipid levels lowering treatment during the study.

6.8. Sample Size

We used the following formula to determine sample size: S.S. = Number of direct variables. $S.S. = 2 \times 5 = 10$ (minimum); selected: 20. Number of groups: 2. Number of cases per group: 10. Total of cases: 20.

6.9. Patients Selection

Twenty patients were recruited for the study, age 40 - 64. They were informed about the study to be done. A clinical story was made to each of them and they were asked to give a signed letter of consent. After the patients' selection and preliminary tests to detect who were the most eligible candidates for these study groups of 10 individuals were formed. Two groups were formed by 10 individuals, 8 men and 2 women each ($n = 20$). By the second medical consult we asked them to make a profile laboratory study. In the initial lipidic profile measurements we observed an average of total cholesterol numbers of 212 - 316 mg/dl, LDL: 114 - 235 mg/dl, HDL: 30 - 89 mg/dl, Triglycerides: 92 - 198 mg/dl. After the patients' selection and preliminary tests to detect who were the most eligible candidates for this study treatments were administered according to the following established plan: group I was administered two 500 mg hard gel caps, prepared with dry *Hibiscus sabdariffa* L. extract, three times a day for a two months period. Group II patients was established as the control group and they were administered with two 500 mg (fructose) placebo caps, three times a day for the same period and under the same daily diet conditions. Determinations were made after 30 and 60 days of treatment in both cases. Average ages were between

41 and 64 years old ($x = 49$) in both groups. Two patients voluntarily abandoned the study due to a change in their residence to another city.

6.10. Ethical Considerations

All proceedings were made according to the stipulated in the General Health Law Regulations in Health Research.

6.11. Statistical Analysis

Statistical analysis was made by means of Microsoft Excel®, version XP and the SSP version 10 program. Data comparison was made by means of an ANOVA variance program to test the null hypothesis of no difference between the obtained data medias. An X^2 test was used to evaluate the patients who abandoned the study and the ones who reached the objectives distributions.

6.12. Cases Validation

We used inferential statistics because we were handling interval scales (ANOVA) and because we involved diagnostic tests, so we determined sensibility and specificity.

Results can be observed in **Table 4** and **Table 5**.

7. Results Analysis

Table 4 shows that the 10 patients' initial total blood cholesterol levels (TC) in group I varied from 236 - 320 mg/dl, with an average of 274.1 mg/dl on the 10 of them. After 30 days of treatment with the *Hibiscus sabdariffa* L. (hibiscus) dry extract caps, blood cholesterol levels results varied from 216 - 301 mg/dl with an average of 260.3 mg/dl (this represents a 5.03% total cholesterol levels reduction). After 60 days of treatment the observed total cholesterol levels were 184 - 246 mg/dl, with a mean of 210.4 mg/dl, which represents a 23.2% decrease. (the 210.4 mg/dl average value is within the upper limit of desirable values). McKey *et al.* [12] report a statistical difference in blood pressure after including a cup of hibiscus infusion as part of the diet for at least 60 days; this might be related with changes in cholesterol levels.

With respect to low density lipoproteins the initial analysis shows values of 137 - 235 mg/dl with an average of 179.1 mg/dl. After 30 days of treatment with the *Hibiscus sabdariffa* dry extract, LDL levels were 116 - 210 mg/dl, with an average of 167.1 mg/dl (which represents a 6.7% average decrease). After 60 days of treatment results were 92 - 139 mg/dl with an average of 123.8 mg/dl. Considering the average data, a 30.8% decrease was obtained (The average value of 123.8 is within the desirable levels).

In the case of the HDL initial analysis results yielded 30 - 77 mg/dl with an average of 52.8 mg/dl. After 30 days of treatment the obtained results were 34 - 85 mg/dl with a mean of 58.1 mg/dl, which represents a 10.03% increase. After

Table 4. Group I lipid profile.

No.	GROUP	AGE	SEX	INITIAL (mg/dl)				After 30 days (mg/dl)				After 60 days (mg/dl)			
				TC	LDL	HDL	TGCS	TC	LDL	HDL	TGCS	TC	LDL	HDL	TGCS
1	I	41	M	264	169	52	138	256	162	56	131	211	128	60	105
2	I	46	M	248	158	59	120	230	140	64	115	188	105	68	98
3	I	61	M	252	167	53	116	241	155	58	113	189	114	59	91
4	I	54	F	320	209	30	192	301	189	34	190	236	139	41	152
5	I	48	M	298	184	58	164	286	179	65	148	232	133	68	129
6	I	55	M	236	137	61	136	216	116	69	130	184	92	74	109
7	I	40	M	316	235	38	124	289	210	42	115	246	171	52	97
8	I	59	M	289	192	55	139	275	183	59	125	213	121	66	118
9	I	41	F	276	178	77	118	270	173	85	109	209	116	86	100
10	I	45	M	242	162	45	114	239	164	49	100	196	119	59	94
Mean		49		274.1	179.1	52.8	136.1	260.3	167.1	58.1	127.6	210.4	123.8	63.3	109.3

CT = Total Cholesterol; LDL = Low Density Lipoproteins; HDL = High Density Lipoproteins; TGCS = Triglycerides.

Table 5. Group II lipid profile.

No.	GROUP	AGE	SEX	INITIAL (mg/dl)				After 30 days (mg/dl)				After 60 days (mg/dl)			
				TC	LDL	HDL	TGCS	TC	LDL	HDL	TGCS	TC	LDL	HDL	TGCS
1	II	58	F	286	152	89	179	280	146	88	180	281	147	90	178
2	II	40	M	275	157	77	159								
3	II	64	M	304	195	31	186	298	188	32	188	295	185	33	186
4	II	40	F	290	168	69	174	291	169	71	173	293	173	70	170
5	II	44	M	224	125	67	131	225	128	65	129	220	122	66	129
6	II	52	M	260	185	57	92	262	186	59	92	259	184	58	91
7	II	55	M	212	114	53	142	215	116	54	143	210	113	55	139
8	II	49	M	290	131	69	174	289	168	70	171	287	168	68	170
9	II	40	M	235	146	37	141	230	142	35	140	229	142	36	138
10	II	47	M	308	172	74	198	300	167	76	190				
Mean		48.9		268.4	154.5	62.3	157.6	265.5	156.6	61.1	156.2	259.2	154.2	59.5	150.1

CT = Total Cholesterol; LDL = Low Density Lipoproteins; HDL = High Density Lipoproteins; TGCS = Triglycerides.

60 days of treatment the analysis results varied from 41 - 86 mg/dl, with an average of 63.3 mg/dl, which represents a 19.88% increase. The average reached after 60 days of treatment is within the desirable values for both, men and women.

Initial TGCS results are within the range 114 - 192 mg/dl with an average of 136.1 mg/dl. After 30 days of treatment results were found within the range of 100 - 190 mg/dl with a mean of 127.6 mg/dl, which represents a 6.24% decrease. After 60 days results were within a range of 91 - 152 mg/dl, with an average of 109.3 mg/dl, which represents a 19.69% decrease (The average reached with the

treatment was 109.3 mg/dl which is found within the desirable values).

In the case of group II, established as the control group, individuals who were administered fructose caps as a placebo, yielded the following results: TC initial values were within the range of 212 - 308 mg/dl with a mean of 268.4 mg/dl. After 30 days of treatment values were within a range of 215 - 300 mg/dl with a mean of 265.5 mg/dl, which is equivalent to a 1.08% decrease. After 60 days of treatment values varied from 210 - 295 mg/dl with a mean of 259.2 mg/dl or a 3.42% decrease (the obtained 3.42% decrease average is not significant).

With respect to LDL, initial values ranged from 114 - 195 mg/dl, the mean was 154.5 mg/dl. After 30 days of treatment values were 116 - 188 mg/dl, with a mean of 156.6 mg/dl, equivalent to a 1.35% increase. After 60 days of treatment analysis results were 113 - 185 mg/dl with a mean of 154.2 mg/dl or a 0.19% decrease. (Such obtained decrease in LDL was not significant).

In the case of HDL initial values were from 31 - 89 mg/dl, with an average of 62.3 mg/dl. After 30 days of treatment values were 32 - 88 mg/dl, with a mean of 61.1 mg/dl or a 1.92% decrease. After 60 days treatment values ranged from 33 - 90 mg/dl, with an average of 59.5 mg/dl or a 4.49% decrease (The 4.49% decrease was not significant).

For TGCS initial values were 92 - 198 mg/dl, with a mean of 157.6 mg/dl. After 30 days of treatment they were 92 - 190 mg/dl, with a mean of 156.2 mg/dl, or a 0.88% decrease. After 60 days of treatment they were 91 - 186 mg/dl, with a mean of 150.1 mg/dl, equivalent to a 4.75% not significant decrease.

8. Discussion

8.1. Feasibility Degree Description (Technical and Financial)

Technical and financial feasibility to make possible this project is very promising because Mexico grows hibiscus, so there is enough raw material, besides crops could increase if we give them more uses with more added value such as treatments to reduce cholesterol blood levels. Reagents needed for its preparation are easily obtainable in Mexican markets. Equipment is not complex, and it can be found in Mexico.

Investment costs are low, and recovery is within the security range. Calculations were made to determine the present net value (PNV) which resulted in a number higher than zero, which means that the final product yield is higher than the invested. The internal return rate (IRR) resulted in 29.45%. The maximum risk input rate (MRIR) yielded a value of 16%. The yield over the input (YOI) was 261%, considering a 5% inflation. This means that this project ensures profits. The market analysis was considered up to 2025 for this product, which indicates that it is cost-effective [1].

8.2. Social or Technological Impact Description

With *Hybiscus sabdariffa* (hibiscus) dry extract it was proved that it decreases cholesterol blood levels, thus, it can be used as a phytomedicine or health sup-

plement, which could give this product an added value, thus its demand and growing could increase in other zones of Mexico. This could economically benefit one part of the population in this country.

Hypercholesterolemia is a health ailment related to obesity and metabolic disease such as diabetics. In Mexico there are, nearly, 15 million diabetic people as registered plus those people who do not know are suffering this disease.

Obesity in Mexico is already a public health problem due to the high incidence of ill people. If we offer a natural and low-cost alternative a higher amount of people will benefit.

This research verifies those results obtained by other researchers who have studied hibiscus plant (*Hibiscus sabdariffa* L.) and its effects on blood serum lipids [25] [26]; increasing protecting fractions levels in order to decrease heart disease risks that could appear in this health condition. Although most of the reports are made on animals with raw plant extracts or methanol plant extracts, there have been just few studies in humans with high cholesterol blood levels. This study coincides with Álvarez-Suárez *et al.* [27], in their work about strawberries, who also found that anthocyanins, as antioxidants, are capable to decrease blood cholesterol levels in humans.

In Mexico hibiscus is not used as a medication to lower blood cholesterol levels so if this project is taken to an industrial level it will result in an important technological contribution to pharmacology, from which we can keep on making the corresponding studies to assure its efficiency and its effectiveness.

9. Conclusions

Total cholesterol in patients in group I, who were treated with hibiscus dry extract, as observed, had near a 23.2% significant decrease in blood cholesterol levels, reaching average values of 210.4 mg/dl which was very close to the desirable limit values (as compared to the results from patients in group II, who were treated with a placebo who presented a no-significant 3.42% decrease in total blood cholesterol levels).

Low density lipoproteins in group I tables show a 179.1 - 123.8 mg/dl decrease or a 30.87% at the end of the treatment. The obtained average of 123.8 mg/dl is within the reported desirable limits for this type of lipoprotein (130 mg/dl, desirable), while in control group II no significant change was observed.

High density lipoproteins in group I tables show a 19.88% increase, going from a 52.8 mg/dl average at the beginning through 63.3 mg/dl at the end of the treatment. Despite this observed lipoprotein levels, the obtained average is within the desirable limits because for men they normally ranged from 30 - 70 mg/dl and for women it was from 30 - 80 mg/dl. In control group II it was observed, for this lipoprotein a slight, no-significant 4.44% decrease which is within the desirable limits.

With respect to triglycerides, the obtained tables show in group I a 19.69% decrease, from 136.1 mg/dl at the beginning of the treatment through 109.3

mg/dl at the end of it. These values are found within the desirable limits.

Anthocyanins play a very important role as antioxidants because they decrease the blood cholesterol levels in humans.

An important aspect of this study is to present a natural alternative for people with these diseases, for their treatment, which is less expensive and is found in any society level, and easily affordable.

Despite the briefness of this study the obtained results express its efficacy, although it is suggestable to continue with this plant's study. It would also be interesting to test with patients with higher blood cholesterol levels to see what happens.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] <http://www.equilibriovital.com/flor-de-jamaica.php>
- [2] Abubakar, S.M., Spencer, J.P.E. and Lovegrove, J.A. (2016) Acute Impact of *Hibiscus sabdariffa* Calyces on Postprandial Lipids, Biomarkers of Insulin Resistance and Inflammation in Humans. *Proceedings of the Nutrition Society*, **75**, E109. <https://doi.org/10.1017/S0029665116001245>
- [3] https://es.wikipedia.org/wiki/Hibiscus_sabdariffa.
- [4] http://www.hort.purdue.edu/newcrop/duke_energy/Hibiscus_sabdariffa.html
- [5] Lin, T.-L., Lin, H.-H. and Chen, C.-C. (2010) *Hibiscus sabdariffa* Extract Reduces Serum Cholesterol in Men and Women. *Nutrition Research*, **27**, 140-145. <https://doi.org/10.1016/j.nutres.2007.01.007>
- [6] Kao, E.-S., Yang, M.-Y., Hung, C.-H., Huang, C.-N. and Wang, C.-J. (2016) Polyphenolic Extract from *Hibiscus sabdariffa* Reduces Body fat by Inhibiting Hepatic Lipogenesis and Preadipocyte Adipogenesis. *Food and Function*, **7**, 171-182. <https://doi.org/10.1039/C5FO00714C>
- [7] Cisse, M., Dornier, M., Sakho, M., Ndiaye, A., Reynes, M. and Sock, L.O. (2009) Le bissap (*Hibiscus sabdariffa* L.): Composition et principales utilisations. *Fruit*, **64**, 179-193. <https://doi.org/10.1051/fruits/2009013>
- [8] Ismail, A., Khairul, I. and Mohd, N. (2008) Roselle (*Hibiscus sabdariffa* L.) Seeds Nutritional Composition, Protein Quality and Health Benefits. *Food*, **2**, 1-16.
- [9] Gaet, N. (1999) *Hibiscus sabdariffa* L. In: Ivan. A., Ed., *Medicinal Plants of the World*, Human Press, New York, 165-170.
- [10] Ibrahim K.G., Chivandi, F.B., Mojiminiyi, O. and Erlwanger, K.H. (2017) The Response of Male and Female Rats to a High-Fructose Diet during Adolescence Following Early Administration of *Hibiscus sabdariffa* Aqueous Calyx Extract. *Journal of Developmental Origins of Health and Disease*, **8**, 628-637. <https://doi.org/10.1017/S204017441700040X>
- [11] Hexberg, S. and Willumsen, E.N. (1994) A Study on Lipid Metabolism in Heart and Liver of Cholesterol and Pectin Fed Rats. *British Journal of Nutrition*, **71**, 181-192. <https://doi.org/10.1079/BJN19940125>
- [12] Mc Kay, D., Oliver-Chen, C.-Y., Zaltsman, E. and Blumberg, J.B. (2010) *Hibiscus*

- sabdariffa* L. Tea (Tisane) Lowers Blood Pressure in Prehypertensive and Mildly Hypertensive Adult. *The Journal of Nutrition*, **140**, 298-303.
<https://doi.org/10.3945/jn.109.115097>
- [13] Gehrman, K.T. (2005) Medicinal Herbs, a Compendium. Haworth Press, New York, 244 p.
- [14] Peng, C.H., Chyau, C.C., Chan, K.C., Chan, T.H., Wang, C.J. and Huang, C.N. (2011) *Hibiscus sabdariffa* Polyphenolic Extract Inhibits Hyperglycemia, Hyperlipidemia, and Glycation-Oxidative Stress While Improving Insulin Resistance. *Journal of Agricultural and Food Chemistry*, **59**, 9901-9909.
<https://doi.org/10.1021/jf2022379>
- [15] Hirunpanich, V. and Utaipat, A. (2012) Hypocholesterolemic and Antioxidant Effects of Aqueous Extracts from the Dried Calyx of *Hibiscus sabdariffa* L. in Hypercholesterolemic Rats. *Journal of Ethnopharmacology*, **103**, 252-260.
<https://doi.org/10.1016/j.jep.2005.08.033>
- [16] Duh, P.D. and Yen, G.C. (1997) Antioxidativeactivity of Three Herbal Water Extracts. *Food and Chemical*, **60**, 639-645.
[https://doi.org/10.1016/S0308-8146\(97\)00049-6](https://doi.org/10.1016/S0308-8146(97)00049-6)
- [17] Tseng, T.H., Wang, C.J., Kao, E.S. and Chu, H.Y. (1996) Hibiscus Protocatechuic Acid Products against Oxidative Damage Induced Bytert-Butylhydroperoxide(α -BHT) in Rat Primary Hepatocytes. *Chemical and Biological Interaction*, **101**, 137-148.
[https://doi.org/10.1016/0009-2797\(96\)03721-0](https://doi.org/10.1016/0009-2797(96)03721-0)
- [18] Orange, W.A., Sets, J.P., Rondas-Colbers, G.L., Lemmens, P.G. and Wolfenbuttel, B.H. (2001) The Effect of Atorvasiatin on LDL Oxidation and Antioxidant in Normal Cholesterolemic Type 2 Diabetic Patients. *Clinica Chimica Acta*, **311**, 91-94.
[https://doi.org/10.1016/S0009-8981\(01\)00549-6](https://doi.org/10.1016/S0009-8981(01)00549-6)
- [19] Di Carlo, G., Mascolo, N., Lazzo, A.A. and Capasso, F (1990) Flavonoids Old and New Aspects of Class Natural Therapeutic Drugs. *Life Sciences*, **65**, 337-353.
[https://doi.org/10.1016/S0024-3205\(99\)00120-4](https://doi.org/10.1016/S0024-3205(99)00120-4)
- [20] El-Saadany, S.S., Sitohy, M.Z.. and Labib, S.M. (1991) Biochemichal Dynamic and Hypocholesterolemic Action of *Hibiscus sabdariffa* L. (Karkada). *Die Nahrung*, **35**, 567-576. <https://doi.org/10.1002/food.19910350603>
- [21] Ondahunsi, A.A. and Olaleye, M.T. (2003) Toxicological Investigation on Aqueous Methanolic Extract of Calyces of *Hibiscus sabdariffa* L. *Journal of Ethnopharmacology*, **89**, 161-164. [https://doi.org/10.1016/S0378-8741\(03\)00276-9](https://doi.org/10.1016/S0378-8741(03)00276-9)
- [22] Diaz, M.N., Frei, B.J., Vita, A. and Keaney, J.F. (1997) Antioxidants and Atherosclerotic Heart Disease. *New England Journal of Medicine*, **7**, 408-416.
<https://doi.org/10.1056/NEJM199708073370607>
- [23] Anderson, T.J., Meredith, I.T., Yeung, A.C., Frei, B, Selwyn, A.P. and Ganz, P (1995) The Effect of Cholesterol-Lowering and Antioxidant Therapy on Endothelium-Dependent Coronary Vasomotion. *New England Journal of Medicine*, **332**, 488-493. <https://doi.org/10.1056/NEJM199502233320802>
- [24] Núñez, C.E. (2008) Extracciones con Equipo Soxhlet. www.cenunez.com.ar
- [25] Alarcón-Aguilar, F.J. (2014) Effect of *Hibiscus sabdariffa* on Obesity in MSG Mice. *Journal of Ethnopharmacology*, **114**, 66-71.
<https://doi.org/10.1016/j.jep.2007.07.020>
- [26] <http://www.uv.mx/cienciahombre/revistae/vol19num2/articulos/jamaica/index.html>
- [27] Alvarez-Suares, J.M., Giamperi, F., Tulipani, S., Casoli, T., DiStefano, G., González-Paramás, A.M., Santos Buelga, C., Busco, F., Quiles, J.L., Cordero, M.D.,

Bompadre, S., Mazzetti, B. and Battino, M. (2014) One-Month Strawberry-Rich Anthocyanin Supplementation Ameliorates Cardiovascular Risk Oxidative Stress Markers and Platelet Activation in Humans. *The journal of Nutritional Biochemistry*, **25**, 289-296. <https://doi.org/10.1016/j.jnutbio.2013.11.002>