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MEASUREMENT OF ELECTROLYTE LEVELS IN VEGETABLE SAMPLES USING ION SELECTIVE ELECTRODES (ISE) TECHNIQUE

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ABSTRACT: Ion Selective Electrodes (ISE) are the best measuring tools because they can constantly and without damaging the solution watch the activity of certain ions. In this study, a group of ISE is used to create a microcontroller-based instrumentation system for checking the amounts of sodium and potassium in vegetables. Taking a look at the differences between the values found using the other way and the instrument that was made. A comparison is made between the two methods, which shows how accurate the tool that was made is.
Keywords: Atmega 32, Sodium ISE, Potassium ISE, Microcontroller based system, Vegetable samples

1. INTRODUCTION

All bodily functions can be affected by electrolytes. Plasma potassium levels over 5.5 mEq/liter indicate hyperkalemia. Unfortunately, 10% of hospitalized patients always have this condition. One percent of hyperkalemia is severe. It makes the suffering quit. A majority of potassium ions are located inside cells. Potassium levels may rise if cells don't absorb potassium from the kidneys. Some Renin-Angiotensin-Aldosterone system-altering drugs produce hyperkalemia. Renal failure patients must limit potassium intake because their kidneys can't remove it. If you don't get enough potassium, you get hypokalemia. Muscle weakness or transient paralysis might provide the patient normal times. Due to excessive potassium levels, hyperkalemia paralysis is unusual and can paralyze you. Severe hyperkalemia can cause cardiac arrest without symptoms. A dangerous medical emergency occurs when blood potassium levels exceed 7 mmol/l and an ECG deviation occurs. Muscle weakness is often the only indicator of no metabolic issue. Dialysis may be needed when potassium levels drop since it predominantly affects shoulder and pelvic muscles, omitting bulbar muscles. Nerve conduction examinations reveal reduced muscle amplitudes. Electromyography (EMG) recordings may not be available.

Food, environment, and biological materials can be tested for electrolytes. To measure sample analytical concentration in real time, we need autonomous, affordable, and portable equipment. The potentiometric approach uses ISE, the greatest tool for measuring sodium, potassium, chloride, calcium, lithium, and fluoride. Body fluid homeostasis requires potassium and salt. The most prevalent positively charged ion in external fluid is sodium. Most intracellular cations are negatively charged potassium. Cells have 30 times more potassium than the exterior. Cells contain ten times less sodium. The differential in potassium and sodium provides cell membrane potential, which is needed for heart activity, muscle contraction, and nerve impulse transmission. Mineral deficiencies must be avoided at all costs through proper nutrition due to their link to chronic diseases. This includes potassium and salt deficiencies. Most fruits, dairy, cheese, and meat have high quantities of potassium and salt. Because they contain minerals and micronutrients, vegetables are vital to human nutrition. Extracting from banana and plant stems has enormous benefits.

Calcium ions can come from several sources, but they must meet strict quality standards. Adding nutrients to processed banana stem juice powder to suit nutritional needs is typical. People consider it a complete, nutritious meal. veggies and banana stem juice extract absorb Ca^{2+} better into the intestines than cereals and veggies. Young children need calcium ions to grow. Calcium is essential for numerous biochemical and physiological processes.

Optimal blood coagulation, muscular contraction, intercellular communication, and secretion require regular calcium ion intake. Inorganic compound homeostasis requires calcium ions. The Institutes of Medicine recommend 800 mg of calcium ions daily for 4–8-year-olds. The recommended daily dose for 9-18-year-olds is 1300 mg. Adults 19–50, including pregnant and breastfeeding women, should consume 1000 mg of calcium ions daily. Individuals 51 and older should aim for 1200 mg daily.

Calcium, potassium, and sodium ions can be quantified using many current methods. Atomic absorption spectrometry, spectrophotometry with various chemicals, EDTA titration, and potentiometric analysis using ion-selective electrodes are used. Due to their low cost and simplicity, ion selective electrodes are a better alternative.

This research monitors vegetable salt and potassium concentrations with an Ion Selective Electrode in a real-time microcontroller system. By comparing the system's analytical performance to other methods.

2. SYSTEM INTERFACE

Figure 1 shows a picture of the System Interface circuit. These two types of inputs allow the Instrumentation Amplifier CA3140 to connect to the output of the Integrated Assembly of Sodium and Potassium Ion Selective Electrodes (ISE). Two sensors are linked to two different amplifiers [18]. Through PAO and PA1, the amplifier's output is linked to the ATmega32 microcontroller's ADC. The ATmega 32 is an 8-bit processor that is known for how well it works and how little power it uses. There are 2 kilobytes of random access memory (RAM) and 32 kilobytes of flash memory in the whole thing. The microcontroller's pins PB0, PB1, PB2, and PB3 are linked to the stepper motor so that the electrode sensor probe can move in a controlled way. This makes it possible to lower the instrument into the sample for measuring reasons. If you give the stepper motor the right orders, it can turn both clockwise and counterclockwise. After this, the motion changes from a circle to a straight line, which moves the electrode probe forward. An infrared position monitor tells us where the instrument was when it was first set up. There is a switching transistor and a hex buffer 7404 used to connect the DC pump motor to the controller's PB4. Every time the wire moves, the motor starts up [19]. When the motor goes up, calibrator 1 is put into the electrode, and when it goes down, it is taken out. The PC4, PC5, and PC6 keys can talk to each other. By linking the screen to microcontroller port D, the results are shown.

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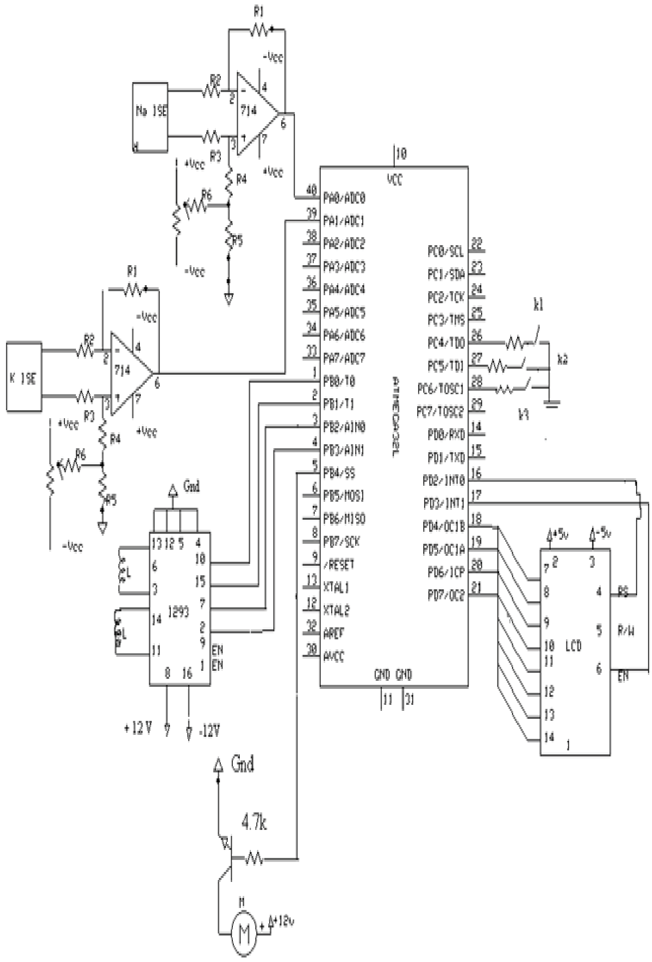

Figure1: System interfacing with microcontroller AT mega 32.

3. MATERIALS AND METHODS

The potentiometric membrane's make-up is based on what has been written [20, 21]. Adipate (56.3%) (Fluka), PVC (37.1%) (Aldrich), and sodium ionophore VI (6.3%) (Sigma) are the chemicals used to make sodium membranes. For making potassium membranes, chemicals like nitrobenzene (16.3%), Valinomycin (2.14%) from Sigma, Adipate (51.1%) from Fluka, and PVC (30.9%) from Aldrich are used. The membrane solution is put in place using PVC tube that has potassium in the second groove and sodium in the first. Ag/AgCl is used as a reference electrode. After being cleaned, the veggies are put in plastic bags to store them after being bought at the market. The extracts from them were taken out and put in plastic cups for the whole experiment. The device needs to be calibrated at two points. There are two ways to calibrate that are used. To make calibrators 1 and 2, the right amounts of potassium chloride and sodium chloride are dissolved in double-distilled water. Both of these liquids have different amounts of sodium and potassium in them. Keeping the electrode in solution calibrator 1 all the time makes sure it is always ready to be measured and condition. The pump motor is used to put the calibrator 1 solution on the electrode and take it off again. The calibrator 2 is put inside a sample cup during the testing process. The device goes down to read calibrator 2 after finding the potential at calibrator 1. To find the slope of the calculation, the Nernst equation is used. After that, the calibrated slope number is used to find the

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unknown concentration of the sample. The relationship is used to figure out how much potassium and sodium are in a sample.

$$\frac{Ex - Es1}{Es1 - Es2}\left(Log\, as1 / as2\right) = Logax / as1$$

Ex, Es1, and Es2 are the sensor's potentials at the sample, cal 1, and cal 2 solutions, in that order. In the same way, mmol/L is used to measure the amounts of activities as1, as2, and ax.

SOFTWARE

Assembler language and C are used to make software that can read data from the keyboard, start A/D conversion, check EOC, read higher and lower bytes of data, get readings for standard1, standard2, and sample, turn on the stepper and dc motors, process data, and show the results on the LCD display (Figure 2).

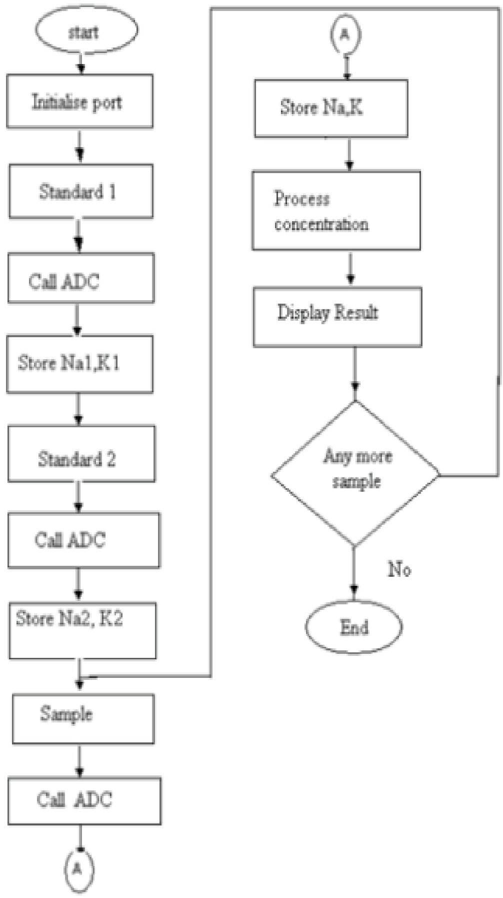

Figure 2: Flowchart.

4. RESULTS AND DISCUSSION

The levels of potassium and sodium in veggies were found using the Flame Photometry and ISE methods, which are shown in Tables 1 and 2. The results show that the numbers obtained by the ISE method and the other method are comparable. The system that was put in place can be repeated with less trouble than a different method that was considered. The F-test is a statistical way to measure how accurate two different methods are. That there is no significant difference between the variances of the two sets of data at the 5% level is the null hypothesis, which is based on a d.f. of 4. Table 3 shows the mean and standard deviation of two measurements where the flame photometry principle and the new device don't show any noticeable differences. The number of the correlation coefficient between the Flame photometry system and the system that was put in place is very good. When you use both ways, you get almost the same maximum and minimum values for sodium and potassium concentrations. Flame photometry and ISE were used to find the sodium amounts shown in Figure 3. An intercept of -0.62 and a slope of 1.029 were found. The potassium concentration line is shown in Figure 4. It has an intercept of -0.1 and a slope of 1.158. The fact that the line in both graphs is straight shows that the instrument that was made can be used with the other way. The findings show that potatoes have a low amount of sodium and beetroot has a high amount. Compared to carrots, beets don't have as much potassium. On average, you shouldn't get more than 4700 mg of potassium and 4000 mg of sodium per day. It is okay for people with hypernatremia, hyponatremia, or both to eat vegetables, depending on their unique medical conditions.

Table 1: Concentration of sodium in vegetables.

Sample	The concentration of Sodium (mmol/ ltr)	
	By developed system	By Flame Photometry
Carrot	22 ± 1	25 ± 2
Potato	6	7 ± 1
Beans	18 ± 2	15 ± 4
Tomato	7.9 ± 0.2	6 ± 2
Beetroot	127	130 ± 2

Table 2: Concentration of potassium in vegetables.

Sample	The concentration of Sodium (mmol/ ltr)	
	By developed system	By Flame Photometry
Carrot	67 ± 2	70 ± 2
Potato	47 ± 1	44 ± 4
Beans	37 ± 1	36 ± 2
Tomato	57.5	60 ± 3
Beetroot	32	30 ± 3

Table 3: Statistical results obtained between the implemented systems versus flame photometry method.

Variable	Mean		S.D	
	Sodium	Potassium	Sodium	Potassium
Concentration by ISE	180.9	240.5	36.18	48.1
Flame Photometry	183	240	36.6	48
Residual	2.1	0.5	0.42	0.1
R	0.99	0.99	-	-

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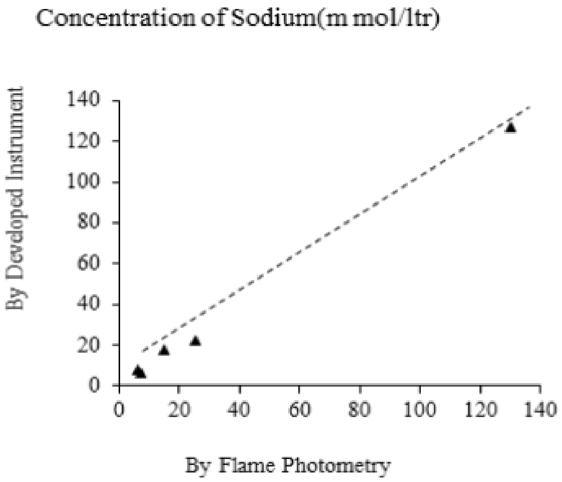

Figure 3: Comparison line between the two methods for sodium concentration.

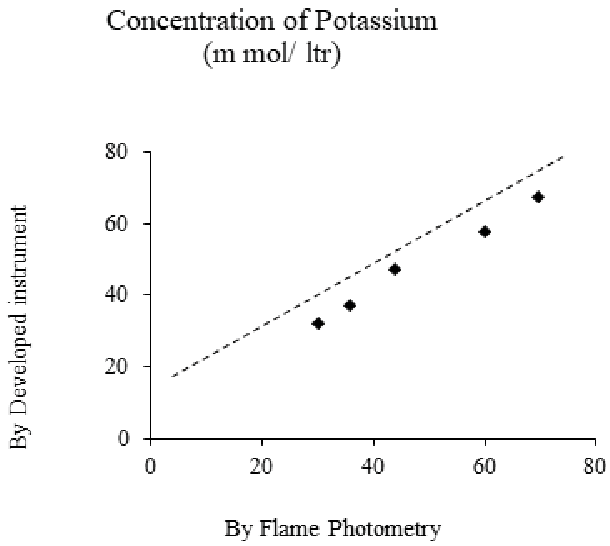

Figure 4: Comparison line between the two methods for potassium concentration.

5. CONCLUSION

The Atmega 32 microcontroller is used to build an instrumentation device that measures and counts the amounts of potassium and sodium. The scientific power of this system is compared to that of the Flame Photometry system. An analysis of the data showed that there was a strong link between the two methods. This straight potentiometric analyzer is easy to use and doesn't need to be maintained. The method that was put in place can measure the amount of sodium and potassium in different food samples. This will make it easier to look into different ideas about what the best electrolyte composition of foods is, such as fruits and veggies.

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