Electrolytes in Coconut Water

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Objectives of the Study

Study 1 - Biochemical profiling of coconut water .

The study aims to generate data on the electrolytes, biochemical, and physico-chemical profiles of the three varieties (Aromatic Dwarf, Catigan Dwarf and Laguna Tall Varieties). Same properties will be compared from fruits ranging from 5 to 12 months maturity.

Study 2 – Development of coco water beverage.

The study aims to develop a low-glycemic, high electrolyte ready-to-drink coconut water beverage

Electrolytes

Substances containing free ions that make it electrically conductive.

Typical form are **ionic solutions**, some are molten electrolytes – solid electrolytes.

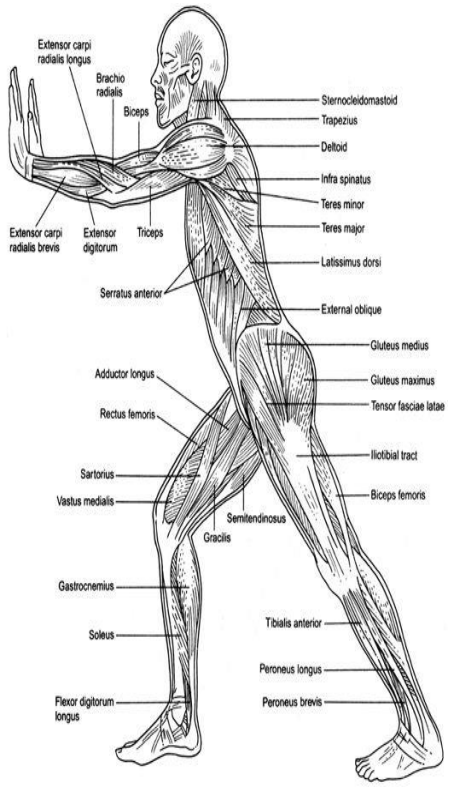
As solutions of acids, bases or salts.

Electrolyte solutions can also result from the dissolution of some biological and synthetic polymers **- polyelectrolytes**, which contain charged group.

Electrolyte solutions are formed when a salt is placed into a solvent e.g. water and the components dissociate due to the thermodynamic interactions between solvent and solute molecules, in a process called ***solvation.***

$$NaCl_{(s)} \rightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$$

Importance of electrolytes

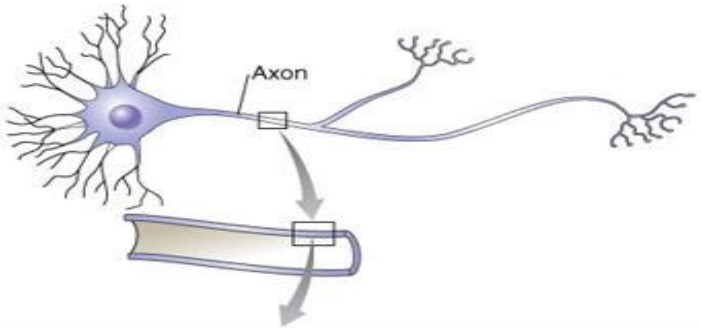


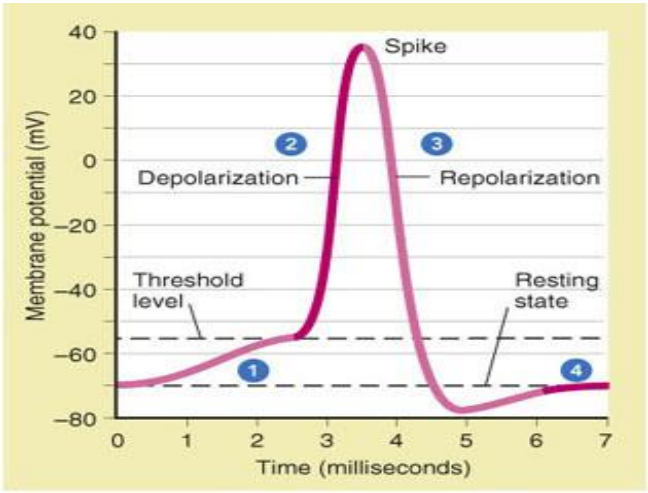
Muscles and neurons are activated by electrolyte activity between the extracellular fluid or interstitial fluid, and intracellular fluid.

Electrolytes may enter or leave the cell membrane through specialized protein structures embedded in the plasma membrane called **ion channels**.

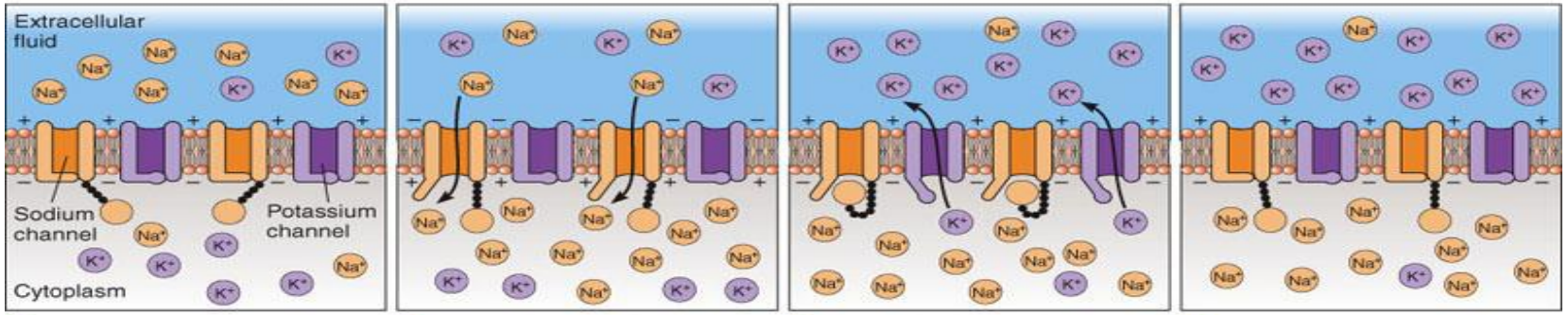
For example, ***muscle contraction*** is dependent upon the presence of calcium (Ca^{2+}), sodium (Na^{+}), and potassium (K^{+}). Without sufficient levels of these electrolytes, muscle weakness or severe muscle contractions may occur.

Electrolytes in the neurons





(a) Action potential. When the axon depolarizes to about −55 mV, an action potential is generated. (The numerical values vary for different nerve cells.)



1 Resting state. Voltage-activated Na^+ and K^+ channels are closed.

2 Depolarization. At threshold, voltage-activated Na^+ channels open. Na^+ entering the neuron cause further depolarization. Action potential is generated.

3 Repolarization. Voltage-activated Na^+ channels close; voltage-activated K^+ channels are open; K^+ diffuse out of cell, restoring negative charge to inside of cell.

4 Return to resting state. Voltage-activated Na^+ and K^+ channels close.

(b) The action of ion channels in the plasma membrane determines the state of the neuron.

Sodium

Increased sodium (hypernatremia) in the blood occurs whenever there is excess sodium in relation to water. There are numerous causes of hypernatremia; these may include kidney disease, too little water intake, and loss of water due to diarrhea and/or vomiting.

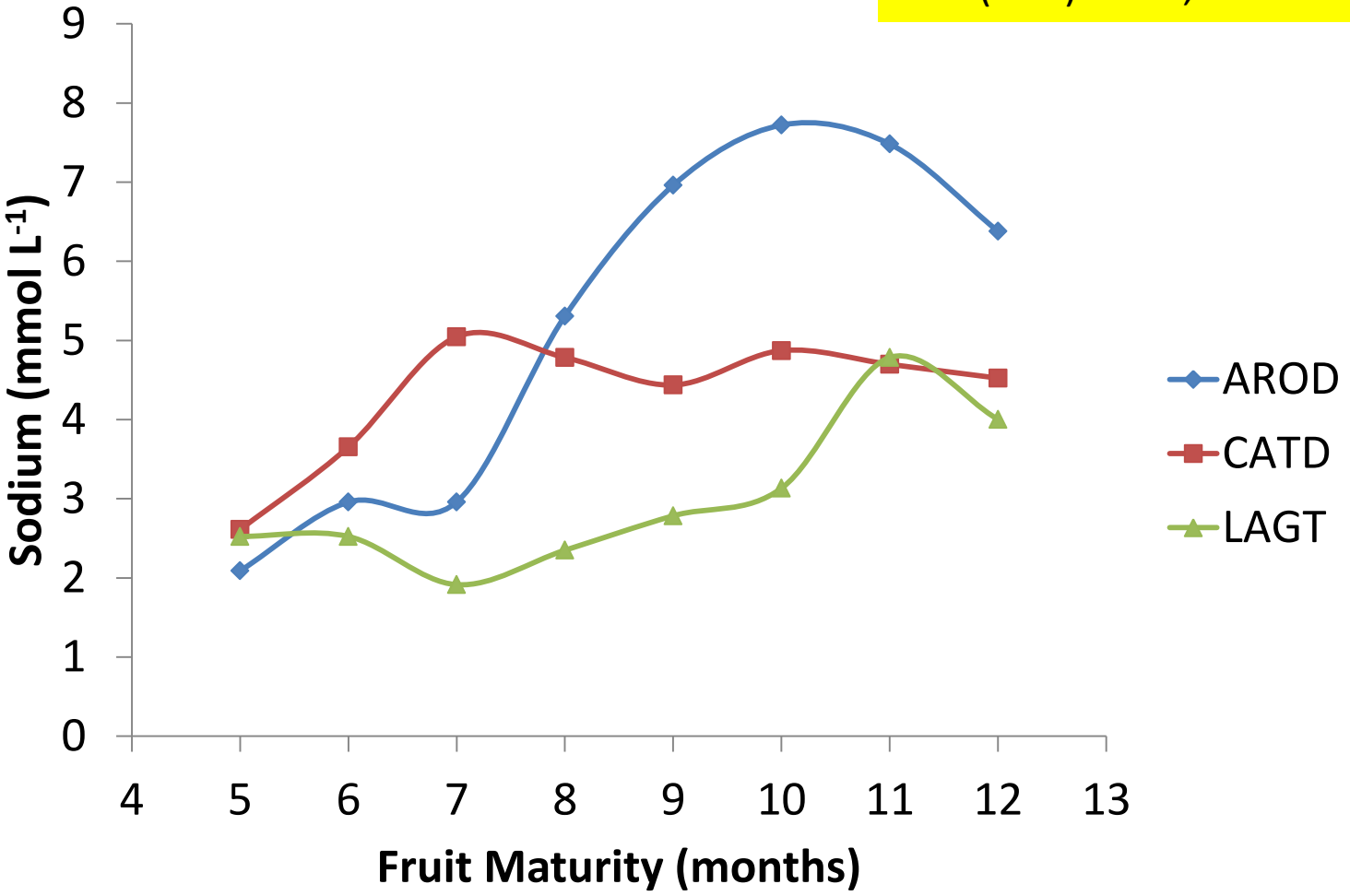
Decreased concentration of sodium (hyponatremia**)** occurs whenever there is a relative increase in the amount of body water relative to sodium.

This happens with some diseases of the liver and kidney, in patients with congestive heart failure, in burn victims, and in numerous other conditions.

Normal blood sodium level is 135 - 145 milliEquivalents/liter (mEq/L), or in international units, 135 - 145 millimoles/liter (mmol/L).

Sodium

75 mmol/L
Reduced Oral Rehydration Salt Solution (ORS) WHO, 2001



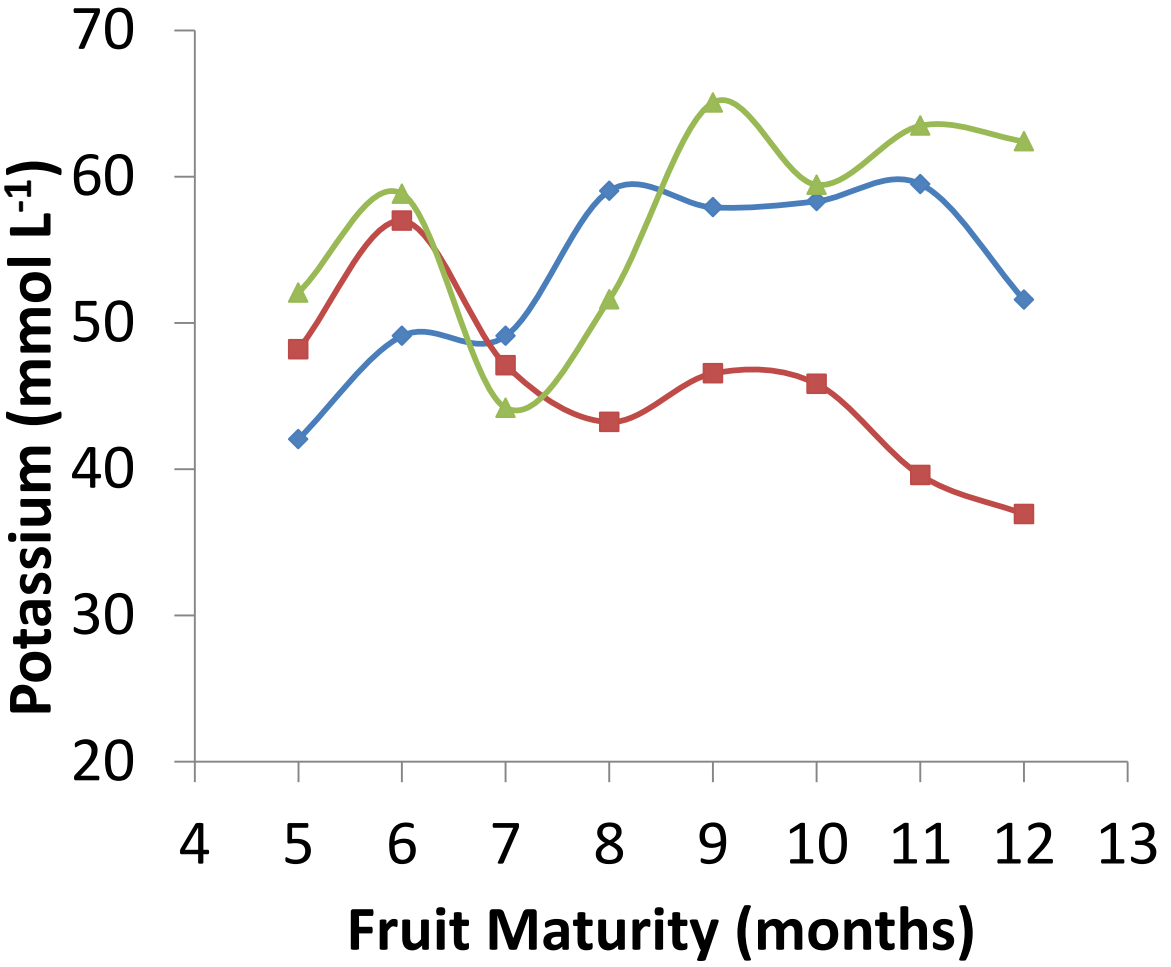
Potassium

Increased potassium (hyperkalemia) Potassium is normally excreted by the kidneys, so disorders that decrease the function of the kidneys can result in hyperkalemia. Certain medications may also predispose an individual to hyperkalemia.

Hypokalemia, or decreased potassium, can arise due to kidney diseases; excessive loss due to heavy sweating, vomiting, or diarrhea, eating disorders, certain medications, or other causes.

The normal blood potassium level is 3.5 - 5.0 milliEquivalents/liter (mEq/L), or in international units, 3.5 - 5.0 millimoles/liter (mmol/L).

Potassium



20 mmol/L
Reduced Oral Rehydration Salt Solution (ORS) WHO, 2001

Magnesium

Magnesium is contained in all unprocessed foods i.e. nuts, unmilled grains, dark-green leafy vegetables, legumes such as peas and beans, and fruits.

Magnesium deficiency can occur due to inadequate intake of magnesium, impaired intestinal absorption of the mineral, or excessive loss of it.

Magnesium can be lost by prolonged exercise, lactation, excessive sweating and chronic diarrhea; the use of drugs such as diuretics, digitalis, cisplatin and cyclosporine; and kidney disease, an overactive thyroid or parathyroid, low blood levels of potassium (hypokalemia) and high urine levels of calcium (hypercalcemia).

Deficiency of magnesium causes increased irritability of the nervous system with tetany (spasms of the hands and feet, muscular twitching and cramps, spasm of the larynx, etc.).

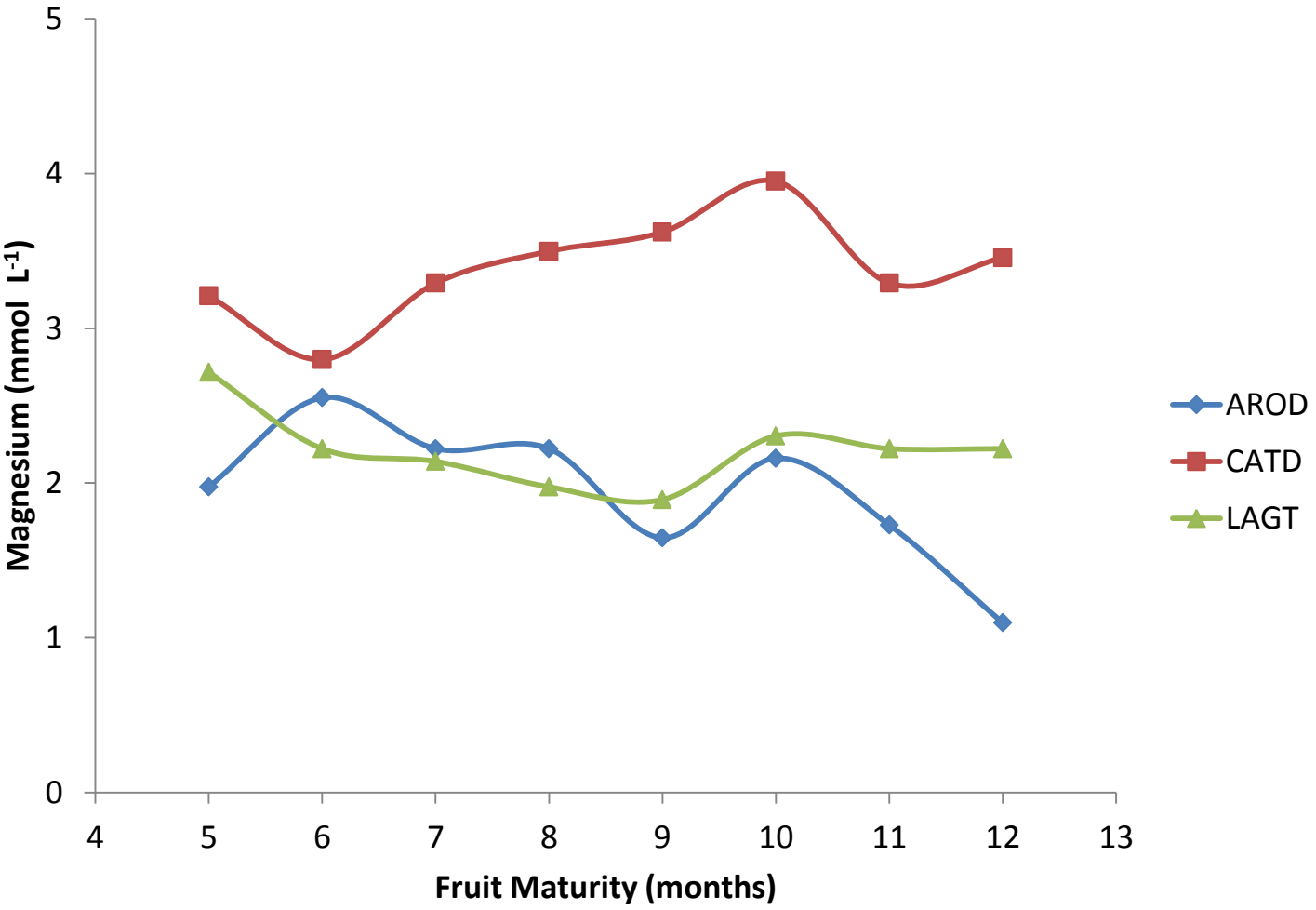
Magnesium

Recommended Dietary Allowance (RDA) of magnesium is 420 milligrams per day for men and 320 milligrams per day for women.

The upper limit of magnesium as supplements is 350 milligrams daily, in addition to the magnesium from food and water. Persons with impaired kidney function should be especially careful about their magnesium intake because they can accumulate magnesium, a dangerous situation.

Magnesium also promotes cell replication.

Magnesium

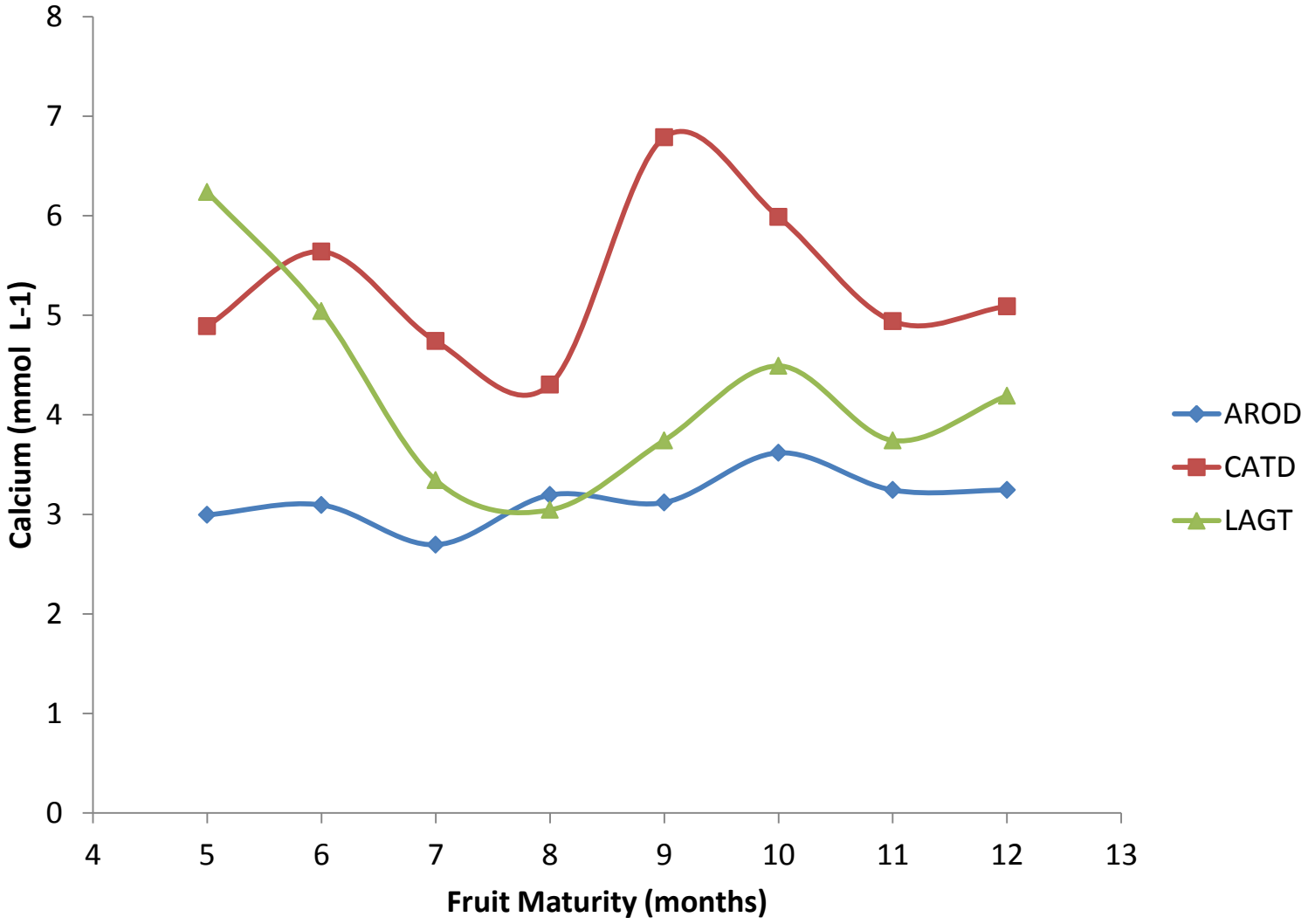

5
4
3
2
1
0
Magnesium (mmol L-1)
4
5
6
7
8
9
10
11
12
13
Fruit Maturity (months)
AROD
CATD
LAGT

Calcium

Hypercalcemia is associated with "moans, stones, abdominal groans"; symptoms include kidney stones, abdominal pain, and depression. Also, too much calcium can be associated with heart rhythm disturbances. Causes include parathyroid tumors, other tumors including breast cancer, excess amounts of Vitamin A or D, Paget's disease, and kidney failure.

Hypocalcemia (hypo=too little) is usually associated with eating disorders or lack of parathyroid hormone. Symptoms include weakness, muscle spasms, and heart rhythm disturbance.

Calcium


8
7
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Calcium (mmol L-1)
4
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9
10
11
12
13
Fruit Maturity (months)
AROD
CATD
LAGT

Chloride

The major anion found in the fluid outside of cells and in the blood.

Chloride plays a role in helping the body maintain a normal balance of fluids.


SODIUM CHLORIDE CRYSTALS

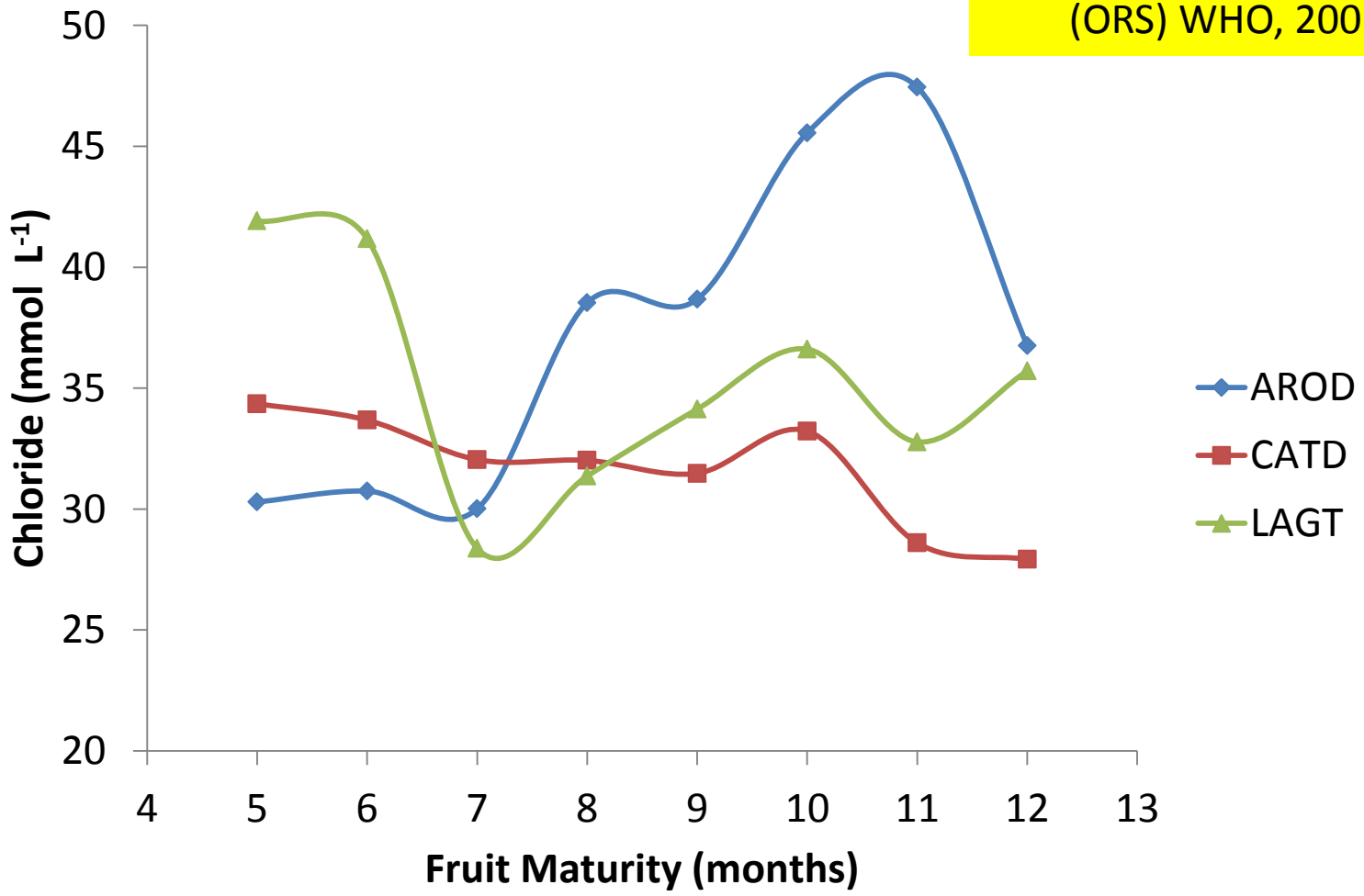
Increased chloride (hyperchloremia): Elevations in chloride may be seen in diarrhea, certain kidney diseases, and sometimes in overactivity of the parathyroid glands.

Decreased chloride (hypochloremia): Chloride is normally lost in the urine, sweat, and stomach secretions. Excessive loss can occur from heavy sweating, vomiting, and adrenal gland and kidney disease.

The normal serum range for chloride is 98 - 108 mmol/L.

Chloride

65mmol/L
Reduced Oral Rehydration Salt Solution (ORS) WHO, 2001



Coconut Water Profile

VARIETY	FRUIT MATURITY (MONTHS)	SAMPLE SIZE	ELECTROLYTE CONTENT (mmol L^{-1})					GLUCOSE (g L^{-1})	PROTEIN (mg mL^{-1})	pH	TSS (Brix)	SPECIFIC GRAVITY
			SODIUM	POTASSIUM	MAGNESIUM	CALCIUM	CHLORIDE					
AROMATIC DWARF (AROD) n=40	5	5	2.09 ± 0.57	42.05 ± 14.58	1.97 ± 0.79	2.99 ± 1.21	30.29 ± 12.23	30.50 ± 3.30	7.53 ± 2.53	4.95 ± 0.12	5.72 ± 1.08	1.0301 ± 0.0017
	6	5	2.96 ± 0.71	49.11 ± 11.23	2.55 ± 1.63	3.09 ± 1.04	30.74 ± 9.70	32.88 ± 1.83	8.81 ± 2.35	5.64 ± 0.33	6.21 ± 0.64	1.0329 ± 0.0012
	7	5	2.96 ± 0.94	49.11 ± 20.72	2.22 ± 1.03	2.69 ± 1.18	30.01 ± 10.31	27.88 ± 7.53	7.40 ± 2.16	5.84 ± 0.33	5.72 ± 0.63	1.0318 ± 0.0032
	8	5	5.31 ± 0.84	59.03 ± 3.23	2.22 ± 0.37	3.19 ± 0.84	38.53 ± 3.62	19.23 ± 2.93	8.49 ± 1.40	5.57 ± 0.28	5.40 ± 0.46	1.0303 ± 0.0027
	9	8	6.96 ± 1.32	57.90 ± 3.99	1.65 ± 0.58	3.12 ± 0.61	38.68 ± 7.28	7.02 ± 3.17	7.60 ± 1.94	5.76 ± 0.36	4.61 ± 0.54	1.0258 ± 0.0015
	10	4	7.72 ± 0.55	58.31 ± 1.55	2.16 ± 0.70	3.62 ± 0.59	45.55 ± 7.32	6.09 ± 3.81	11.42 ± 1.49	5.41 ± 0.25	4.43 ± 0.76	1.0237 ± 0.0015
	11	5	7.48 ± 0.71	59.49 ± 1.74	1.73 ± 0.68	3.24 ± 0.93	47.44 ± 7.52	2.77 ± 1.73	11.20 ± 1.01	5.80 ± 0.31	4.79 ± 0.56	1.0261 ± 0.0022
	12	3	6.38 ± 0.25	51.58 ± 1.41	1.10 ± 0.24	3.24 ± 0.25	36.76 ± 1.92	1.42 ± 0.19	9.52 ± 0.36	6.05 ± 0.06	4.98 ± 0.45	1.0269 ± 0.0015
CATIGAN DWARF (CATD) n=39	5	5	2.61 ± 0.69	48.19 ± 5.56	3.21 ± 0.98	4.89 ± 0.45	34.36 ± 5.51	24.85 ± 1.50	5.28 ± 3.02	5.03 ± 0.33	5.30 ± 0.43	1.0259 ± 0.0030
	6	5	3.65 ± 0.24	56.98 ± 5.81	2.80 ± 1.10	5.64 ± 0.55	33.68 ± 2.80	21.48 ± 4.22	7.66 ± 2.08	5.83 ± 0.15	5.52 ± 0.56	1.0261 ± 0.0010
	7	5	5.05 ± 0.39	47.11 ± 5.28	3.29 ± 0.50	4.74 ± 0.50	32.04 ± 1.10	15.91 ± 2.73	7.47 ± 2.15	5.50 ± 0.11	5.01 ± 0.52	1.0260 ± 0.0036
	8	4	4.78 ± 0.62	43.22 ± 7.22	3.50 ± 0.71	4.30 ± 0.47	32.01 ± 3.97	2.42 ± 0.53	7.10 ± 1.06	5.33 ± 0.10	3.70 ± 0.50	1.0225 ± 0.0015
	9	5	4.44 ± 0.94	46.55 ± 2.31	3.62 ± 0.54	6.79 ± 0.65	31.48 ± 3.81	4.16 ± 3.20	9.82 ± 2.27	5.21 ± 0.09	4.43 ± 0.32	1.0233 ± 0.0017
	10	5	4.87 ± 0.65	45.83 ± 2.04	3.95 ± 0.62	5.99 ± 0.35	33.23 ± 2.84	1.82 ± 1.04	7.44 ± 1.31	5.37 ± 0.17	3.95 ± 0.62	1.0219 ± 0.0051
	11	5	4.70 ± 1.21	39.59 ± 5.68	3.29 ± 0.41	4.94 ± 0.80	28.60 ± 5.66	1.29 ± 0.14	10.11 ± 2.58	5.71 ± 0.09	3.33 ± 0.50	1.0185 ± 0.0021
	12	5	4.52 ± 0.66	36.93 ± 3.87	3.46 ± 0.75	5.09 ± 0.91	27.92 ± 6.52	2.32 ± 3.33	11.89 ± 1.24	5.76 ± 0.17	3.91 ± 0.59	1.0207 ± 0.0022
LAGUNA TALL (LAGT) n=40	5	5	2.52 ± 0.57	52.07 ± 14.17	2.72 ± 0.99	6.24 ± 2.20	41.91 ± 12.08	16.20 ± 1.60	4.88 ± 0.96	4.92 ± 0.07	3.50 ± 0.20	1.0198 ± 0.0016
	6	5	2.52 ± 0.19	58.83 ± 5.91	2.22 ± 0.23	5.04 ± 0.97	41.18 ± 2.30	22.79 ± 3.29	5.91 ± 1.38	4.74 ± 0.05	3.55 ± 0.88	1.0209 ± 0.0019
	7	5	1.91 ± 0.39	44.20 ± 8.59	2.14 ± 0.94	3.34 ± 1.04	28.38 ± 8.30	25.14 ± 2.74	8.01 ± 2.42	4.98 ± 0.13	3.06 ± 0.87	1.0256 ± 0.0025
	8	5	2.35 ± 0.50	51.61 ± 3.24	1.97 ± 0.54	3.04 ± 0.37	31.37 ± 0.83	27.28 ± 3.31	6.53 ± 2.48	5.06 ± 0.11	3.40 ± 1.15	1.0269 ± 0.0011
	9	5	2.78 ± 0.58	65.07 ± 2.97	1.89 ± 0.55	3.74 ± 1.09	34.13 ± 3.88	25.54 ± 2.12	5.33 ± 1.32	5.49 ± 0.44	4.03 ± 0.56	1.0267 ± 0.0021
	10	5	3.13 ± 0.89	59.44 ± 3.21	2.30 ± 0.37	4.49 ± 0.00	36.61 ± 2.59	18.45 ± 5.24	5.5 ± 2.13	5.34 ± 0.15	3.29 ± 1.16	1.0261 ± 0.0025
	11	5	4.78 ± 1.63	63.48 ± 8.11	2.22 ± 0.47	3.74 ± 0.81	32.78 ± 5.60	18.10 ± 8.18	5.51 ± 1.69	5.68 ± 0.17	3.56 ± 0.74	1.0254 ± 0.0021
	12	5	4.00 ± 1.21	62.41 ± 10.19	2.22 ± 0.37	4.19 ± 0.62	35.71 ± 3.60	13.52 ± 8.39	4.87 ± 1.49	5.61 ± 0.22	3.30 ± 0.96	1.0251 ± 0.0042

✓ Generally, the biochemical and physico-chemical properties of coconut water are dependent on the variety and maturity of the fruit. The levels of Magnesium and Chloride were not significantly different with the maturity of the fruit, but differs significantly with variety.

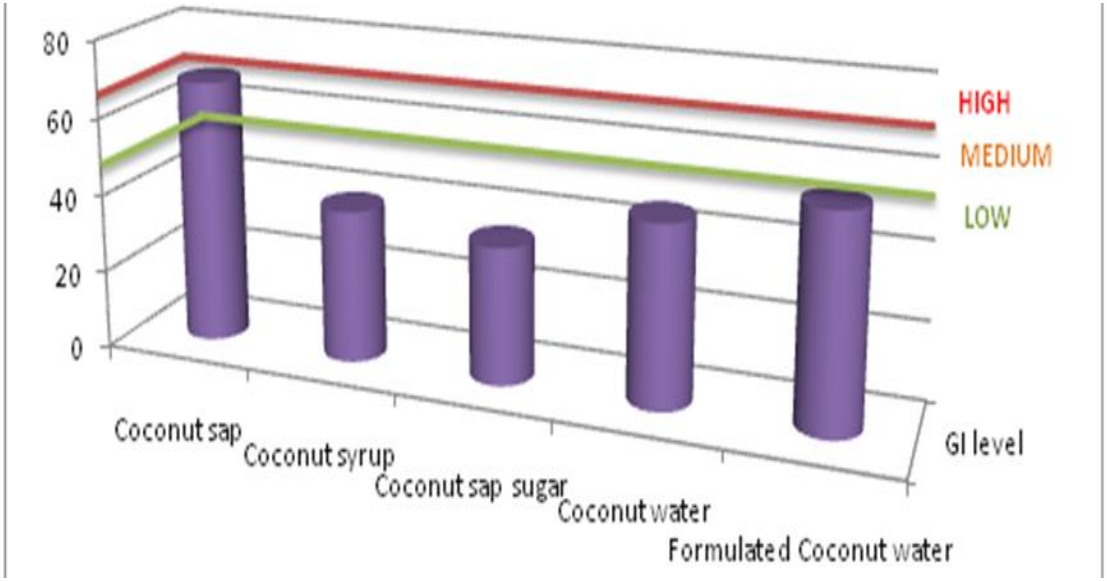
Coconut Varieties

Aromatic Dwarf | Laguna Tall | Catigan Dwarf

Scale bar: 24 cm

Glycemic Index of selected coconut products

Coconut Product	Serving size (g or ml)	Available CHO	GI	Classification
Coconut sap	160	25	**68±2**	Medium
Coconut syrup	33	25	***39±4***	Low
Coconut sap sugar	25	50	**35±4**	Low
Coconut water	100	4.8	**46±4**	Low
Formulated Coconut water	100	4.7	**54±4**	Low



Electrolyte level of formulated coco water drink, commercial sports drink and ORS.

ELECTROLYTES	Formulated Coco water drink (mg/100 ml)	Commercial Sports Drink (mg/100 ml)	Oral rehydration solution (WHO, 2001) (mg/100 ml)
Potassium	196	11.7	78.20
Sodium	14	41	172.42
Chloride	76	39	230.44
Magnesium	6	7	None

Proximate composition of Pure and Formulated Coconut Water Drink

PARAMETERS	METHODOLOGY	Coconut water (per 100 ml)	Formulated Coconut Water Drink (per 100 ml)
Calories (cal)	By computation	20	19
Calories from fat (Cal)	By computation	0	0
Total Carbohydrates (g)	By computation	4.8	4.7
Ash (g)	Gravimetry	0.44	0.09
Moisture (g)	Gravimetry	94.6	94.8
Protein, (g)	Kjeldahl	0.14	0.39
Total Fat (g)	Solvent Extraction	ND	ND
Total dietary fiber (g)	Enzymatic- Gravimetry	ND	ND
Glycemic index value	GI standard method for 25 g avail carbohydrates	46 $\pm$ 4	54 $\pm$ 4

Result:

- No significant change in the proximate composition of the formulated drink compared to pure coconut water except for protein content which increased from 0.14 to 0.39 which may be due to addition of coco syrup

High-Electrolyte, Low-Glycemic and Ready-to-Drink Coconut Water Beverage "

(IP Patent)

Applications of the Electrolyte Profile of Coconut Water

- Used in designing novel beverages.
- Guide for designing treatments and/or for adjuncts oral rehydration therapies.
- Electrolyte applications...
- Mineral uptake studies/applications.

Yaman ng PiNOY

Coconut-derived materials can applied to produce novel, innovative and commercially important products…

A perfect example of Biotechnology in ACTION.

Acknowledgement

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