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Effect of processing methods on nutrient and tannin content of tamarind seeds

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Abstract. *Ly J, Sjofjan O, Djunaidi IH, Suyadi.2017. Effect of processing methods on nutrient and tannin content of tamarind seeds. Trop Drylands 1: 78-82.* The seeds of tamarind (*Tamarindus indicus*) are abundant in semi-arid region of Indonesia and have the potential to be utilized as animal feed sources. Yet, the seeds contain tannin which might have adverse effects on the animals, implying that processing seeds are necessary to reduce the tannin content. The study aimed to evaluate the nutrient content of tamarind seeds collected from Kupang, East Nusa Tenggara, Indonesia and to examine the effect of physical processing methods on nutrient and tannin content. Four treatments using a completely randomized design were trialed: sun-dried seeds (T0); dry fried/roasted seeds (T1); moistening seeds 12 hours after dry fried/roasted (T2); and moistening seeds 24 hours after dry fried/roasted (T3). Dry frying increased significantly ($P<0.05$) crude protein (CP), essential amino acids (EAA), and non-essential amino acids (NEAA) but reduced ($P<0.05$) crude fiber (CF), free fatty acids (FFA), SAFA, UFA and tannin contents of sun-dried tamarind seeds. Moistening 12-24 hours improved significantly ($P<0.5$) CP, SAFA, UFA; reduced ($P<0.5$) CF, FFA, EAA, NEAA; and released 7-8.5% additional tannin contents of ground dry fried seeds kernel. The study highlighted that Indonesia's semiarid region tamarind seeds contain comprehensive nutrients and tannin compounds. Dry frying, dehusked tamarind seeds and grinding followed by moistening the ground dry fried seed's kernel could reduce tannin compound and improve the nutrient content.

Keywords: Dry-fried, moistening, processing, tamarind, tannin

INTRODUCTION

Some regions in Indonesia have semi-arid areas including islands in East Nusa Tenggara Province. While these regions generally have low floristic diversity due to low rainfall and hot temperature, they are endowed with local grains and seeds which have the potentials as feed sources. Tamarind seeds produced from *Tamarindus indicus* are one of the potential wild plant seeds that can be produced in the range of 3000-5000 tons annually in East Nusa Tenggara Province (Statistics of Indonesia 2014). However, 99% of this production is wasted (East Nusa Tenggara Central Statistical Bureau 2014), and only 1% were traditionally used for pigs feeding due to astringent taste, inaccessible processing method and unavailable comprehensive nutrient content data (Ly 2016).

Vadivel and Pugalenthi (2010) reported that raw tamarind seeds contain 675.0±0.12 mg/100 g tannin compound of which about 90% are stored in the seed's husk, and such tannin is responsible for the astringent taste in tamarind seeds. Tannin compound is dangerous for monogastric animals, such as pigs, as it inhibits nutrient digestion and absorption, causing constipation and inducing digestive tract disorders (Pugalenthi et al. 2004; De Caluwé et al. 2010). On the other hand, raw tamarind seeds contain 23% crude protein (CP) (Vadivel and Pugalenthi 2010) which have the potential as protein source. Nonetheless, knowledge regarding nutrient and tannin content in Indonesian tamarin seeds, and proper processing method to remove tannin compounds in tamarind seeds are not available. Therefore, comprehensive information on nutrient content and method for eliminating tannin compounds are important to optimize tamarind seeds utilization for animals.

The tannin compound in the tamarind seed's husk is technically hard to be removed. Dehusking by heating the seeds has been suggested as the initial step to remove the tannin (Pugalenthi et al. 2004; Vadivel and Pugalenthi 2010), but 10% of tannin content remain in the seed's kernel. Grinding seed's kernel continued with moistening them with water are assumed to ameliorate the remaining tannin content without destroying the essential nutrients in the tamarind seed's kernel. It is because tannin is a water-soluble compound (Khanbabaee and van Ree 2001). But tamarind seed kernel is hard, and grinding it is the easiest way to facilitate water penetration into the hard tamarind seed's kernel. Reliable attempts to find out the proper way in processing tamarind seeds are rarely studied. The present study aimed to evaluate the nutrient content in tamarind seeds collected from Kupang District, East Nusa Tenggara Province, Indonesia, and to examine the effect of drying and moistening treatments of seed kernel on nutrient and tannin content.

MATERIALS AND METHODS

Material preparation

Thirty kg of raw sun-dried tamarind seeds were collected from several tamarind center areas in Kupang District, East Nusa Tenggara Province, Indonesia. The seeds were cleaned and sun-dried for two days. Eight kg of those seeds were then randomly sampled for study purposes. The samples seeds were treated with four different processing methods. Crude protein (CP), fat, crude fiber (CF), and energy as well as amino acids, fatty acids, and tannin contents were analyzed by the Integrated Laboratory in Bogor Agricultural University (IPB), Bogor, West Java, Indonesia.

Experimental design and treatments

Sun-dried tamarind seeds were randomly allotted to the following treatments in a completely randomized design consisting of 4 treatments with 5 replicates: (i) T0: sun-drying the seed kernels, (ii) T1: dry-fried the seed kernel, (iii) T2: moistening 12 hours the dry-fried seed kernel, (iv) T3: moistening 24 hours the dry-fried seed kernel.

Physical processing procedure

Eight kg of sun-dried tamarind seeds samples were divided into two groups of 2 kg for T0 and 6 kg for T1, T2, and T3. Two kg of the T0 seeds group were dehusked with a low-speed peeling machine to separate the husk from the seed kernel. The clean seed kernels were then ground into 0.6-1 mm particle size. As much as 500 g ground sun-dried seed's kernel was sampled for T0 then divided into five replicates of 100 g of each. Six kg of T1, T2 and T3 treatments were dry fried in an iron wok at ± 60^{o}C for 15 minutes. The fried seeds were immediately taken out from the hot wok as soon as the color of the seeds turned into dark brown and fissures around the husk followed with peanut aromatic appeared from the fried seeds. The fried seeds were cooled in open air for 15 minutes and dehusked as for T0 seeds group. Clean fried seeds' kernels were then ground into 0.6-1 mm particle size and 500 g of them were sampled for T1 which was divided into five replicated of 100 g of each. Ten sample units consisting of five replicates of T0 and T1 each were analyzed in the laboratory to evaluate the crude protein, fat, crude fiber, Ca, P, amino acids, fatty acids and tannin contents.

Moistening ground dry fried seeds kernel with water

One kg of ground dry-fried seed kernels was divided into two groups of 500 g. The first 500 g groups were randomly allotted to T2, and the remaining 500 g were allotted to T2. Each group was divided into 5 replicates with 100 g each. As much as 600 mL distilled water was prepared and equally divided into the ten replicates with 60 mL each. Each replicate (100 g) of T2 and T3 was mixed with each 60 mL of prepared distilled water to perform a moist mixture of ground dry-fried tamarind seeds' kernel. The ratio of 100 g ground seed kernels: 60 mL distilled water was considered as the optimal mixing ratio to gain the best moist mixture as prescribed by Zamindar et al. (2013). Each replicate of T2 and T3 was stored in a 100 g aluminum bowl with the T2 bowls were opened after 12 hours and T3 bowls after 24 hours incubation. Before being analyzed in the laboratory, the units of T2 and T3 were weighed and immediately put into a 60 ^{o}C oven for one hour to halt the moistening process, dry and well separate the mixture particles. The moistening stages are briefly shown in Figure 1.

Variables studied

Variables studied consisted of: (i) Nutrient content: crude protein, fat, crude fiber, and gross energy were analyzed using proximate analysis (AOC); amino acids and fatty acids content were analyzed using Chromatographic; (ii) Tannin content was analyzed using Spectrophotometric method (AOC).

Statistical analysis

Proximate and tannin content were analyzed using one-way Analysis of Variance (ANOVA) to test the significance of the treatments, and Duncan's multiple range test was used to compare differences between treatment means (P<0.05) according to Steel and Torrie (1997) using SPSS v. 19.0. AA and FA data were descriptively analyzed.

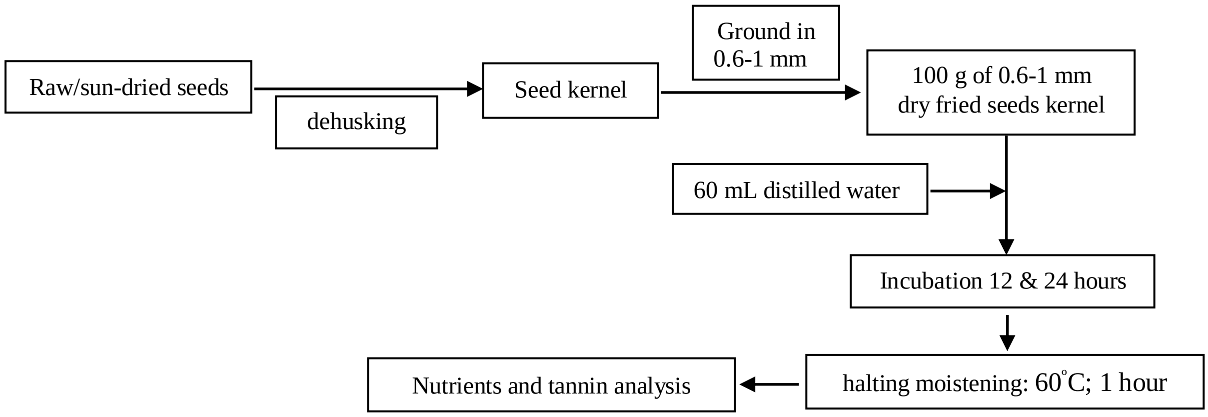

Figure 1. Diagram of processing stages of tamarind seeds adopted from van Der Stege et al. (2011)

RESULTS AND DISCUSSION

Nutrients and tannin contents

The results of proximate analysis and tannin content are shown in Table 1. Amino acids and fatty acids compositions are shown in Table 2 and Table 3, respectively.

Dry frying treatment increased 7.83% DM content, but moistening 12 and 24 hours reduced 27% DM content of ground tamarind seed's kernel. Dry frying increased 1.9% CP content of sun-dried seed kernels; moistening 12 and 24 hours respectively increased 1.1% and 1.4% CP content ($P<0.05$). Fat content decreased 45.5% ($P<0.01$) by the dry frying process, but moistening 12 and 24 hours respectively improved 9.9% and 8.8% ($P<0.05$) fat content. CF content was reduced 52% ($P<0.01$) by dry fried, and moistening 12 and 24 hours reduced CF content 5.5% and 2.7%, respectively ($P<0.05$).

Tannin content was high (92.3%) in the husk and low (7.7%) in the kernel of seeds. Dry frying reduced 23.5% tannin content in the husk and 10% tannin in the kernel. Moistening 12 hours reduced 1.5%, but moistening 24 hours released 7% additional tannin content. Statistical analysis shows that effect of treatment is significant at $P<0.05$ on DM, CP and tannin; and highly significant at ($P<0.01$) on fat and CF contents (Table 1).

Amino acids (AA) composition

Amino acids compositions were measured in 3 groups: total (AA), essential (EAA) and non-essential (NEAA) amino acids of the seeds. Sun-dried (raw) tamarind seed's kernel contained 13.34 mg/100 g CP, consisting of comprehensive EAA (6.06 mg/100 g CP) and NEAA (7.28 mg/100 g CP). Dry frying increased 7.2% of total AA, 4% of EAA and 11% NEAA contents. Moistening 12 and 24 hours reduced 6.2% and 7.1% of total AA, 6.8% and 7.5% of EAA, and 6.3% and 7.6% of NEAA contents, respectively. Total AA, EAA and NEAA contents of moistening results were similar to raw seeds' kernel contents. The change is EAA/NEAA ratio had similar range (1/1.2 to 1/1.3) between dry frying and moistening processes (Table 2).

Free fatty acids (FFA) compositions

FFA compositions were divided into three main categories: total FFA, SAFA and UFA contents. Sun-dried tamarind seed's kernel contained 74.1 mg FFA/100 g fat, consisting of 19.5 mg SAFA and 54.6 mg UFA/ 100 g fat. Dry frying reduced 55.7% total FFA, 2.6% SAFA and 74.2% UFA. Moistening 12 and 24 hours, respectively, improved 47.2% and 67.3% total FFA, 26.8% SAFA and 55% UFA (Table 3). The data show that UFA group has higher reduction than SAFA by all processing methods. Heat during dry frying might have a high impact on both fatty acids fractions which UFA fractions are more sensitive to heating since they have a lower melting point (-49.5-13.4°C) compared to SAFA fractions (44.2-86°C). It seems that moistening could not recover all the part of those fatty fractions that were melted during dry frying.

Table 1. The results of proximate analysis and tannin contents of tamarind seed

Contents	Sun-dried seeds (T0)		Dry fried seed (T1)		Moistening	
	husk	kernel	husk	kernel	T2	T3
DM (%)	na	91.5^{b}	na	98.7^{b}	71.2^{a}	71.6^{a}
OM (%)				97.0^{a}	97.0^{a}	97.1^{a}
CP (%)		16.2^{a}		18.1^{b}	19.2^{b}	19.5^{b}
Fat (%)		7.06^{c}		3.85^{a}	4.23^{b}	4.19^{ab}
CF %		7.7^{b}		3.7^{a}	3.5^{a}	3.6^{a}
Ca %		0.72^{a}		0.75^{a}	0.72^{a}	0.72^{a}
P %		0.30^{a}		0.37^{a}	0.31^{a}	0.31^{a}
GE (MJ/kg)		18.0^{a}		19.0^{a}	19.1^{a}	19.3^{a}
Tannin (mg/100 g)	3620	300^{b}	2760	270^{ab}	266^{ab}	289.3^{b}

Note: ^{abc} Means in the same row without similar letter are different at P <0.05. na: not analyzed

Table 2. Amino composition of tamarind seeds

Amino acids (mg/100 g CP)	T0	T_1	T_2	T_3
Aspartic acid	1.59	2.0	1.88	1.83
Glutamic acid	2.40	2.8	2.69	2.57
Serine	0.78	0.91	0.86	0.84
Histidine	0.33	0.32	0.30	0.28
Glycine	0.82	0.58	0.52	0.62
Threonine	0.46	0.50	0.47	0.49
Arginine	1.04	1.03	0.97	0.96
Alanine	0.61	0.68	0.63	0.63
Tyrosine	0.58	0.63	0.61	0.60
Methionine	0.15	0.16	0.18	0.11
Valine	0.69	0.73	0.68	0.66
Phenylalanine	0.75	0.85	0.78	0.78
Iso-leucine	0.74	0.80	0.73	0.76
Leucine	1.18	1.32	1.24	1.26
Lysine	1.18	0.99	0.88	0.89
Total amino acids	***13.34***	**14.30**	**13.42**	**13.28**
EAA	*6.06*	*6.30*	*5.87*	*5.83*
NEAA	*7.28*	*8.06*	*7.55*	*7.45*
EAA/NEAARatio	*1/1.2*	*1/1.3*	*1/1.3*	*1/1.3*

Table 3. FFA composition of tamarind seeds

Fatty acids composition (mg/100 g fat)	T_0	T_1	T_2	T_3
Total fat %	7.06	3.85	4.23	4.19
Caprilic. C8:0	0.05	0.14	0.11	0.20
Lauric. C12:0	0.48	0.02	0.02	0.31
Myristic. C14:0	0.36	0.10	0.09	0.33
Pentadecanoic. C15:0	0.03	0.05	0.05	0.07
Palmitic. C16:0	5.72	6.31	7.11	10.34
Palmitoleic. C16:1 **(1)**	***0.03***	***0.03***	***0.03***	***0.19***
Heptadecanoic. C17:0	0.08	0.10	0.12	0.17
Stearic. C18:0	3.56	3.53	4.64	4.84
Oleic. C18:1n9c **(2)**	***18.00***	***7.91***	***10.41***	***13.20***
Elaidic. C18:1n9t	0.03	0.03	0.04	0.09
Linoleic.C18:2n9c (3)	**35.89**	**5.83**	**13.77**	**10.89**
Linolenic. C18:3n3 (n3) **(4)**	*nd*	*0.04*	*0.04*	*0.09*
Arachidic. C20:0	1.79	1.69	2.41	2.60
Eicosenoic. C20:1	0.82	0.33	0.53	0.55
Eicosenoic. C20:2 (5)	**0.13**	**0.03**	**0.07**	**0.08**
Eicosapentaenoic. C20:5n3 **(6)**	*0.05*	*nd*	*0.04*	*0.05*
Heneicosanoic. C21:0	0.03	0.06	0.08	0.08
Behenic. C22:0	2.38	2.73	3.72	3.96
Erucic. C22:1n9	nd	nd	0.02	0.02
Decosahexaenoic. C22:6n3 (n3) **(7)**	*nd*	*0.05*	*0.06*	*0.06*
Decosenoic. C22:2 (8)	**nd**	**0.02**	**0.02**	**Nd**
Tricosanoic. C23:0	0.12	0.18	0.20	0.23
Lignoceric. C24:0	4.55	3.63	4.73	5.05
Total FFA	*74.1*	*32.8*	48.29	54.88
Saturated fatty acids (SAFA)	19.50	19.00	24.10	29.50
Unsaturated fatty acids (UFA)	54.60	13.91	24.42	24.57
Mono unsaturated Fatty acids (MUFA) (1+2)	***18.03***	***7.94***	***10.44***	***13.39***
Poly unsaturated fatty acids (PUFA) (n3+n6) (1+5+8)	**36.07**	**5.97**	**13.98**	**11.18**
UFA/SAFARatio	2.77/1	1/0.73	1/1.01	0.83/1
MUFA/PUFARatio	1/2	1/0.75	1/1.34	1/0.83
n-3 PUFA (4+6+7)	***0.05***	***0.09***	***0.14***	***0.20***
n-6 PUFA (3+5+8)	**36.02**	**5.88**	**13.84**	**10.98**
n-3/n-6Rasto	**1/720**	**1/65.3**	**1/98.9**	**1/55**

Note: [abc] Means in the same row without similar letters are different at P <0.05. na: not analyzed; nd: not determined; MUFA: oleic+palmitoleic; PUFA (poly-unsaturated fatty acids): linoleic and linolenic.

Discussion

CP content of sun-dried (raw), dry fried and both moistening processes of seed's kernel in this study are lower than those in India as reported by either Pugalenthi et al. (2004) (sun-drying and roasting) or Vadivel and Pugalenthi (2007, 2010) (roasting and soaking 12 hours in the water). Increasing CP content by moistening could be a way to release bound protein from other binding protein molecules such as carbohydrates groups and tannin compounds. It could occur because there are some protein fractions bound to carbohydrate fractions such as sugar and fiber (Sooriyaarachchi 2010) and tannin compound (Frutos et al. 2004).

Total fat of raw seeds in this study is lower than in Indian tamarind raw seeds reported by Pugalenthi et al. (2004) or Vadivel and Pugalenthi (2010). The following two factors might have contributed to the difference: seed moisture content and chemical soil properties. Total fat content was found to decrease highly significantly by dry frying process, which then was improved slightly by moistening. These results are similar to the results of roasting process reported by Vadivel and Pugalenthi (2010) in Indian tamarind seeds. Melting cases could occur by heat in dry frying the seeds that resulted in fat content reduction in the kernel; then they were condensed by moistening (Steane 2016). The heat broke bonds between the fat molecules and converted the solid state into a liquid state. In moistening projecting-H atoms of water were linked to fat molecules projecting-OH groups to produce unoriginal water (H_2O) (Steane 2016), resulting in losing water and performing condensed state of fat.

Tannin content of whole tamarind seeds in this study is lower than tannin content of whole seeds of Indian tamarind seeds reported by Pugalenthi et al. (2004) but slightly higher than that of Nigerian raw tamarind seeds reported by Yusuf et al. (2007). Dry frying result of this study is lower than that of roasted result of Pugalenthi et al. (2004) study. Moistening results of this study are lower than soaked results of Pugalenthi et al. (2004) study in Indian tamarind seeds. Dry fried reduced tannin content in both the husk and kernel of the seeds. It may be because heat reduced water content and broke down bonds among tannin molecules resulting in reducing water-soluble tannin fractions for tannin is naturally a water-soluble compound (Khanbabaee and van Ree 2001). Moistening the seeds in 12 hours reduced tannin content in the ground seed kernels but moistening 24 hours increased the tannin slightly.

Total AA of raw tamarind seeds of this study is in the range of two studies reported by De Caluwé et al. (2010). Dry fried increased total AA, EAA and NEAA contents in tamarind seeds but moistening reduced them. Increasing AA may relate to the increase in total DM content, resulting in higher AA content in CP and AA contents. Reducing total AA, EAA and NEAA contents by moistening is not aligned with the increasing of proximately CP content. It can be assumed that the increase of CP content is only because of increasing non-protein nitrogen (NPN) group as a result of protein denaturation to yield NPN group. It may occur since longer moistening damaged more building protein amino acids or built more NPN than building protein nitrogen group. Overheating in dry frying is the most suspicious influencing factor damaging protein structure in protein duration to yield NPN group (Whittemore and Kyrizakis 2006).

UFA contents were reduced by drying then increased 41-63.6% after moistening. It shows that moistening achieved 20% and fermentation performed 11-23% improvement. The 12 hours moistening had the highest UFA enhancement (23%) from dry frying, yet these all are still lower than raw seed contents.

The data show that UFA group had higher reduction than SAFA in all processing methods. It may be because molecules bonds among UFA are looser, resulting in more sensitivity to heat (frying) compared to SAFA molecules. UFA is the group of fat with low melting point meaning that it is easily melted and reduced by heat. UFA molecule bonds could be easily loosened and more sensitive to heat (frying) because they are built-in branching carbon chain that easily reacts with O_2 in oxidation process (Lehninger 1982).

Total FFA, UFA and SAFA contents of raw seeds were reduced by dry frying but those of ground kernel was improved by moistening, and these figures aligned with the figure of total fat content. It is shown that UFA content reductions were higher than that of SAFA groups. The difference in melting point between those two FFA groups could be the primary influencing factor. Tannin and nutrient contents presented in Tables 1-3 show that dry frying is better in eliminating tannin but not in maintaining nutrient content. Moistening is better in improving nutrient content with a slight increase of tannin content.

In conclusion, the study highlighted that Indonesian semiarid region tamarind seeds contain comprehensive nutrients and low tannin compounds. Dry frying, dehusking tamarind seeds and grinding continued with moistening the ground dry fried seed kernels as presented in this study could optimally eliminate tannin compound and maintain essential nutrients of tamarind seed kernels in this study. A study using other processing methods is required to find out the best way to eliminate tannin and maintain nutrient content of tamarind seeds.

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