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Dynamics of the physical properties of soybean during storage under tropical condition

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ABSTRACT

This research study was carried out for 16 weeks to evaluate the effect of ambient storage conditions on the physical properties of soybean. Two soybean varieties named Pb-1 and PM-13 were used for the experiment. The hardness, bulk density, moisture content and thousand seed mass changed significantly within the storage period (P<0.05). Hardness and bulk density of seeds increased with time while thousand seed mass and moisture content decreased with storage time in both varieties. The 'L' and 'a' color values were not changed significantly with storage time however, the 'b' color values were significantly altered with storage time in both varieties. Seed physical property changers are directly affected to its processing conditions such as grading, separation, drying and grinding. Therefore, soybean processing conditions and processing power requirements required to be altered accordingly.

Key words: Change of properties, Physical properties, Soybean, Storage, Tropical conditions.

INTRODUCTION

Soybean is one of the most important protein rich food crop among legume (pules). It contains high quality protein that required to contain in human diets. The amino acid profile of soy protein is nearly equivalent in quality to meat, milk and egg protein (Miglani and Sharma, 2017; Narayan *et al.,* 1988). Further, it is used as the most economical important oilseed in the world market Duarte *et al.* (2004). Generally, soybean is ingredients for hundreds of food products such as infant and breakfast formulas, tofu and Textured Vegetable Protein (TVP).

Soybean is cultivated as a seasonal crop in most countries therefore, it requires storage for consumption or processing until next season. Generally, most of local farmers store soybean at ambient conditions and ambient environment conditions such as temperature and relative humidity are highly fluctuated under tropical condition. Further, stored soybean seed are biologically alive therefore, respiration and other metabolic reactions take place continuously as a result, seed mass loss, moisture gain or loss and change of physiochemical properties occurred during storage. These changes directly affect physical and organoleptic qualities and processing parameters of soybean seeds (Gunathilake *et al.,* 2018; Hou and Chang, 2004).

Therefore, the objective of good storage practice should be to preserve the characteristics of seed that exist just after harvesting. Relatively high temperature and relative humidity are major problems for soybean storage in the natural environment of tropical regions, when compared with temperate or cold climates (Hridya *et al.*, 2018; Abba and Lovato, 1999). Therefore, it is very important to study, how soybean physical properties are behaved under ambient tropical storage conditions. In past, many researchers have investigated changing behavior of physical properties with storage for various other agricultural crops such as lentil grains (Carman, 1996), locust bean seed (Olajide and Ade-Omowage, 1999), pumpkin seeds Joshi *et al.,* (1993), chick pea seeds Konak *et al.,* (2002), pea seeds Yalçin *et al.,* (2007) and sunflower seeds (Gupta and Das, 1997). However, lack of studies are found for soybean seeds.

The physical properties of pulse crops were not only important for its quality but they were also important to design the equipment and machines for sorting, separation, transportation and processing Brooker *et al.*, (1992). Change of physiochemical properties can be major economic losses as well seed moisture content is one of the most important factors influencing seed quality in terms of price and seed storability and it may be affected economic return (Kaur *et al.,* 2016; Narayan *et al.,* 1988). Therefore, this study was conducted to analyze the changes of physical properties of soybean under tropical ambient storage conditions.

MATERIALS AND METHODS

This research work was carried out at Sri Lanka under tropical climatic conditions. Locally cultivated soybean varieties namely Pb-1 and PM-13 were used for this study. They were stored at ambient conditions in the warehouse and used for measuring the physical properties. The data were recorded once every two weeks over 4 months

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duration. The physical properties of soybean such as thousand (1000) seed mass, hardness, moisture content, bulk density and seed color were measured and following methods had been adopted to measure these properties.

Determination of moisture percentage: The method identified by [ac 2-41 (14)] American Oil Chemists Society (AOCS) was adapted for measuring moisture content (percentage) of soybean samples. Soybean sample of 10g heated in laboratory oven at 130°C for 3 hours and dry mass of the sample was measured. Accordingly, moisture content of seeds was calculated using the equation (1). It was replicated 3 times.

$$\text{MC (wet basis)} = \frac{\text{W1-W2}}{\text{W1}} \times 100 \qquad (1)$$

W1 = Initial mass
W2 = Final mass
W2- W1 = mass loss

Determination of 1000 seed mass: 10 seeds were selected from the sample and their mass were measured. It was replicated ten times and average mass of 10 seeds was taken. Thousand (1000) seed mass value obtained by multiplying the average mass value of 10 seed by 100. Precision laboratory top loading balance was used to measure the mass of the seed.

Determination of bulk density: Bulk density is defined as the mass of the sample per unit bulk (seed + air space) volume. The volume of laboratory bulk density apparatus was filled by soybean. Mass of filled soybean was measured and bulk density was determined using equation (2). It was replicated three times.

$$\text{Bulk Density} = \frac{\text{Mass of the sample}}{\text{Total voume of bulk density apparatus}} \qquad (2)$$

Determination of seed hardness: A compression test was carried out to measure seed hardness (yield stress). The Instron, TA, XT2 texture analyzer has been adapted to perform a compression test. Force at rupture was considered as the seed hardness. Three replicate were considered for each measurements and the measured compression force was averaged.

Determination of seed color: Soybean seed color was measured by using Mini-scan XE plus Hunter Lab Colorimeter. Hunter scale 'L' 'a' 'b' values were measured. 'L' stood for lightness (black=0, white=100), '*a*' represented for greenness and redness (+*a*, redness; -*a*; greenness), 'b' indicated blueness and yellowness (-*b*, blueness; +*b*, yellowness).

Statistical analysis: Analysis of Variance (ANOVA) on complete randomized design (CRD) by General Liner Model (GLM) procedure was performed. Treatment mean were separated by Duncan Multiple Range Test (DMRT) and each treatment were replicated three times. Minitab statistical package was used for analyzing the data.

RESULTS AND DISCUSSION

Moisture content (MC): Initial MC of Pb-1 was 13.58% and the final MC after 14th week was 12.51% therefore, moisture loss was 1.07% and that of PM-13 was 11.70% and the final MC after 14th week was 11.30% so, moisture loss was 0.57% (Fig 1). MC of Pb-1 showed significant reduction in comparison to PM-13 as well, initial MC was high in Pb-1in comparison to PM-13, therefore Pb-1moisture removal was higher than PM-13. Generally, MC remove or gain until it become equilibrium with environmental moisture under ambient conditions.

Thousand seed mass (TSM): The 1000 seed mass of Pb-1 loosed 20.53g from 163.6g to 143.07g and seed mass loss of PM-13 was 13.33g from 145.5g to 132.17g (Fig 2) during experiment time. The 1000 seed mass loss of Pb-1 was greater than PM-13 because, Pb-1 has observed high initial MC in comparison to PM-13. But 1000 seed mass was changed significantly in both verities due to dry matter alteration during storage period. Moisture contribute to seed mass therefore, moisture removal caused to seed mass loss however, seed mass mainly changes due to dry matter alteration. Dry matter of seed altered mainly due to seed's respiration and disease, insect & pest attack. (Tavakoli *et al.*, 2009; Altuntaş and Demirtola, 2007).

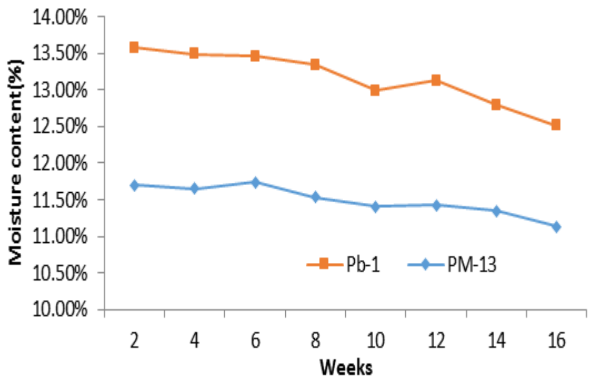

Fig 1: Change of moisture content of Pb-1 and PM-13 varieties.

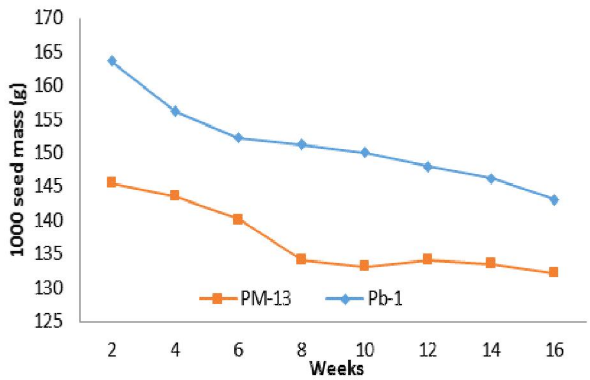

Fig 2: Change of 1000 seed mass of Pb-1 and PM-13 varieties.

Bulk density (BD): BD is important physical property to determine storage space requirements. The bulk density of Pb-1 increased by 18.23kgm^{-3} from 775.28kgm^{-3} to 793.51kgm^{-3} and that PM-13 increased 8.75 kgm^{-3} from 797.64kgm^{-3} to 806.39kgm^{-3} (Fig 3). Bulk density of PM-13 was greater than Pb-1 because, when comparing volume of these two varieties, PM-13 volume was less due to less MC than Pb-1. Seed volume reduction was directly proposal to seed MC removal (Deshpande *et al.*, 1993; Altuntaş and Demirtola, 2007). Higher BD change was observed in Pb-1(18.23 kgm^{-3}) in comparison to PM-13 (8.75 kgm^{-3}) due to higher volume decreasing (high moisture loss 1.07% WB) in Pb-1. However, the BD was changed significantly in both varieties with time. Deshpande *et al.*, (1993) showed, the bulk density of soybean increased from 644.4 to 749.1 kgm^{-3}, as moisture content decreased from 14.20% to 10.37% (dry basis).

Seed hardness (HD): Seed hardness can be defined as maximum tolerable force; seed can withstand without breaking (force at rupture). The hardness of Pb-1decreased till 6th week and then start increasing from 45.1N to 60.7N and that of PM-13 decreased till 8th week and then start increasing from 39.4N to 61.8N (Fig 4). Seed hardness changed significantly in both varieties with storage time. The hardness was inversely proportional to seed MC therefor, decreasing seed moisture caused to increase hardness. The lower rupturing forces were observed at higher moisture contents. (Tavakoli *et al.*, 2009; Altuntaş and Demirtola, 2007). Isik, (2007) pointed out that increasing of seed hardness, affected for seed processing requirements.

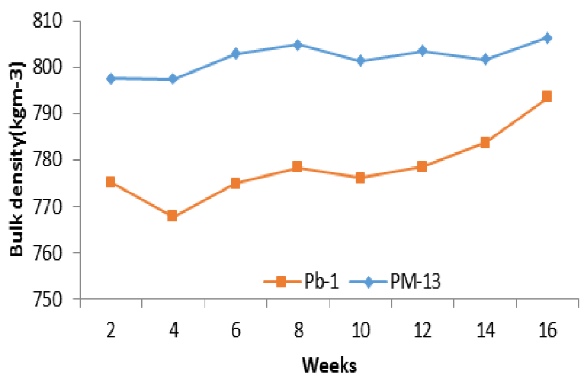

Fig 3: Change of bulk density of Pb-1 and PM-13 varieties.

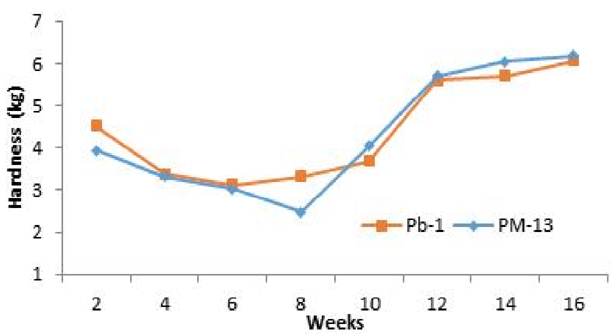

Fig 4: Change of seed hardness of Pb-1 and PM-13 varieties.

'L' color value: It was clear from the results (Fig 5) that the 'L' value did not change significantly in two varieties with storage time. 'L' value was nearly similar in both varieties on 14th week. This results indicated that change of seed lightness/brightness was minimum during storage time.

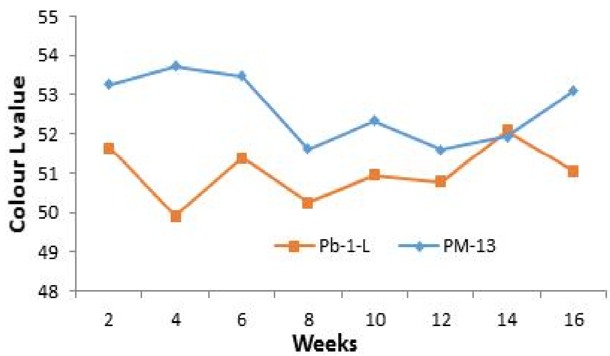

Fig 5: Change of L colour value in Pb-1 and PM-13 varieties.

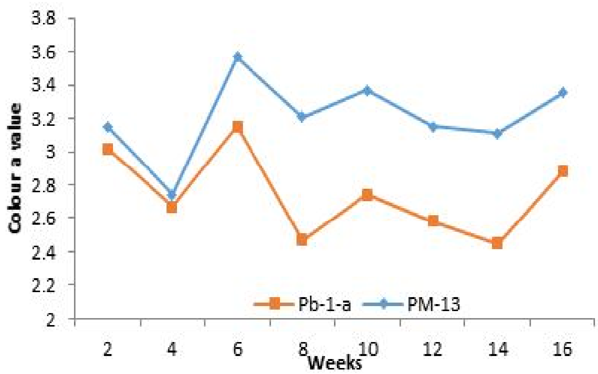

Fig 6: Change of 'a' color value of in Pb-1 and PM-13 varieties.

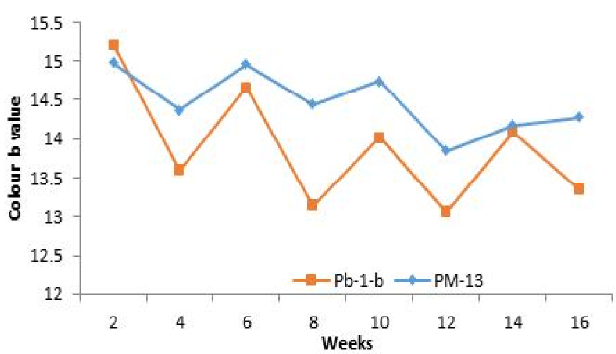

Fig 7: Change of 'b' color value in Pb-1 and PM-13 varieties.

Table 1: The results of multiple mean comparison of initial (1st week) and final (16th week).

	MC %		TSM (g)		BD (kgm^{-3})		HD (kg)		Color 'L'		Color 'a'		Color 'b'	
	Pb1	**PM13**	**Pb1**	**PM13**	**Pb1**	**PM13**	**Pb1**	**PM13**	**Pb1**	**PM13**	**Pb1**	**PM13**	**Pb1**	**PM13**
Initial	13.6^{a}	11.7^{a}	163.6^{a}	145.5^{a}	775.3^{a}	797.6^{a}	4.5^{a}	3.9^{a}	51.6^{a}	53.3^{a}	3.1^{a}	3.15^{a}	15.2^{a}	15.0^{a}
Final	12.5^{b}	11.3^{a}	143.1^{b}	132.2^{b}	793.5^{b}	806.4^{b}	6.1^{b}	6.2^{b}	51.5^{a}	53.1^{a}	2.9^{a}	3.17^{a}	13.3^{b}	14.1^{b}

[a]Columns having same letter are not significantly difference at α = 0.05 by DMRT.

'a' colour value: Initially *'a'* color value of both varieties was nearly equal however, it become unequal after 4th week (Fig 6). The gap between two curves increases from 6th week however, after 8th week the difference between curves remaining same until 16th week. Further, *'a'* color value was not changed significantly in both varieties during storage time. *'a'* colour value represented for greenness and redness (+*a*, redness; -*a*; greenness) accordingly, +*a* value indicated that seed colour closer to red colour than green.

'b' colour value: The -b indicate blueness + b indicates yellow color. Seeds are yellow + b value prove it. The 'b' value variation almost same between two varieties, during storage duration (Fig 7). However, 'b' value has significantly reduced for 4 months' storage period it indicated that yellow color of the seeds was reduced significantly in both varieties with storage time.

Table 1 shows the results of DMRT. MC of Pb-1 showed significant reduction in comparison to its initial MC. High initial MC was observed in Pb-1 compare to PM-13. Final values of 1000 seed mass, seed hardness and bulk density were significantly changed in both varieties in comparison to their initial values. The *'b'* color value was significantly altered during storage time. However, 'L' and 'a' color values were not changed significantly with storage time.

CONCLUSION

It can be concluded that hardness, bulk density and 1000 seed mass changed significantly within the storage period at $P<0.05$. Hardness and bulk density of seeds increased with storage time while 1000 seed mass and moisture content decreased with time in both varieties. However, MC did not change significantly in PM -13 due to its low initial MC. The 'L' and 'a' color value in two varieties did not significantly change with time, however, 'b' color value changed significantly during storage. It indicated that yellow color of seed reduced with storage time. Finally, it can be concluded that most of physical properties of soybean were changed during storage time, therefore, these changers need to be taken into account during storage because they directly reflect to product quality.

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