ORIGINAL ARTICLES

The Control of Hypertension by use of Coconut Water and Mauby: Two Tropical Food Drinks

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ABSTRACT

In this study, the authors investigated the effect of regular consumption of two tropical food drinks, coconut (Cocos nucifera) water and mauby (Colubrina arborescens), on the control of hypertension. Twenty-eight hypertensive subjects were assigned to four equal groups and their systolic and diastolic blood pressures recorded for two weeks before and then for another two weeks while receiving one of four interventions. One group (the control) received bottled drinking water, the second group received coconut water, the third received mauby and the fourth group, a mixture of coconut water and mauby. Significant decreases in the mean systolic blood pressure were observed for 71%, 40% and 43% respectively of the groups receiving the coconut water, mauby and the mixture ($p \leq 0.05$). For these groups, the respective proportions showing significant decreases in the mean diastolic pressure were 29%, 40% and 57%. For the group receiving the mixture, the largest decreases in mean systolic and mean diastolic pressure were 24 mmHg and 15 mmHg respectively; these were approximately double the largest values seen with the single interventions.

El Control de la Hipertensión Mediante el uso del Agua de Coco y el Mauby: Dos Bedidas Tropicales Naturales

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RESUMEN

En el presente estudio, los autores investigaron el efecto del consume regular de dos bebidas tropicales naturales: el agua de coco (Cocos nucifera) y el mauby (Colubrina arborescens) sobre el control de la hipertensión. A veintiocho sujetos hipertensos asignados a cuatro grupos iguales, se les hizo un registro de su presión sanguínea sistólica y diastólica por espacio de dos semanas antes, y luego otras dos semanas mientras que recibían una de cuatro intervenciones. Un grupo (de control) recibió agua mineral embotellada; un segundo grupo recibió agua de coco; un tercer grupo recibió mauby; y finalmente el cuarto grupo recibió una bebida mixta de agua de coco y mauby. Se observaron disminuciones significativas de la presión sistólica media en el 71%, el 40% y el 43% respectivamente, de los grupos que recibieron el agua de coco, el mauby, y la bebida combinada ($p \leq 0.05$). Para estos grupos, las proporciones respectivas que mostraron disminuciones significativas de la presión diastólica media fueron 29%, 40% y 57%. Para el grupo que recibió la bebida mixta, las disminuciones mayores en las presiones medias sistólica y diastólica fueron 24 mmHg y 15 mmHg respectivamente - aproximadamente el doble de los valores observados en cada una de las intervenciones.

West Indian Med J 2005; 54: (1) 3

INTRODUCTION

Several studies, (1-5) have confirmed that whereas black populations of Sub-Saharan Africa, *eg* Kenya, exhibit a low incidence of high blood pressure, there is a high incidence of hypertension in the black populations of the Western Hemisphere, including the United States of America and the Caribbean. World Health Organization estimates (3) suggest that over 30% of the adult population in the Caribbean are affected by this chronic disorder. Research has also shown that compared to Caucasians, persons of African descent in the USA and Caribbean are twice as likely to develop hypertension, to do so at an earlier age and have a more severe degree of the disorder (5-6). The more dangerous side effects associated with chronic high blood pressure include increase risk of heart attacks, heart failure, stroke and kidney damage.

While there have been significant improvements in the global treatment of hypertension, a number of these treatments, *eg* the beta blockers and the ACE-inhibitors, are found to be less effective in patients of African ancestry (7). This and the costs of treatment, both to the individual and the

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governments are factors which influence balance of payments and living standards in the Caribbean and other third world nations.

The use of herbs and other natural products for the treatment and control of diseases has been practised by many societies for centuries (8-11). In the vast majority of cases, the Chinese being the notable exception (8), very little has been recorded in written form about the treatments, also very few studies have been carried out to verify the effectiveness of these treatments. With the emergence of modern medicine, the use of herbal remedies was scoffed at and went into decline in western societies. In recent decades however, there have been renewed interest, including increased scientific research, into the use of herbs and other natural products for the treatment of disease (12-17).

Although references to the coconut palm, *Cocos nucifera* (*Palmae*) Linn Sp Pl 1188 dates back to 1000 BC (18), its original habitat remains unclear (19-20). Presently, the coconut tree flourishes in all tropical territories; its fruit called the coconut is put to a wide variety of uses. In many tropical countries the water of the fruit "coconut water" is consumed as a refreshing drink and the endosperm (meat) is used in many ways. The immature endosperm – soft coconut meat or "jelly" to the locals – is eaten while the dried, grated endosperm is used in the preparation of cakes, pastries, and confectioneries. The milk of the dried endosperm is used to flavor meals and the oil extracted from the dry meat (copra) is used to make cooking oil and margarine; the oil is also used in the production of soap, cosmetics and candles (18). Although there are no claims that coconut water is useful for the treatment of any specific diseases, it is a widely held view among Caribbean people that the water of the young coconut is beneficial to the kidneys. In fact in the words of one popular Caribbean song of the 1950s/1960s, '*co-co-nut water, good for your daughter*'. More recently, scientific analysis has shown that coconut water is comparatively rich in both sodium and potassium ions but the concentration of potassium ions is more than twice that of sodium (21).

Mauby is a bitter dark liquid extracted from the bark of the mauby tree, *Colubrina arborescens (Rhamuaceae)*. It is usually diluted with water and sweetened to produce a bittersweet drink that is popular among Caribbean people. The drink is thought by locals to stimulate the appetite. Also, the unsweetened diluted liquid is used by some Caribbean people for the treatment of diabetes mellitus (22) but to date little of its chemical composition has been published.

In this paper, we present the findings of a study in which coconut water and mauby, either individually or mixed, were administered to groups of hypertensive subjects. The study found that both the coconut water and mauby brought about significant decreases in blood pressure in a large proportion of the subjects. Surprisingly, some very large decreases in blood pressure were observed when the coconut water-mauby mixture was administered.

SUBJECTS AND METHODS

Data Collection

Twenty-one hypertensive subjects employed at an industrial company in North West Trinidad and seven from the St Augustine Campus of The University of the West Indies were used for the study. The subjects were either of African descent, Indian descent or of mixed ethnicity. Persons of African and Indian descent account for over 80% of the population in Trinidad and Tobago. The study followed the guidelines of the Declaration of Helsinki and Tokyo and was approved by the Ethics Committee of The University of the West Indies. All subjects were fully briefed on the nature of the study and signed consent forms.

For all subjects in this 'single blind' study, the systolic and diastolic blood pressures were measured in the sitting position for a minimum of five out of ten consecutive working days after which an intervention was commenced. During the intervention, blood pressure readings were again taken for a minimum of five out of ten consecutive working days. For each subject, all measurements were taken at approximately the same time of day and by the same researcher on each occasion. Subjects were required to rest for a minimum of 15 minutes before readings were taken. Blood pressure measurements were made using an Omron HEM-737 digital monitor approved by the British Heart Foundation for research. Subjects were asked to make no changes in their daily routine with particular reference to exercise and diet while enrolled in the study. Also the University's ethics committee stipulated that those subjects taking prescription antihypertensive medication should continue their treatment during the investigation; about 60% of the participants fell into this category.

The data generated in the study were analyzed by the Minitab statistical package. For each subject the mean blood pressure before and after commencing the intervention was calculated and two-sample t-test used to test the hypothesis that the mean blood pressure after the interventions was lower than before. Additionally, for each subject the highest and lowest systolic and diastolic blood pressure before and after the interventions were tabulated.

Intervention

The intervention was either coconut water, mauby (commercial mauby syrup diluted with commercial bottled drinking water) or a mixture of coconut water and mauby (commercial mauby syrup diluted with coconut water). Drinking water from a commercial source was employed as a control. The drinks, including the drinking water, were supplied to subjects in identical sealed, reusable 300 ml glass bottles which were sterilized each time before use. The subjects were divided into four groups of seven with each group receiving one of the four different bottled drinks. Subjects were required to consume 300 ml of the respective drinks twice daily for two weeks. Except for deductions

based on smell and taste, subjects were unaware of the nature of the drinks and were not aware if their allocation was expected to have any effect on blood pressure.

Preparation of interventions

Coconut water: Moderately ripe coconuts, with little or no endosperm (soft jelly), were washed, dried and cut open at one end. The water was emptied into 20 L containers *via* large funnels containing strainers; the strainers removed all solid matter. The coconut water was then dispensed in 300 ml bottles.

Coconut water-mauby mixture: The coconut water-mauby mixture was prepared by adding 180 ml of commercial mauby syrup to 5L of coconut water, the mixture was then dispensed in 300 ml bottles.

Mauby: Mauby beverage was prepared by diluting 180 ml of commercial mauby syrup with 5L of commercial bottled water. The beverage was then dispensed into 300 ml bottles.

Bottled water: Commercial bottled drinking water (the control) was obtained in 5 L containers and dispensed into 300 ml bottles. All drinks were sealed and refrigerated until required.

RESULTS

For four (57%) of the seven control subjects who received commercial bottled water, there was an increase (≥ 4 mmHg) in the mean systolic pressure. Only the largest increase, 7 mmHg for subject C8 was significant ($p \leq 0.05$), (Fig. 1). None of the subjects showed large (≥ 4 mm Hg) or significant decreases in their mean systolic pressure and there were no significant increases or decreases in the mean diastolic pressure for the subjects in this control group.

Of the seven subjects receiving coconut water, the mean systolic pressure decreased by at least 4 mm Hg in all but one instance where the decrease was smaller (Fig. 2)**.** In five cases (*ie* 71 % of the study group) the decreases were significant ($p \leq 0.05$). The decreases were 17, 15, 8, 7 and 6 mmHg for subjects C9, R11, C6, R3 and C2 respectively. Two members of this group (29%) also exhibited significant decreases ($p \leq 0.05$) in the mean diastolic pressure; the decreases were 9 mmHg and 7 mmHg for C6 and R11 respectively (Fig. 2).

Only five of seven subjects in the group receiving mauby completed the study. Of these, two (40%) showed decreases in the mean systolic pressure that were significant, ($p \leq 0.05$). The decreases were 8 and 7 mm Hg for S3 and S5 respectively (Fig. 3). For the other three subjects in this group two showed decreases (5 and 4 mmHg) and the other an increase of 3 mmHg in the mean systolic pressure. Although four of the subjects in this group showed a decrease of between 4 and 5 mmHg in the mean diastolic pressure, only two of these, S3 and S5 (40% of the group) were calculated to be statistically significant ($p \leq 0.05$) (Fig. 3).

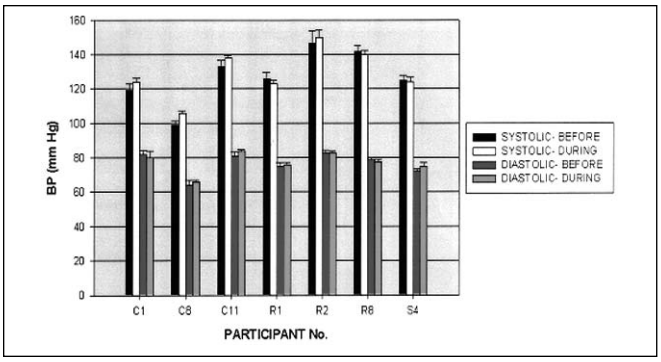

Fig. 1: Consumption of Commercial Bottled Water. The figure shows the mean ± SEM systolic and the mean ± SEM diastolic pressures for seven subjects, before and during the consumption of commercial bottled water, 300.00 ml taken twice daily

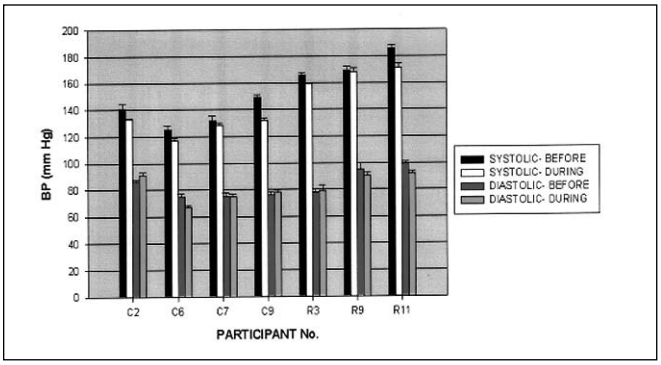

Fig. 2: Effects of Coconut Water on Blood Pressure. The figure shows the mean ± SEM systolic and the mean ± SEM diastolic pressures for seven subjects, before and during the consumption of coconut water, 300.00 ml taken twice daily

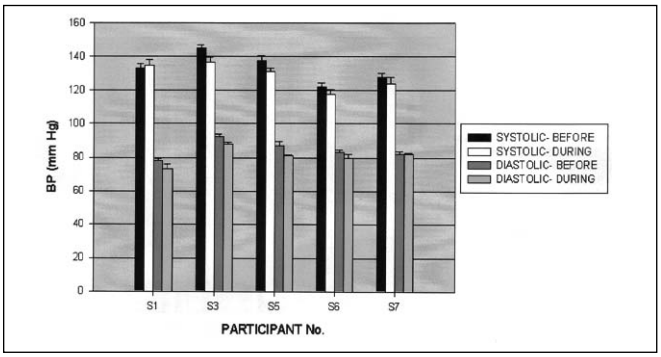

Fig. 3: Effects of Mauby on Blood Pressure. The figure shows the mean ± SEM systolic and the mean ± SEM diastolic pressures for five subjects, before and during the consumption of mauby, 300.00 ml taken twice daily

Four of the seven subjects receiving the coconut water-mauby mixture (*ie* 57%) showed large, significant decreases in either the mean systolic, the mean diastolic pressure or both. Very large decreases in mean systolic pressure (24 and 15 mm Hg) which were statistically significant ($p \leq 0.05$) were observed for two, C5 and R10 respectively, while smaller decreases (5, 4 1, and 1 mmHg) were observed for

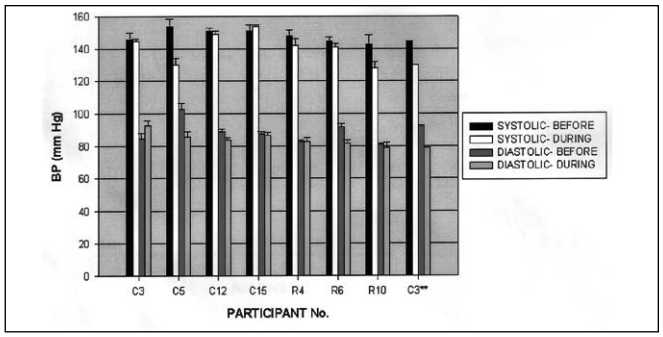

Fig. 4: Effects of Coconut Water-Mauby Mixture on Blood Pressure. The figure shows the mean ± SEM systolic and the mean ± SEM diastolic pressures for seven subjects, before and during the consumption of a coconut water-mauby mixture, 300.00 ml taken twice daily. At the end of the initial study subject C3 increased the intake from twice to three times per day over a three day period; the results are shown in C3**

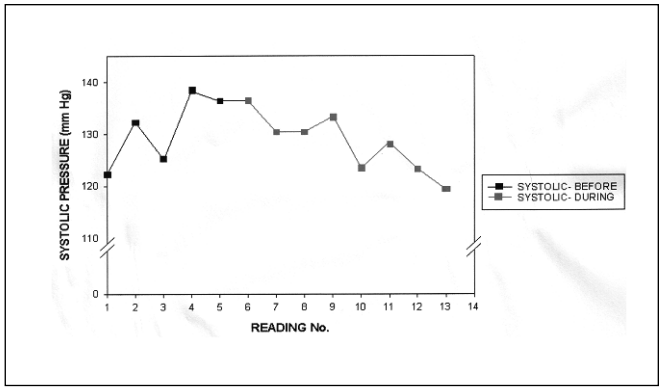

Fig. 5: Coconut Water effects on systolic pressure. The figure compares systolic pressure recorded over two week periods before (black) and during consumption of coconut water (red) for subject C7

another four, R4, R6, C12 and C3 respectively. In contrast there was an increase in the mean systolic pressure (3 mmHg) for one subject (C15) (Fig. 4). Three of the seven (47%) subjects (C5, R6 and C12) showed significant decreases ($p \leq 0.05$) in the mean diastolic pressure; the decreases were 16, 10 and 6 mmHg respectively. For one subject (C3), there was a significant increase (8 mmHg) in the mean diastolic pressure.

Towards the end of the study, two subjects in the group receiving the mixture of drinks (C3 and C15) were singled out for additional experimentation. Subject C3 had showed a small decrease in systolic but a large, significant increase (8 mm Hg) in diastolic pressure. Subject C15 had showed a small decrease in diastolic but an increase (3 mm Hg) in systolic pressure. For both of these subjects, the allocation was increased from 300 ml twice a day to 300 ml three times per day over a three day period. The increased allocation had no effect on subject C15 but for C3 it triggered large reductions in both the systolic and diastolic pressures; the mean decreases were 16 and 14 mm Hg respectively (C3**, Fig. 4). With this result, it now meant that five out of seven subjects or 71% showed significant decreases in blood pressure on consumption of the coconut water-mauby mixture.

Figure 5 compares the systolic readings before and after consumption of coconut water for subject C7. Although the p-value (0.133) suggests that the decrease in mean systolic pressure was insignificant, the graph shows a clear switch from an upward trend before to a downward trend once consumption of coconut water started. To provide additional insights into the possible effects of the interventions, the Table summarizes the highest and lowest systolic and diastolic pressures before and during intervention for all decreases in either the mean systolic or the mean diastolic pressures equal to or greater than 4 mmHg

Table: The Table summarises the highest and lowest systolic and diastolic pressure recorded before and during intervention for subjects that showed a decrease equal to or greater than 4 mmHg in either the mean systolic or the mean diastolic pressure and for which significance testing suggested insignificance ($p > 0.05$). CW is coconut water; M is mauby and MCW is a coconut water-mauby mixture. Large differences are highlighted

	Subjects			
Blood Pressure	**S6(M)**	**R9(CW)**	**R4(MCW)**	**C7(CW)**
Highest systolic before	136	175	155	139
Highest systolic during	126	178	152	134
Lowest systolic before	113	161	140	123
Lowest systolic during	110	158	127	120
Highest diastolic before	93	106	86	81
Highest diastolic during	87	96	86	81
Lowest diastolic before	77	84	81	66
Lowest diastolic during	75	82	74	67

and which were calculated to be insignificant ($p > 0.05$). For subject S6 following consumption of mauby, the highest systolic pressure observed fell from 136 to 126 and the highest diastolic fell from 93 to 87 mmHg. For R9 who received coconut water, the highest diastolic before compared to after was 106 compared to 96 mmHg. Finally for R4 who received the mixture, the low point of both the systolic and diastolic appeared to be affected. The changes were: the lowest systolic before was 140 compared to 127 mmHg after, while the lowest diastolic before was 81 compared to 74 mmHg after.

DISCUSSION

In Trinidad and Tobago, many persons drink one or two coconuts a week and a large number of people drink at least one coconut daily. The volume of water to be found in a ripe coconut varies with species and also with season. In the dry season, most coconuts would yield approximately 250-300 ml of water which increases to about 400-500 ml in the rainy season; some varieties may yield up to 750 ml. Mauby too, which in the last few decades has become available in supermarkets in the form of a syrup, is consumed by many on a daily basis, usually as an alternative to carbonated beverages. Many persons in Trinidad and Tobago and the rest of the Caribbean, therefore consume significant quantities of coconut water and mauby though perhaps not as regularly as was employed in the present study. The impact of this routine consumption of coconut water and mauby on blood pressure is the subject of another study.

Overall, five of the seven subjects (71%) receiving coconut water showed significant decreases in the systolic pressure. Also for this group, the diastolic pressure decreased significantly for 29% of the subjects. Similarly, there were significant decreases in the systolic pressure (between 5 and 10 mmHg) for 40% of those receiving mauby; a significant decrease in diastolic pressure was observed for one fifth of the group. In contrast, systolic pressure increased by as much as 7 mm Hg, while the diastolic increased slightly or remained unchanged for those receiving the commercial bottled water. These results suggest that both coconut water and mauby, if taken on a regular basis, exert haemodynamic properties among persons of African and Indian descent. It appears, however, that both food drinks, exert a greater effect on the systolic than on the diastolic blood pressure (Figs. 2, 3).

For subjects receiving the mixture of coconut water and mauby, the decreases in the systolic and diastolic pressure were much larger than those seen for subjects taking either drink on its own. Decreases as large as 24, 16 and 15 mmHg were seen in the systolic and decreases as large as 16, 16, 10, 6 and 6 mmHg were seen in the diastolic pressure. Also, whereas, singly the coconut water and the mauby affected the diastolic pressure of only a small fraction of the subjects (29% and 40% respectively), when taken together, the coconut water-mauby mixture significantly decreased the diastolic pressure in some 57% of the subjects. These results suggest that the effects of the drinks, when taken together, is at least additive if not synergistic.

Although the statistical analysis confirmed that coconut water, mauby and the coconut water-mauby mixture possess haemodynamic properties, the change from an upward to a downward trend in systolic pressure seen for subject C7 (Fig. 5) and the large decreases in the highest and lowest blood pressure (Table) suggest that evaluation of the effectiveness of these interventions based purely on significance testing might underestimate their impact. There are two possible reasons for this. Firstly, to establish significance for small differences requires a large number of data points: n was between five and ten in this study. Secondly, for a given data set, the p-value is exactly the same whether the numbers fluctuate or follow an upward or downward trend.

A number of other interesting observations that are possibly linked emerged from this study. Firstly, it does appear that there is a relationship between the magnitude of the decrease in blood pressure and the volume of drink consumed. During preliminary investigations in which three bottles of coconut water (900.00 ml) were consumed per day, a number of persons reported that they urinated with increased frequency; as both factors had influenced compliancy, a smaller volume, two bottles per day were employed in the present study. For two of the seven subjects receiving the coconut water-mauby mixture however, the two bottles per day had negligible effect. When the allocation was increased from two to three bottles per day, this brought about a large decrease in blood pressure in one of two subjects, (C3, C15 and C3**) (Fig. 4). The latter observation coupled to the increased frequency in urination suggest a possible diuretic action.

Since there were no previous reports that either coconut water or mauby exert haemodynamic properties, those subjects taking antihypertensive prescription drugs were required to continue taking their medication during the study. Wassertheil-Smoller and Lamport (23) have pointed to the difficulties and need for careful experimentation in order to disentangle the true active ingredient(s) and mode of action in studies of the present type where drug and dietary factors are combined in the treatment of hypertension. The results of the present study should propel further investigations and open the way for studies that are simpler to interpret. In spite of the need for much more experimentation, one other factor appears to give further support to the diuretic theory.

In all cases examined to date (data unpublished) all persons consuming coconut water on a regular basis showed an increase in the plasma level of potassium. A number of animal and human studies, including those of Treasure and Ploth (24); Anderson *et al* (25); Corrigan and Langford (26), have pointed to an inverse relationship between potassium levels and blood pressure. It would be reasonable therefore

to assume that the observed increase in plasma potassium would be a contributing factor in the decreases in blood pressure seen in this study. The increase in plasma potassium, coupled to the reports of increased urination appear to suggest the action of a potassium sparing natriuretic.

During the last three decades, a number of studies (27-29) suggested that regular use of coconut oil contributed to hypercholesterolaemia and hypertension in animal models. Also a study by Beegom and Singh (30) suggest a link between coconut oil consumption and hypertension in man. In 2000, Pehowich *et al* (31) showed that coconut oil contained mostly medium rather than long chain fatty acids and therefore with moderate use might reduce susceptibility rather than being a risk factor for coronary heart disease (CHD). That study confirmed earlier findings (21) which indicated that coconut water, unlike the other edible components of coconut, have an extremely low lipid content. This latter finding would suggest that coconut water consumption is very unlikely to be a risk factor for CHD. On the basis of the findings of this study it would seem that coconut water probably is not only '*good for your daughter*', but particularly when mixed with mauby, may also be excellent for your hypertensive son.

ACKNOWLEDGEMENTS

For kindly assisting/participating in this study we wish to thank the following. Nurse Ali-Amin and the management and participating staff at The Trinidad Port Authority: Dr V Pooran, nurses: Barrow, Caesar, and Alexander along with the management, the secretary Beverly Noel and participating staff at the Trinidad Carib Brewery; my assistants Damian, Curtist, Jerome, Earl and Usha; the technical staff in the Unit of Biochemistry and participating staff at The University of the West Indies (UWI). For funding and supplies, we thank The Campus Research and Publication Committee, the Campus Principal, The Coconut Growers Association and Prestine Waters. For technical assistance we thank Professor S Akingbala and his staff in the Unit of Food Science and Technology, Department of Chemical Engineering, The University of the West Indies.

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