Page 76 to 82

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Role of *Moringa oleifera* on Electrolytes Levels and Cardiovascular Function in Human

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Abstract

Background/Aim: *Moringa oleifera* is one of the many plants that are being used today in treating various pathological conditions. The current study investigates the effects *Moringa oleifera* leaf powder has on the levels of serum Sodium, Chloride and Potassium ions in the bodies of healthy human subjects.

Method: Thirty (30) participants took part in the oral administration of 5.0g of *Moringa oleifera* for duration of 7 days. Readings for the serum electrolytes were taken before onset and after the 7 days administration of the *Moringa oleifera* extract, with the previous readings serving as a control.

Results: There was a significant decrease ($P < 0.05$) in Sodium and Chloride ions, and a non-significant decrease in potassium ions.

Conclusion: The decrease in electrolytes levels has been associated with the active phytochemical constituents present in the *M. oleifera* leaves. Therefore *Moringa oleifera* leaf has beneficial hypotensive potential on cardiovascular functions in human.

Keywords: *Moringa oleifera; Serum electrolytes; Hypotensive potentials; Cardiovascular function*

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Introduction

Medicinal values of several plants have over time provided alternatives to conventional medicines in the treatment of many ailments, and importantly, at a cheaper rate, especially in developing nations. Among such useful plants is *Moringa oleifera*, which has recently gained the attention of many researchers. The plant belongs to the family *Moringaceae*. It is a highly valued plant, distributed in many countries of the tropics and subtropics.

Moringa oleifera is known to have impressive range of medicinal uses and high nutritional value. Nearly every part of this plant, including its root, bark, gum, leaf, fruit (pods), flowers, seed, and seed oil have been used for treatment of various ailments in the indigenous medicine [1]. Studies on animal and human models have demonstrated these benefits attributed to it. For instance, *Moringa* flowers are used as traditional remedies for tumours, the seeds and leaves are applied as poultice to sores and rubbed on the temples of the head to relieve pains and headaches [2].

Moringa leaves contain several compounds that have direct effect on blood pressure, and thus used for keeping blood pressure at optimal levels [3]. The compounds leading to blood pressure lowering effect include nitrile, mustard oil glycosides and thiocarbamate glycosides present in *Moringa leaves* [4]. In addition, diuretic activity of Moringa exists in its roots, leaves, flowers, gum and the aqueous infusion of seeds [5]. Its leaf extracts also have the potential for cancer chemoprevention due to their apoptotic and anti-proliferative effects as seen in human tumour cells because of the presence of quercetin and kaempferol [6]. Administration of *Moringa* oleifera extracts (root bark, stem bark, and leaves) with hypoglycaemic properties can lower the blood sugar levels and can be used for the management of diabetes [3,7]. Moreover, *Moringa leaves* also contain a bioactive phytoconstituent known as b-sitosterol which has cholesterol lowering effects. This compound is capable of reducing cholesterol level from the serum of high fat diet fed rats [8]. Extract of *Moringa oleifera* leaves have also been effectively used to manage anaemic patients because of it potent activities in both low and relatively high dose in improving red cell count [9].

Moringa oleifera methanolic extract also has the capability of protecting experimental rats from induced gastric lesions, as well as enhancing the healing process of induced chronic gastric lesions in experimental animals [10]. *Moringa* plant parts have substantial anti-inflammatory activity. For instance, the root extract exhibits significant anti-inflammatory activity in carrageenan induced rat paw edema [11,12]; and n-butanol extract of the seeds show anti-inflammatory activity against ovalbumin-induced airway inflammation in guinea pigs [13]. Furthermore, a study using ethanolic extracts of *Moringa concanensis* tender pod-like fruits in experimental animals, observed a significant analgesic activity [14].

Moringa oleifera is a rich source of antioxidant [15]; the aqueous extracts of its leaf, fruit and seed act as an antioxidant [16]. Recent experiment demonstrated that the ethanolic extract of *M. oleifera* was found to have anti-malarial effects on some malaria-induced mice [17].

Vitamin A deficiency is a major cause of blindness, which ranges from impaired dark adaptation to night blindness. Consumption of *Moringa oleifera* leaves, pods and leaf powder which contain high proportion of vitamin A can help to prevent night blindness and eye problems in children, and ingesting the leaves with oils can improve vitamin A nutrition and can delay the development of cataract [18].

Serum electrolytes

Electrolytes are substances that become ions in solution and acquire the capacity to conduct electricity; sodium, potassium, and chloride are among the most commonly monitored electrolytes in the body. Serum electrolyte concentration is among the most commonly used laboratory tests for assessment of a patient's clinical conditions and disease states, because electrolyte balance in the body is essential for normal functioning of cells & organ1s [19].

Physiology of Sodium ion

The most abundant cation in the extracellular fluid is sodium; and it is also the major regulating factor for body water balance (normal serum Na+ = 130-145 mmol/L). Extracellular (i.e., intravascular and interstitial) and intracellular sodium contents are affected by the body fluid status. Sodium is important for maintaining the transmembrane electric potential for action potential and neuromuscular functions, but its principal is to regulate serum osmolality as well as fluid balance [20].

The kidneys are responsible for the retention and excretion of body sodium and water. The glomeruli receive and filter about 180 L of plasma and 600g (nearly 26,000 mEq) of sodium per day. On average, less than 2 liter of water and between 0.1-40g of sodium are excreted in the urine, depending on the fluid status of the individual. While almost 100% of the plasma sodium is filtered by the glomeruli, less than 1% is excreted in the urine under normal circumstances. The proximal tubule and the Loop of Henle each account for approximately 45% of sodium reabsorption [20].

The homeostatic mechanism for water and sodium involves the equilibrium among intravascular, interstitial, and intracellular fluids [21]. Net movement of water occurs from areas of low osmolality to areas of high osmolality. This effect can be readily observed in patients with a low serum osmolality due to a deficit of serum sodium or excess of plasma water. Water then moves from the plasma compartment to the higher osmolality in the interstitial space to minimize the osmolar gap [21]. In the presence of high hydrostatic and oncotic pressure gaps across capillary walls, the net effect is excessive interstitial water accumulation and edema formation [21,22]. The three major mediators whose pathways can alter the homeostasis of water and sodium include vasopressin or antidiuretic hormone (ADH), the renin- angiotensin-aldosterone system (RAAS), and natriuretic peptides.

Antidiuretic hormone (ADH), also known as arginine vasopressin, is a non-peptide hormone that regulates renal handling of free water. Alteration of the amount of water reabsorbed by the kidney has an important effect on serum sodium concentration. ADH is secreted by the neurons in the supra-optic and paraventricular nuclei of the hypothalamus, and its release is stimulated by (1) hypovolemia (detected by baroreceptors), (2) thirst, (3) increased serum osmolality, and (4) angiotensin II [22].

In the renin-angiotensin-aldosterone system, renin catalyzes the conversion of angiotensinogen to angiotensin I, which is further converted to angiotensin II (in the lungs or kidneys), [22]. Angiotensin II, which is a vasocontrictor, is important in maintaining optimal perfusion pressure to end organs, especially when plasma volume is decreased. It also induces the release of aldosterone, ADH, and, to a lesser extent, cortisol. Aldosterone is a hormone released from the adrenal cortex with mineralo-corticoidal actions, which affects the distal tubular reabsorption of sodium rather than water [22].

Besides angiotensin II, various dietary and neuro-hormonal factors including low serum sodium, high serum potassium, and low blood volume can also stimulate its release.

Physiology of Potassium ion

Potassium plays an important role (Normal serum potassium level = 3.5-5.0 mEq/L) in regulation of the heart beat and function of muscles. Potassium along with sodium is involved with regulation of water and acid-base balance in blood and tissue [23]. In mammals, the osmotic pressure and water distribution maintenance is primary function of electrolytes like sodium and potassium. In addition, they play a role in maintenance of pH, in oxidation reduction reactions, in heart muscle functioning and as cofactors for enzymes [24]. The body has two different mechanisms to restore potassium balance when the serum potassium concentration is high: one quick way which is to shift the plasma potassium into cells, while the other slower mechanism is renal elimination [25].

Physiology of chloride ion

Chloride is the most abundant extracellular anion with a concentration of about 95-110 mmol/L. It is passively absorbed from the upper small intestine. Chloride is primarily regulated by the renal proximal tubules, where it is exchanged for bicarbonate ions and passively follows sodium and water throughout the rest of the nephron. Cl^- is influenced by the extracellular fluid balance and acid-base balance [26]. Homeostatic mechanisms indirectly regulate Cl^- through changes in sodium and bicarbonate. The physiological role of chloride is to balance out positive charges in the extracellular fluid and, by following sodium passively, it helps to maintain extracellular osmolality.

Materials/Methodology

Materials

Thirty (30) human test subjects of both gender, *Moringa oleifera* leaf powder, plain serum bottles, syringes and needles, tourniquet, cotton wool, hand gloves, pipette, centrifuge, methylated spirit, chemical weighing balance.

Preparation of Moringa oleifera leaf powder

Air dried *Moringa oleifera* powder was purchased from a vendor at Prince/Princess Estate, FCT, Abuja, Nigeria. It was weighed on a scale and divided into daily portions which made it easier for daily administration.

Recruitment of test subjects

This research was carried out on 30 subjects (persons) (18 females, 12 males) among the students of Bingham University, Karu. The test subjects were obtained through purposive sampling (i.e. the selection of those known with the ability to comply with the research requirements).

Experimental design

Subjects were administered 5.0g of *Moringa oleifera* powder for 7 days. There was no control group. The initial serum electrolyte values of the test subjects were used as a basis for comparison, and therefore stood as the control. The study was extended over a period of a week with *M. oleifera* leaf powder being daily orally ingested by the subjects as a solution of *Moringa oleifera* leaf powder and water.

Collection of blood samples for serum electrolyte analysis

Two sets of blood samples (5 mls) were obtained; one at the beginning and the other at the end of the study, and it was drawn from the cubital fossa of some; and the dorsal surface (of the hand) in others. The blood, drawn out using a disposable syringe and needle was emptied into plain serum bottles; allowed to stand for about an hour and clot; then was centrifuged to separate the serum into a clean bottle for analysis. Prior to collection of the blood samples, each blood sample bottle was labelled.

Determination of serum electrolyte parameter values

The bottled serum samples were put in a flask and transported with ice packs to a clinic in Mogadishu Cantonment, FCT, Abuja. The serum analysis was then conducted by a qualified laboratory technician and the test results were picked up on conclusion of the analysis.

Statistical analysis

Statistical analysis was presented using standard error of mean and paired T-test. SPSS package was used to compute the analysis, which was then exported to Microsoft Word for printing.

Results

Note: Out of the 30 recruited participants in the study, one test subject opted out and the results were only obtained from 29 subjects who completed the study.

Electrolyte	Mean initial (mmol/L) (ie before administration of Moringa)	Mean final (mmol/L) (ie after 7-day administration of Moringa)
Serum sodium levels	131.0483 ± 0.96247	128.4241 ± 0.99969*
Serum potassium levels	3.9276 ± 0.05974	3.8828 ± 0.05682 ns
Serum chloride levels	103.6793 ± 0.81598	99.4759 ± 0.84883*

Mean ± Standard Error of Mean (SEM)

*= statistically significant at $P < 0.05$;

*ns = not statistically significant at $P < 0.05$

Results, show that there is a significant decrease in the mean serum Na^+ and Cl^+ levels at $P < 0.05$; and a non-significant decrease in the mean serum potassium level at $P < 0.05$.

Table 1: *Showing effects of Moringa oleifera on serum Na^+, K^+, and Cl^- levels.*

Discussion and Conclusion

Discussion

Effect of *Moringa oleifera* on Electrolyte Concentration

The serum sodium and chloride were found to have decreased significantly ($P < 0.05$) after 5g *Moringa oleifera* intake for 7 days. The significant decrease in serum sodium agrees with the research on the effect of the administration of aqueous *Moringa oleifera* leaf extract on serum sodium level of the wistar rats [27]. This decrease can be associated with the blood pressure lowering effect present in *Moringa* leaves due to nitrile, mustard oil glycosides and thiocarbamate glycosides [3, 28]. These hypotensive effects have been attributed to specific compounds: niazinin A, niazinin B, niazimicin and niazinin A + B present in *Moringa* leaf which showed a blood pressure lowering effect in rats, and may also explain this effect in humans, possibly due to calcium antagonist effect [29].

The decrease in Na^+ and Cl^- could also be due to dietary changes. Acute reduction in serum sodium is an electrolyte abnormality which is caused usually by a fall in plasma osmolality [30]. Conservation or excretion of sodium depends on the sodium content of the extracellular fluid (ECF) and the blood volume. Decreased serum concentrations might be due to increased sodium loss, water imbalance or retention.

Physiologically, excessive salt intake (NaCl) results in high plasma levels of sodium which leads to high water retention in the kidneys, and because sodium is not excreted it can result in a condition known as hypervolemia or fluid overload (abnormal increase in blood volume). This abnormal increase in total blood volume increases blood pressure (hypertension), thereby exposing human subjects to various diseases such as left ventricular hypertrophy, stroke and atherosclerosis among others. Therefore, the above evidence suggests that *M. oleifera* can be used in the prevention of some cardiovascular diseases.

On the other hand, the serum potassium showed no statistically significant decrease ($P < 0.05$) after *M. oleifera* intake. This conforms to a research work conducted by Okwari on wistar rats which documented no significant decrease in mean serum potassium after intake of the aqueous extract of the leaves of *M. oleifera* [27]. However, another experiment verified the presence of high amounts of potassium ion in pods and leaves [31]. The lack of correlation between the results of this study and the above report, could be due to the variation in the diets of the subjects during the week of administration. It may also be due to the short duration of the study; the duration may not have been long enough to produce a significant decrease in the serum potassium. Decrease in serum K+ may occur in gastrointestinal or urinary loss or with increase cellular up take, in stool and large doses of diuretics [30].

Low serum Cl^-, whether associated with a hypoosmotic state or not, may facilitate Cl– currents, acting as an enhancer to the phenomena that have been traced as possible triggers increasing the probability of an open state of these channels [32]. Such phenomena include ischemia-induced local hypoosmotic state leading, in turn, to swelling of the cell and stimulation by tumor necrosis factor-α and interleukin-1β. Experimental evidence support the potential role of several Cl^- channels in the heart including CFTR, ClC-2, ClC-3, CLCA, Bestrophin, and TMEM16A which may contribute to cardiac arrhythmogenesis, myocardial hypertrophy and heart failure, and cardio protection against ischemia–reperfusion [32].

Other potential mechanisms may relate to non-cardiac and non-renal roles for Cl^-. For examples, Cl^- channels are present in the surface and transverse tubular membranes of mammalian skeletal muscle and Cl^- moves into muscle during t-tubular action potentials or

with K^+-induced depolarization of the sarcolemma. Extracellular Cl^- has been shown to be protective against fatigue (with implications for survival and cardiovascular risk) involving high-intensity contractions in both fast- and slow-twitch mammalian muscle possibly by preventing excessive depolarisation with exercise-induced decline in trans-sarcolemmal K^+ gradient [32].

Cl−-dependent mechanisms appear to underlie a plethora of critical pathways underlying cardiovascular disease and blood pressure regulation highlighting the need for further studies to elucidate the mechanistic underpinnings of these observations [32]. However, the relationship between dietary chloride, serum chloride, and intracellular chloride all appear to have different pathophysiological effects, and further studies are needed to determine the mechanistic underpinnings of the epidemiologic findings.

Conclusion

The decrease in sodium and chloride ions has been associated with the active phytochemical constituents present in the *M. oleifera* leaf. It appears that *Moringa oleifera* may reduce blood pressure because of its evident effect on sodium levels, and this explains the use of this plant (especially the leaves) in the management of hypertensive subjects and some other cardiovascular diseases. Therefore *Moringa oleifera* has beneficial hypotensive potential.

Limitation

The blood pressure of the subjects was not taken before and after the commencement of administration *Moringa oleifera*. This would have formed stronger bases for its hypotensive potentials.

Recommendation

Further and more detailed research work may be needed to improve on the current results. These could include taking ambulatory blood pressures, before and after serum iron, iron-binding capacity, or ferritin levels and reticulocyte counts over a 10-14 day period, together with urinary electrolytes, aldosterone, and glucose levels of the subjects. Further work could also look at dose-dependent effect of the extract on the hypertension, and clinical utility of each of the properties of the extract.

Research Ethics: Ethical review and clearance of the research protocol, research instruments and consent procedures were obtained from the Ethical Review Committee of the Department of Human Physiology, Bingham University, Karu, Nigeria.

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