Physiological cost of work and drudgery experienced in opening a tender coconut

N DIVYA PRANATHI, NEERAJA TELAPROLU and V PRASUNA

Department of Family Resource Management, College of Home Science
Acharya NG Ranga Agricultural University, APGC
Lam, Guntur 522034 Andhra Pradesh, India
Email for correspondence: divyapranathidp.25@gmail.com

© Society for Advancement of Human and Nature (SADHNA) ***Received: 17.04.2021/Accepted: 10.05.2021***

ABSTRACT

This study was conducted to gain knowledge of the physiological cost of work and the drudgery experienced during opening a tender coconut in traditional process and by using punch cum splitting machine and tender coconut opener. Local tender coconut vendors aged between age of 28 and 45 years having a minimum experience of 5 years in tender coconut vending formed the sample. The results of the study revealed that the physiological cost of work for punching tender coconut by three methods differed significantly. Traditional method of punching tender coconut by using a hand sickle was found comfortable and vendors relatively experienced less physiological cost of work in this method. Out of the three methods, vendors experienced comparatively less physiological cost of work while using traditional method. Both tools selected were equally causing body discomfort while operatiing. It was observed that the drudgery for punching tender coconut by three methods differed significantly. Punching tender coconut by using coconut punch and splitter was found less drudgery prone and comfortable and vendors relatively experienced less drudgery with this tool.

Keywords: Tender coconut; drudgery; tools; traditional method; physiological cost

INTRODUCTION

Coconuts play an imperative role in Indian culture, tradition and economy. Coconut is a symbol of righteousness, politeness, productiveness and lucky thing. It is a common practice to break open a coconut during religious functions and starting of new goings-on. Coconut water is a natural, healthy, nutritious drink formed naturally in the fruit and contains 94 per cent water and very little fat. Coconut water has a sweet and nutty taste. It contains easily digested carbohydrates in the form of sugar and electrolytes as reported by Zulaikhah (2019).

Tender coconut water has a therapeutic effect containing various nutrients such as minerals, vitamins, antioxidants, amino acids, enzymes and growth hormones (Bhagya et al 2012). Recent studies have shown that tender coconut water is rich in L-arginine, a free form amino acid and vitamin C which can prevent heart disease and lipid (Lukose 2013). Tender coconut water also contains various important compounds for the body such as magnesium, potassium, calcium, selenium, methionine, zinc, iodine, manganese, boron, molybdenum and phyto-hormone such as auxins, cytokines, gibberellins etc (Prathapan and Rajamohan 2011, Fife 2008).

India is the third largest coconut producer in the world with production over 119 million tonnes (https://www.worldatlas.com/articles/the-world-leaders-in-coconut-production.html). The south Indian states alone constitute to 90 per cent of the total coconut production in the country (Yedida et al 2020).

It is an important horticultural crop cultivated in 17 states and three union territories across the country, making India the largest producer of the fruit, accounting for 31 per cent of the world production. In the country the total area under coconut cultivation is 20.96 lakh hectares of which Kerala alone accounts for 7.60 lakh hectares (Anon 2020). Andhra Pradesh

ranks fourth among the coconut producing states in the country.

Tender coconut water vending is the most common street business in India. Cutting a tender coconut open requires a lot of skill and is considered to be risky. In order to understand the risk factors of the tender coconut vending there is need for studying the physiological cost of work and drudgery experienced by the vendors. The aim of the present study was to find out the physiological cost of work and drudgery of the workers while opening a tender coconut with traditional sickle and other manually operated tender coconut opening tools.

For the purpose of study, a sub-sample of fifteen tender coconut vendors out of thirty vendors was selected for studying physiological cost of work and drudgery index of the workers while opening tender coconut by the selected two manually operated tender coconut tools and conventional process. The manually operated tender coconut tools selected were coconut punch and splitter and tender coconut opener as illustrated in Plate 1.

Physiological cost of work (PCW)= Total cardiac cost of work/Total time of the activity
Total cardiac cost of work= Cardiac cost of work + Cardiac cost of recovery
Cardiac cost of recovery (CCR)= (Average recovery heart rate – Average resting heart rate) x Duration of recovery
Cardiac cost of work (CCW)= AWHR x Duration of the activity
Working heart rate (WHR)= Average working heart rate – average resting heart rate

$$\text{Average heart rate (during rest, work and recovery period)} = \frac{1^{st}\text{ reading} + 2^{nd}\text{ reading} + 3^{rd}\text{ reading} + 4^{th}\text{ reading} + 5^{th}\text{ reading}}{\text{Number of times readings taken}}$$

The experiment was designed for studying physiological cost of work and drudgery index. The physiological workload of the respondents can be determined by recording the heart rate at rest, during work and after completion of the work (Kalita 2015). The formula developed by Varghese et al (1989) on the basis of heart rate and energy expenditure was used. While performing the activity, five readings of heart rate with one minute intervals were noted.

After five minutes the respondents were asked to stop the activity and they were allowed to recover. At recovery phase another five heart rate readings with one minute intervals were taken. Then the vendors were asked to report the intensity of exertion of the activity they perceived and measured as per Borg's rating of exertion scale. The same procedure was repeated three times with every selected coconut punching tool.

Drudgery is generally conceived as physical and mental strain, agony, fatigue and monotony experienced by human beings.

Drudgery index was calculated by using the formula given below (Borah and Kalita 1998):

$$\text{Drudgery index} = \frac{X + Y + Z}{3} \times 100$$

where X= Coefficient pertaining to difficulty score, Y= Coefficient pertaining to performance score, Z= Coefficient pertaining to average time spent

Analysis of variance (ANOVA) was carried out using SAS PROC MIXED (SAS v9.4) procedure considering tender coconut punching tools as fixed and vendors/respondent, replication as random. Means were calculated for tender coconut tools from ANOVA and also performed pair-wise comparisons using t-statistic for significant tender coconut punching tools effects.

The statistical model for ANOVA was the sample observations Z_{ijk} on tender coconut tools, i in vendors, j of replication k modeled as:

$$Z_{ijk} = \mu + w_i + f_j + r_{ijk} + \varepsilon_{ijk}$$

where μ= Grand mean, w_i= Fixed effect of tender coconut tools I, f_j= Random effect of vendor j and is ~ NID(0, σ^2_f), r_{ijk}= Random effect of k^{th} replication f j^{th} vendor in i^{th} tender coconut tool i and is ~ NID(0, σ^2_r), ε_{ijk}= Random residual effect and ~ NID(0, σ^2_ε) (SAS Institute Inc 2015)

Coconut punch and splitter | Tender coconut opener

Plate 1. Coconut opening tools

Table 1. Distribution of physiological cost of work during tender coconut opening with tools

Tender coconut opening tool	Physiological cost of work [energy expenditure (kj/min)]			
	Minimum	Maximum	Mean	SD
Coconut punch and splitter	21.8	56.4	35.96	9.86
Tender coconut opener	16.2	48.6	27.56	8.67
Traditional method	9.8	43.4	23.27	9.02

RESULTS and DISCUSSION

Physiological cost of work

Most of the respondents had physiological cost of work ranging from 26.1 to 45.83 kj/min with coconut punch and splitter. Slightly less than three fourth of the sample the physiological cost of punching tender coconut with tender coconut opener was in between 18.89 and 36.23 kj/min. The mean physiological cost of punching tender coconut by traditional method was 23.27 kj/min (Table 1). For sixty per cent of the samples the physiological cost of punching tender coconut by traditional method was in between 14.24 and 32.3 kj/min.

The physiological cost of work by the subjects while punching tender coconut by using coconut punch and splitter, tender coconut opener and traditional method has been computed in Tables 2 and 3. Significant variance among vendors (P= 0.0113) was observed as shown. There was a highly significant mean difference (P= <.0001) in the physiological cost of work by vendors while punching tender coconut using coconut punch and splitter, tender coconut opener and traditional method. With reference to physiological cost of work, the vendors experienced relatively high physiological cost of work while operating coconut punch and splitter followed by tender coconut opener and traditional hand method.

Highly significant mean difference in physiological cost of work (P= <.0001) was found between coconut punch and splitter and tender coconut opener. Every tool differed significantly with other two

Table 2. Analysis of variance in punching tender coconut by three different tools with reference to physiological cost of work

Random effect

Covariance parameter	Covariance parameter estimates			
	Variance component	Standard error	Z-value	Pr Z
Replications	-0.1113	0.4546	-0.24	0.8066
Tender coconut vendors	62.3537	24.6283	2.53	0.0113
Sample error	25.1957	3.3084	7.62	<.0001

Fixed effect

Effect	Type 3 tests of fixed effects			
	Numerical DF	Denominator DF	F-value	Pr>F
Machine	2	116	74.45	<.0001

Table 3. Means and pair-wise mean comparisons while punching tender coconut by traditional method and by using punch cum splitter and tender coconut opener with reference to physiological cost of work

Machine	Least squares means		Pair-wise comparisons				
	Physiological cost of work	Standard error mean	Machine 1	Machine 2	Difference of means	t-value	Pr>|t|
Coconut punch and splitter	35.9644	2.1633	Coconut punch and splitter	Tender coconut opener	8.4000	7.94	<.0001
Tender coconut opener	27.5644	2.1633	Coconut punch and splitter	Traditional method	12.6933	12.0	<.0001
Traditional method	23.2711	2.1633	Tender coconut opener	Traditional method	4.2933	4.06	<.0001

Table 4. Distribution of drudgery index during use of tender coconut opening tools

Tool	Drudgery index			
	Minimum drudgery	Maximum drudgery	Mean drudgery index	SD
Coconut punch and splitter	2.6	3.3	2.94	0.19
Tender coconut opener	3.1	3.7	3.3	0.16
Traditional method	2.9	3.5	3.21	0.17

tools in physiological cost of work. Physiological cost of work was relatively less in traditional method of cutting and punching tender coconut. Highly significant mean difference (P= <.0001) in physiological cost of work was found between punch cum splitting machine and traditional method of opening tender coconut using a hand sickle. Highly significant mean difference (P= <.0001) was observed in physiological cost of work between tender coconut opener and traditional method of punching tender coconut.

It was observed that the physiological cost of work for punching tender coconut by three methods differed significantly. Traditional method of punching tender coconut by using a hand sickle was found comfortable and vendors relatively experienced less physiological cost of work in this method.

Drudgery index

The respondents mean drudgery score was 2.94 for opening tender coconut with coconut punch and splitter (Table 4). More than seventy per cent (73.33%) of the respondents experienced drudgery of 2.75 to 3.13.

The mean drudgery experienced by the vendors while punching tender coconut with tender coconut opener was 3.3. Eighty per cent of the respondents felt drudgery in between 3.14 - 3.46 with tender coconut opener. The mean drudgery experienced by the vendors while punching tender coconut in traditional way was 3.21 and standard deviation was 0.17. More than fifty per cent (53.33%) of the respondents perceived drudgery of 3.04 - 3.39.

The drudgery was more while punching tender coconut with tender coconut opener. Punching tender coconut with the coconut punch and splitter was found with less drudgery than the traditional method of punching. The lever mechanism used in the tool might have contributed for the reduction in the drudgery.

Drudgery is the perceived physical and mental strain, agony, fatigue and monotony experienced by workers (Borah and Kalita 1998). Drudgery index is the drudgery of the tender coconut vendor while punching tender coconuts by traditional method and by using punch cum splitter machine and tender coconut opener.

The drudgery experienced by the subjects while punching tender coconut by using coconut punch and splitter, tender coconut opener and traditional method was computed (Table 5). Significant variance among vendors (P = <.0001) was observed. There was a highly significant mean difference (P = <.0001) in the drudgery experienced by the vendors while punching tender coconut using coconut punch and splitter, tender coconut opener and traditional method.

Further to understand the significant mean difference pair-wise mean comparisons were conducted (Table 6) with reference to drudgery, the vendors relatively experienced more drudgery while

Table 5. Analysis of variance in punching tender coconut by three different tools with reference to drudgery

Random effect

Covariance parameter	Covariance parameter estimates			
	Variance component	Standard error	Z-value	Pr Z
Replications	0.004571	0.005547	0.82	0.2050
Tender coconut vendors	0.02622	0.007008	3.74	<.0001

Fixed effect

Effect	Type 3 tests of fixed effects			
	Numerical DF	Denominator DF	F-value	Pr >F
Machine	2	28	20.19	<.0001

Table 6. Means and pair-wise mean comparisons while punching tender coconut by traditional method and by using punch cum splitter and tender coconut opener with reference to drudgery

Tool	Least squares means		Pair-wise comparisons				
	drudgery index	Standard error mean	Machine 1	Machine 2	Difference of means	t-value	Pr >|t|
Coconut punch and splitter	2.9400	0.4531	Coconut punch and splitter	Tender coconut opener	-0.3600	-6.09	<.0001
Tender coconut opener	3.3000	0.4531	Coconut punch and splitter	Traditional method	-0.2733	-4.62	<.0001
Traditional method	3.2133	0.4531	Tender coconut opener	Traditional method	0.08667	1.47	0.1539

operating tender coconut opener followed by traditional hand method and coconut punch and splitter.

Highly significant mean difference in drudgery (P= <.0001) was found between coconut punch and splitter and tender coconut opener while punching tender coconut. No significant mean difference (P= <.0001) in drudgery was found between punch cum splitting machine and traditional method of opening tender coconut using a hand sickle was found. Highly significant mean difference (P= 0.1539) was observed in drudgery between tender coconut opener and traditional method of punching tender coconut.

According to the results of the study, it was observed that the drudgery for punching tender coconut by three methods differed significantly. Punching tender coconut by using coconut punch and splitter was found less drudgery prone and comfortable and vendors relatively experienced less drudgery in this method.

CONCLUSION

It was found that the physiological cost of work while punching tender coconut with the coconut punch and splitter was highest (35.96). In case of traditional method of cutting tender coconut physiological cost of work was less. With reference to physiological cost of work, the vendors experienced relatively high physiological cost of work while operating coconut punch and splitter followed by tender coconut opener and traditional hand method. The drudgery was more while punching tender coconut with tender coconut opener. Punching tender coconut with the coconut punch and splitter was found with less drudgery than the traditional method of punching.

The lever mechanism used in the tool might have contributed for the reduction in the drudgery. With reference to drudgery, the vendors relatively experienced more drudgery while operating tender coconut opener followed by traditional hand method and coconut punch and splitter.

REFERENCES

Anonymous 2020. On World Coconut Day, Kerala looks to Centre to improve yield. Indo-Asian News Service, 2 Sep 2020.

Bhagya D, Prema L and Rajamohan T 2012. Therapeutic effects of tender coconut water on oxidative stress in fructosa fed insulin resistant hypertensive rats. Asian Pacific Journal of Tropical Medicine **5(4):** 270-276.

Borah R and Kalita M 1998. Identifying drudgery prone farm activities performed by women. Indian Journal of Hill Farming **11(1-2):** 7-12.

Fife B 2008. Coconut water for health and healing. Piccadilly Books Ltd, USA, 224p.

https://www.worldatlas.com/articles/the-world-leaders-in-coconut-production.html

Kalita M 2015. Physiological cost of storage of paddy and ergonomic intervention for drudgery reduction. PhD Thesis, Assam Agricultural University, Jorhat, Assam, India.

Lukose RM 2013. The chemical composition of tender coconut (*Cocos nucifera* L) water and coconut meat and their biological effect in human body. International Journal of Green and Herbal Chemistry **2(3):** 723-729.

Prathapan A and Rajamohan T 2011. Antioxidant and antithrombotic activity of tender coconut water in experimental myocardial infarction. Journal of Food Biochemistry **35(5):** 1501-1507.

Varghese MA, Atreya N and Bhatnagar A 1989. Studies on workload and perceived exertion in household works. Department of Family Resource Management, Departmental Research Support (UGC), Bombay, Maharashtra, India.

Yedida S, Singh AK, Anand S and Prakash S 2020. Suggested extension strategies for enhancing coconut production of East Godavari district of Andhra Pradesh. International Journal of Chemical Studies **8(4):** 230-232,

Zulaikhah ST 2019. Health benefits of tender coconut water (TCW). International Journal of Pharmaceutical Sciences and Research **10(2):** 474-480.