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Tender Coconut Water: An ideal fluid for parenteral substitute

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ABSTRACT

In this study tender coconut water was studied for biochemical, microbiological, pharmacological properties and for its effect of infusion in dogs. The high nutritive content, sterile, pyrogen-free, non-haemolysing in dogs and humans and free from acute and sub-acute toxicity suggest its valuable therapeutic applications. Autoclaving increases the shelf life without affecting its nutritive value. Intravenous administration of tender coconut water (100 ml/kg) in dogs decreased serum Na^+ and increased serum K^+ & Ca^{2+} levels immediately after stopping infusion; it came back to baseline after 1 hour of stopping infusion. Electrocardiogram did not show any evidence of hyperkalemia as high content of magnesium in tender coconut water acts as physiological antagonist to potassium. Tender coconut water showed no effect on psychomotor behaviour and analgesic activity of animals. Repeated administration of tender coconut water did not reveal any anaphylaxis or allergic reaction. It is naturally available, cost effective, highly nourished ideal fluid for parental substitute.

Keywords: Tender coconut water; intravenous use; infusion; serum; electrolytes.

INTRODUCTION

Oral use of tender coconut water has been in use since time immemorial. Coconut water is easily attainable, cheap, sterile, pyrogen-free, non-antigenic and non-hemolysing in dogs and humans.[1,2] The varied results in respect of content of coconut water have been reported. Coconut water contains some minerals (calcium, potassium, phosphorus and Cobalt) and several amino acids (glutamine, tyrosine, alanine, histidine, phenylalanine and serine).[3]

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In many underdeveloped countries in emergency conditions, at times it is impossible to prepare solutions locally and sufficiently pure to be employed for intravenous use. Sometimes their availability is poor and unaffordable. There is still a need for an ideal intravenous infusion fluid. Due to its specific gravity and isotonicity with plasma, it has been used in dyspepsia in newborns[4], as diuretics in renal disorders[5], in nutritional disturbances[6] and nutritional oedema.[7]

A systemic study on the profile of physical, biochemical, microbiological and pharmacological properties of coconut water is lacking in literature. Since the therapeutic efficacy of coconut water depends upon its electrolyte balance and pharmacological actions, the present study examines its physical, biochemical, sterility and pharmacological properties, anaphylaxis and effect of tender coconut water infusion in dogs. Due to its nutritive value, it gets contaminated easily, therefore autoclaved coconut water was also analyzed for any change in nutritional value and shelf life.

MATERIALS AND METHODS

Tender coconuts of the cocus nucifera type, 5-7 months (age determined by plant specialist), were chosen for this study. Tender coconut water was collected in sterile container under all aseptic precautions as per method of Acharya *et al* (1965).[8]

Fresh and autoclaved tender coconut water was analyzed and compared for total reducing sugar, protein, fat (neutral) and minerals at Food and Research Laboratories, Hyderabad, India. The following tests were performed on the fresh tender coconut water.

A. *Physical Properties*

Tender coconut water was examined for colour, pH, specific gravity and its effect on fragility of human red blood cells.

B. *Microbiological tests*

Fresh and autoclaved tender coconut water was cultured for any pathogenic organism for seven subsequent days and on thirtieth day.

C. *Pharmacological tests*

Effect of fresh tender coconut water was studied on the central nervous system (behaviour) and pain. The following tests were performed on Wistar albino rats (120-150 gms) and Swiss albino mice (20-35 gms) of either sex. Animals were housed in a group of six in polypropylene cage and maintained on standard diet and water at libitum.

i. **Pentobarbitone induced sleeping time:** Pentobarbitone sodium (40 mg/kg, i.p.) was injected to a group of six rats pre-treated (30 min before) with tender coconut water (10 ml/kg i.p.) or normal saline (control). The time interval between loss and recovery of the righting reflex was taken as sleeping time.[9]

ii. **Open field test (OFT):** The method of Dandiya and Kulkarni[10] was followed. The two-minute score of ambulation, rearing and grooming in mice for normal saline (control), tender coconut water (10 ml/kg, i.p.) and

chlorpromazine treated (3 mg/kg, i.p.) groups were compared.

iii. **Swimming stress:** On the first day mice were subjected to 15 minutes forced swimming test (FST), using a 2 litre beaker containing water up to 6 cms at 26^{o}C. The next day, the forced swimming test was repeated after 30 minutes of pre-treatment with normal saline and fresh tender coconut water (10 ml/kg, i.p.) or chlorpromazine (3 mg/kg, i.p.). Immobility time during the 5-minute period was recorded. Immobility or motionless means haunched upright position with head above the surface of water.

iv. **Analgesic activity:** Analgesic activity was recorded using the following methods:

a. Hot Plate method: Eddy's hot plate was maintained at 50^{o}C$\pm$2^{o}C. In rats, the reaction time was noted by observing the licking of hind paws. After 30 minutes of pre-treatment with fresh tender coconut water (10 ml/kg, i.p.) or normal saline, hot plate test[11] was performed and results were compared with morphine (5 mg/kg, s.c.).

b. Acetic acid induced writhing: Writhing response was produced by 10 ml/kg of 0.6% acetic acid administered intraperitoneal (i.p.) in mice as per method of Collier (1964).[12] Writhing score was done for 10 minutes. The results of tender coconut water (10 ml/kg, i.p.) and normal saline (10 ml/kg, i.p.) were compared with morphine (5 mg/kg, s.c.).

c. Tail immersion test: The tail of rat was dipped in hot-water bath maintained at 50^{o}C$\pm$1^{o}C. The tail withdrawal was taken as reaction time.[13] The reaction time for tender coconut water (10 ml/kg, i.p.) and normal saline (10 ml/kg, i.p.) was recorded and compared with morphine (5 mg/kg, s.c.).

v. **Toxicity Studies**

a. Acute Toxicity: A group of 6 mice each was given a single dose of tender coconut water or normal Saline (10,100 & 1000 ml/kg, i.p.) orally and intravenously. The animals were observed for 48 hours for any gross effect or mortality.[14]

b. Subacute toxicity: Two groups of 6 mice each were given fresh tender coconut water (10 ml/kg, i.v.) and normal saline (10 ml/kg i.v.) daily for 7 days. Postmortem biopsy of viscera (liver, lung, kidney, pancreas, brain, etc.) were taken and subjected to histopathology.[14]

vi. **Experimental anaphylaxis:** It was performed on two groups of 6 rabbits each weighing 1-1.5 kg. Repeated dose of tender coconut water (10 ml/kg) and normal saline (10 ml/kg) were administered intravenously at 0, 2, 6 and 100 days

interval. Any untoward change was noticed.

vii. **Intravenous use of tender coconut water in dogs:** Tender coconut water (100 ml/kg) was infused in six dogs over a period of 3-4 hours (10-20 drops/minute). An intravenous infusion set with double filters was used to strain out small pieces of coconut flesh. Dogs were anaesthetized with pentobarbitone sodium (40 mg/kg, i.v.); baseline blood pressure (electronic sphygmo-manometer), pulse rate (femoral artery), electrocardiogram, and serum electrolytes (K^+, Na^+ & Ca^{2+}) were estimated. These parameters were recorded before the infusion, immediately and one hour after the infusion was over. The results were compared with baseline readings.

Statistics

Results are presented in Mean ±SEM. The Dunnet and Student's 't' test was applied to find the significance ($p<0.05$).

RESULTS

Fresh tender coconut water is colourless to slight hazy whereas autoclaved tender coconut water varies from colourless to light straw colour. There was no significant difference in specific gravity of fresh and autoclaved tender coconut water (Table I). Fresh and autoclaved tender coconut water in varying dilution did not have any effect on fragility of human RBCs. Slight anisocytosis was noticed in one case.

Composition of fresh and autoclaved tender coconut water is given in table I. After autoclaving, the protein content decreased from 428.75±9.65 mg % 315.5 ±6.65 mg % ($p<0.001$) and triglyceride content decreased from 172.5±3.22 to 148±3.74 mg% ($P<0.01$) whereas alteration in other constituents was not significant (Table I).

Table I: Mean composition of human plasma, fresh and autoclaved tender coconut water (TCW)

	Plasma	*Fresh TCW*	*Autoclaved TCW*
pH	7.4	4.8±0.15	4.86±0.09
Specific gravity	1.027	1.020	1.020
Total reducing sugar (mg%)	100	2980±500	2800±470
Protein (mg%)	6000	428.75±9.65	315.5±6.65***
Triglyceride (mg%)	142	172.5±3.22	148±3.74**
Cholesterol (mg%)	150	40.25±1.84	31.25±3.81
Mg^{2+} (meq/lt)	1.8	16.66±0.99	17.1±0.56
PO^{-}_{4} (meq/lt)	2	5.08±0.74	4.8±0.34
Na^+ (meq/lt)	140	4.26±0.276	4.16±0.38
Cl^- (meq/lt)	105	51±3.85	51.4±4.15

K^+ (meq/lt)	4	47.6±1.93	46.96±1.77
Ca^{2+} (meq/lt)	5	11.41±0.78	10.4±0.81

Fresh and autoclaved TCW are compared using Students' test, *P<0.05, **P<0.01, ***P<0.001.

Fresh and autoclaved tender coconut water was found sterile on all the seven subsequent days and at one-month period. The culture of coconut with damaged shell showed the presence of pathogenic organism *viz* staphylococcus, proteus and salmonella. Fresh coconut water at room temperature turned hazy and gave stale smell after 1-2 days, whereas autoclaved tender coconut water was found as such even after one month. This suggests that autoclaving increases the shelf life of tender coconut water if stored in sterile container.

Tender coconut water did not show any effect on animal behaviour, pain and phenobarbitone sleeping time. In open field test and swimming stress there was no significant difference in ambulation, rearing and grooming and immobility time respectively between fresh tender coconut water and normal saline but significant as compared to chlorpromazine (Table II). Tender coconut water did not show any effect on analgesic activity as compared to normal saline (Table III).

Tender coconut water is free from any acute or subacute toxicity even at the doses of 1000 ml/kg. Haematological and histopathology of viscera was normal. Repeated administration of tender coconut water in six rabbits did not cause any allergy or anaphylaxis.

Infusion of fresh tender coconut water in 6 dogs was uneventful. Immediately after stopping the infusion, there was significant decrease in serum Na^+ level ($p<0.05$) and increase in serum K^+ level ($p<0.01$); these values came back to baseline after 1 hour of stopping infusion. The rise in serum calcium level was not significant (Table IV). Electrocardiogram, heart rate, blood pressure and body temperature before and after one hour of stopping infusion were not altered significantly (Table IV). In one dog temperature was raised by 2^0F, which came back to baseline after four hours of stopping infusion.

Table II: Behavioural activity of animals in response to fresh tender coconut water, normal saline (NS) and chlorpromazine (CPZ) (n=6).

Treatment (dose, route)	*Score in OFT (in 2 min)*			*Swimming stress Immobility (Sec.)*
	Ambulation	*Rearing*	*Grooming*	
NS (10 mg/kg, i.p.)	29.3±1.63	4.66±0.88	18.33±1.24	181.6±5.39
TCW (10 mg/kg, i.p.)	31±1.03	4.9±0.9	17.9±1.4	190±6.5
CPZ (3 mg/kg, i.p.)	14.5±1.43**	3.5±0.38*	9.16±0.8**	218.83±7.64*

Dunnet test: *P<0.05; **P<0.01

Table III: Effect of fresh tender coconut water (TCW), normal saline (NS) and chlorpromazine (CPZ) on pain by different methods (n=6).

Treatment (dose, route)	*Tail Immersion Test (sec.)*	*Hot Plate Test (sec.)*	*Writhing Test (No.)*
NS (10 mg/kg, i.p.)	1.08±0.06	9.58±0.37	16.5±0.76
TCW (10 ml/kg, i.p.)	1.08±0.80	8.85±0.46	15.6±0.84
Morphine (5 mg/kg, s.c.)	3.06±0.171**	29.16±1.7**	4.16±0.47**

Dunnet test: **P<0.01

Table IV: Mean changes in serum electrolytes and vital parameters before, during and after infusion of fresh tender coconut water (100 ml/kg) in dogs anaesthetized with phentobarbitone (40 mg/kg, i.v.)

Electrolyte	*Before infusion*	*Immediately after stopping infusion*	*1 hour after stopping infusion*
Na^+ (meq/L)	144.6±1.43	134.5±2.92*	144±0.9
K^+ (meq/L)	4.3±0.13	6.78±0.18**	4.5±0.6
Ca^{2+} (meq/L)	3.73±0.24	4.48±0.13*	3.8±0.6
Respiratory rate	15±6.0	16±1.7	16±0.6
Heart Rate (beats/min)	86±6.0	90±4.5	88±6.2
Systolic B.P. (mmHg)	110±7.2	119±6.0	120±2.0
Temperature (^oF)	37±0.5	38±0.4	37±0.3
Electrocardiogram	Normal	Normal	Normal

Dunnet test: *=P<0.05 **=P<0.01

DISCUSSION

The observed pH, electrolyte, total reducing sugar, protein and triglyceride contents of tender coconut water (Table I) agree with the values reported by many workers.[1,3] Many workers have reported a fall in haemoglobin, plasma protein, serum Ca^{2+}, Na^+ and other constituents of blood after the infusion of dextran and other plasma substitutes prepared in water and saline[15,16]; on the similar bases decrease in serum Na^+ level after tender coconut water infusion can be explained. The immediate rise in serum K^+ and Ca^{2+} may be due to their high content in tender coconut water (Table I). The rise in serum Na^+ level have been reported after infusion of normal saline[17]; on the similar basis immediate rise in serum K^+ and Ca^{2+} level can be explained. The high content of K^+ (47.6±1.93 meq/Lt) (Table I) in tender coconut water can cause hyperkalemia leading to neuromuscular and cardiovascular toxic effects but electrocardiogram did not reveal any abnormality suggestive of hyperkalemia. It is believed that high content of calcium (11.41±0.78 meq/lt) and magnesium (16.6±0.99 meq/lt) (Table I) in coconut water acts as a physiological antagonist to potassium and counteracts the deleterious effect of potassium on myocardium.[19]

Tender coconut water showed no effect on pain and psychomotor behaviour of animals. Acute and sub-acute toxicity studies suggest that it is free from local and systemic toxicity. Repeated infusion of tender coconut water in rabbits did not show

any allergy or anaphylaxis reaction, because it does not contain complex molecules of protein.[3] Study of the proteins of tender coconut water revealed that they are desired proteins of the order of acid metaproteins and or peptones. The acidic medium (pH 4.6-4.8) of coconut water hydrolyses the proteins and are incapable of producing allergic reactions.[3] It is rich in various amino acids including lysine, leucine, cystine, phenylalanine, histidine and tryptophan essential for proper nutrition. The electrolyte content comprises Na^+, Ca^{2+}, K^+ and Mg^{2+} salts of organic acids, chloride and phosphates. The highest content is K^+ so it seems to be more useful in case of gastroenteritis. Few workers have advocated as a precautionary measure, that coconut water should not be used in patients who are in oligemic shock with oliguria[20], but it was found that none of the cases showed either clinical signs or electrocardiographic evidence of hyperkalemia.

Despite the facts that tender coconut water is a natural, harmless, vegetable product available in a perfect transportable container, good nutritive value with no propensity of adverse events, it has not gained popularity as an ideal intravenous fluid. The favourable profile of tender coconut water makes it an ideal parenteral substitute fluid. Further extensive clinical studies are suggested on human volunteers.

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REFERENCES

1. Eisemann B. Intravenous infusion of coconut water. *Arch Surg* 1954; **68**: 167-178.
2. Suresh TP, Hedges VR, Setty SVS, and Rangachar TSR. Fluid therapy by tender coconut water in veterinary practice. *Ind Vet J* 1968; **84**: 829-837.
3. Pradera ES, Fernadez E and Calderin O. Coconut water: a clinical and experimental study. *Am J Dis child* 1942; **64**: 977-996.
4. Bejarno J. Treatment of dyspepsia in the new born with coconut milk. *Rev Fac Med Bogota* 1933; **2**: 16-18.
5. Brito JC and Dreiss G. Coconut water as I/V diuretic

   in cases accompanied by kidney disease. *Arch Hosp Rosales* 1943; **24**: 420-423.
6. Gesteira M and Bahia UA. Coconut milk in nutritional disturbance in infants. *Arch Ped* 1932; **50**: 205-210.
7. Majumdar NG. Intravenous use of green coconut water in pediatric practice. *JIMA* 1951; **20**: 211-212.
8. Acharya VN, Gupta KC, Golwala AF, Store SD and Sheth UK. Comparative study of intravenous use of natural coconut water, synthetic coconut water and glucose saline in acute gastro-enteritis. *Ind J Med Res* 1965; **53** (11): 1069-1073.
9. Dandiya PC and Collumbine H. Studies on Acorus Calamus (III): Some actions of the volatile oil. *J Pharmacol Exp Ther* 1959; **125**: 353-357.
10. Dandiya PC and Kulkarni SK. A study of the open field behavior as a single parameter. *Ind J Pharmacol* 1975; **7**: 1-4.
11. Eddy NB and Leimbach D. Synthetic analgesics. II. dithienybuternyl and dithienybutylamine. *J Pharmacol Exp Ther* 1953; **107**: 385-393.
12. Collier HHJ. Analgesics in Laurence, DG & Bacharach, AL (eds). Evaluation of Drug Activity and Pharmacometrics, Academic press, New York, 1964; 183-203.
13. Ghosh MN. Some Evaluation Techniques: Evaluation of Analgesics agents in Fundamentals

of Experimental Pharmacology, 2nd edition. Scientific Book Agency, Calcutta, 1984; 144-145.

14. Paget GE and Bormes JM. Toxicity tests in Evaluation of Drug activities. Pharmacometrics Eds Laurence DR and Bacharach AL. Academic Press, New York 1964.
15. Gowdey CW, Hatcher JD and Sunahara FA. Cardiovascular responses in dogs to large intravenous infusion. *Can J Biochem Physiol* 1954; **32**: 282-292.
16. Fowler NO, Franch RH, and Bloom WL. Haemodynamic effect of anemia with and without plasma volume expansion. *Cir Res* 1956; **4**: 319-324.
17. Papper SL, Saxon JP, Rosenbaum and Cohen HW. Effects of isotonic and hypertonic salt solution on renal excretion of sodium. *J Lab Clin Med* 1956; **47**: 776-782.
18. Smith SG. Respiration and paralysis as they relate to magnesium potassium antagonism. *Am J Physiol* 1951; **164**: 702-704.
19. Rao PS, Rao RR, Kumar SV, Murthy KJR and Dussey P. Intravenous administration of coconut water. *J Asso Physicians Ind* 1972; **10** (3): 235-239.