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Seed Viability and Oil Content of Castor Bean (*Ricinus communis* L.) as Affected by Packaging Materials during Storage

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Abstract

The use of a good and approviate packaging material can maintain seed quality during storage. The research aims was to investigate the effect of some packaging materials on the seed viability and oil content of castor bean (Ricinus communis L.) during 12 months storage. The seeds were stored under room conditions using three different packaging materials, namely polypropylena plastic, rami (jute), and goni (cloth) bags. Samples were drawn monthly for seed viability test, water and oil content. The results showed that seed viability and oil content decreased during storage in all packaging materials. The best packaging material for better seed viability and oil content was polypropylena plastic bag. The bag still could maintain the seed viability above 80% after 12 month storage.

Keywords: ageing, quality, germination, vigour

1. Introduction

Castor bean (*Ricinus communis* L.) is a non-edible oil seed crop with enormous significance. Uniform seedlings establishment is dependent on the rate of germination and germination percentage of the seeds, seed physiological conditions, seeds storage time, and the present of pathogens. For biodiesel purposes, seed oil content is also an important consideration (Tiwari *et al*. 2007). Although seed quality is generally determined by geneticand physiological factors, and physical attributes of the seeds, harvesting and handling process, seed storage also should be considered. Simic *et al*. (2007) reported that, pests and diseases infection, seed oil content, seed moisture content, mechanical damage, seed longevity, packaging, pesticides, air temperature and relative humidity are responsible for quality decline in seed under storage.

The success of packaging is determined by packages materials and packaging techniques. Plastic (polythene and polypropylen) bags and jute fibers, rami, and plastic bottles are widely used for storing seeds. Good and approviate packaging materials enable to maintain the quality and viability of seed for a long period of time. Hasnam and Mahmud (2006) stated that *Jatropha* seeds stored in a plastic bag at a temperature of 16 ^{O}C could be maintained the viability at 80% but was reduced by 50% under unfavorable conditions. Proper storage could mantain the quality and oil content of castor seeds for at least one year (Sangwan *et al*. 1992).

Some packaging materials are commonly used for storing seeds, but their suitability depends on the kind or type of seeds and their protection ability to the seed in storage. This article described the effect of common used packaging material and storage period on the castor seed viability and oil content.

2. Materials and Methods

Materials

A laboratory and glasshouse experiment was conducted from November 2011 to December 2012. Castor seed of *Beaq Amor*, a local variety of West Nusa Tenggara, Indonesia was collected from standing trees on a dryland experimental field of Faculty of Agriculture, University of Mataram, Indonesia. The climate of the seeds source was characterized by an annual precipitation of 600 to 1,000 mm and a temperature of 25 to 35^{o}C. Seed samples were taken from the main and primary spikes with 75% of fruit maturity, and harvested manually, and then extracted. To reduce the moisture content, the seeds were then air-dried for 3 days. The seed moisture content after drying was around 6.15%.

Collection, Packaging, and Storing of the Seeds

After drying to 6 - 6.5% moisture content, as much as 2 kg of the seeds were placed in a polypropylen (PP), rami, and goni bags, and then stored for 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 months under ambient room conditions. Three bags of samples were drawn from each packaging material at the end of each month for determination of seed viability, water, and oil content. Three replicates were used for each bag of treatment. The storage room temperature and relative humidity were measured using a portable thermohygrometer.

The range of ambient temperature and relative humidity of the storage room was presented in Table 1. In brief, the temperature ranged from 26.1 to 30.2 °C, and the humidity ranged from 71.4 to 83.1%. The condition of the storage room was relatively steady during the storage period.

Figure 1: Castor seeds in Plastic Polypropylen (left), rami/jute (centre), and goni/cloth (right) bags

Working Samples and Variables Determination

Sample about 100-150 g of seeds was derived from each seed sack and was taken monthly for the determination of seed viability (number of germinating seeds and germination rate), water content, and oil content. The initial seed viability, water content, and oil content were determined and recorded before packaging the seeds.

Seed viability (percentage of germination and germination rate) was determined by germinating 100 seeds in plastic container containing sterilized soil-sand (1:1 v/v) under greenhouse conditions. The media was kept moist by routine watering. Daily germination counts was taken and recorded up to 15 days (time after which no seed was observed to germinate) and categorized into normal and abnormal seedlings. Seed water content was determained every month using the standard hot air oven method at 105± 1^{O}C for 24 hours (Pradhan *et al.*, 2009). Seed oil (lipid) content was determined using the Soxchlet extraction method (AOAC, 1999) with hexane as the solvent. The extracted lipid was obtained by filtrating the solvent using a rotary evaporator apparatus at 40^{O}C followed by heating in an oven at 105^{O}C for three hours to evaporate any remaining solvent and water.

Statistical Analysis

Analysis of Variance was applied to test the variation among different sack and storage period through seed viability, seed water content, seed oil content, and other characteristics. Least Significant Difference (LSD at 5% level) was also subjected on significant findings.

3. Results and Discussion

Packaging materials exerted significant effect on the castor seed viability throughout the storage period. Castor seeds viability in response to different packaging material during storage was shown in Table 2, 3, and 4.

Tables 5 and 6 showed the seed water content and kernel seed oil content respectively. Castor seed viability decreased with the increase of storage time in all three packaging materials. Similarly, seed oil content decreased slightly.

Initially, seed viability was low, with 79.6% of seed germination (Table 2), germination rate was 8.4 days (Table 3), and percentage of abnormal germinating seeds was 13.1% (Table 4). Then, the seed viability increased after storage and this was due to seed dormancy phenomenon. However, from those three tables showed that as the storage time increased, there were decrease in seed viability.

Seed germination was significantly affected by packaging material after storage (Table 2). Seed germination decreased with an increase in length of storage time in all materials of packaging. The germination results elaborated in Table 2 also showed that seeds storaged in polypropylena plastic had higher germination, compared to the other two packaging materials. Polypropylena bag still could maintain the seed germination above 80%, a minimum seed certification standard, while jute bag was only for 8 months, and cloth bag was only for 3 months.

Table 3 showed that there was no significant difference among packaging materials on germination rate during the first three months of storage. In the following months, however, it was significantly affected by packaging materials until 12 months of storage. Polypropylena plastic bag showed as a better packaging material for maintaining the seed germination and germination rate up to 12 months of storage periode.

There was a significant difference in the percentage of abnormal seedling among different packaging materials during 12 months of storage (Table 4). The best packaging material for maintaining the seed viability during storage was recorded in polypropylena plastic bag, 85% of seed germination and 10% of abnormal seedling.

Table 5 showed that, there was a significant difference in seed water content among different packaging materials during the last two months. Eventhough the ambient room conditions were relatively steady during the storage period (Table 1), but the different in packaging materials could affect on seed water content. From the results of the 12 months storage in which the seed oil analyses of the seed samples were carried out, it could be inferred that, there was a significant effect of the packaging materials on the seed oil content (Table 6). Air space on the packaging using jute and cloth would easily fit into the package that would be easy to affect the seed moisture, which would likely lead to an increase in moisture of the seeds saved.

This study showed that, polypropylene plastic bag was the most effective in maintaining the viability of castor seed compared to the other two packaging materials with 85.1% of power of germination, 10.1 days of germination time, and 10.6% of abnormal seedlings. This impermeable container prevented the seed to absorpt moisture from the surrounding air, which helped them to maintain the lower seed moisture content during the 12 months of storage period. This was an evident that polypropylena plastic bag acted as a moisture proof barrier, then resulted in lower respiration rate and metabolic activity, and maintained the higher seed vigour during storage.

Similar observations was recorded by Ginwal *et al*. (2004) in *Jatropha curcas* seed, and the present study in line with reports of Owolade *et al*. (2011). Seeds packed using material allowing surrounding air humidity to be absorbed, the moisture content will increase until the equilibrium moisture content is reached. As seed water content increases, the rate of deterioration also increases, and storage life will get shorter. However, these results were not in agreement with the findings of Rai *et al*. (2011), that corn seeds stored in jute bags enhanced the storage life, as compared to that in plastic sacks. The main reason was the development of fungus in seeds stored using goni (jute) sack. This sack material allows surrounding humidity to increase the seed moisture content which is a suitable environment for fungus to grow and develop easily. As a result, the seed viability reduce quickly and significantly.

ADRA (2004) documented that poor storage coupled with diseases infection and resulted in the loss of germination in *J. curcas* seeds. The seed germination falling below 50% within 15 months of storage was also reported by Ginwal *et al*. (2004). In their storage experiment, the seeds infected by *Aspergillus* spp. lost germination capacity within six months when stored at 85% humidity and 30^{o}C of temperature. Uninfected seeds, however, still had high germination percentage (95%) as reported by Neergaard (1979). FAO (1981) reported that disease pathogens were sometimes responsible for the loss of germination in storage seeds.

Similarly reported by Jayaraman *et al*. (2011) that, under a commercial grain storage, fungi were the primary cause of seeds deterioration which was depicted by loss of germinability, decreased in dry matter, increased fat acidity, grain heating, and ultimate sprouting. Anjorin *et al*. (2011) also added that seed-borne pathogens were major factors reducing seed vigour.

Seeds packed using cloth and jute bags were influenced by air movement resulting in moisture condensation and also mould spoilage. On the other hand, using polypropylena plastic bag, the relative humidity around the seed were relatively stable and mantained the seed water content lower than those of seeds packed using jute and cloth bags. Cheema *et al*. (2010) reported that low moisture content reduced respiration and deterioration, and thereby improved stored seed quality. Seed is a hygroscopic material, so then, seed viablity will decline depends on high relative humidity and temperature of the environment in which the seed stored. Seed packing using jute bag (likely open space) would result in rapid seed deterioration due to fluctuations in temperature and humidity. Therefore, the seeds need to be packed with a proper packing material in order to maintain the seeds viability and vigor.

It was also showed that there was a decrease in seed oil content during the 12 months storage period (Table 6). Akowuah *et al*. (2012) reported that the seed ageing process naturally was affected by seed oil content, which was a sensitive factor through oxidation processes. Seeds with hard coat, such as castor seeds, prevented oxygen and moisture enter the seeds leading to autoxidation of linoleic and linolenic acids which are responsible for degradation of cellular organelles (Cantliffe, 1998). In addition, Basra (2006) stated that, the metabolism of seed during storage to provide energy for its physiological activities could be another reason of seed oil decreation during storage.The result observed in this study was in agreement with Akuwuah *et al*. (2012) showing that during a period of three months storage of *J. curcas* seeds, the seed oil content gradually decreased with increasing in storage time. Ginwal *et al*. (2004) reported that *Jatropha* seeds could not be stored for long periode and the germination fell below 50% in 15 months of storage, due to their high oil content. The seed oil content can affect seed germination and consequently storage life. Bankole *et al*. (2005) stated that melon seed was difficult to be stored because the seed germination and vigour deteriorated quickly in storage due to the high seed oil content. Similar observations made by Simic *et al*. (2007) indicated that seed longevity was affected by seed oil content due to a noticeable decrease and deterioration in stored seed oil content, and thus affected seed quality, particularly germination.

4. Conclusions

Packaging materials affected on the seed viability of castor during storage. Seed viability and oil content decreased with increasing storage time in all packaging materials. Polypropylena plastic bag preserved seed viability and oil content better than that when stored in cloth and jute bag. The bag still could keep the seed viability above 80% after 12 month storage period.

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Table 1: The Room Temperature and Relative Humidity During Storage

Storage Period (month)	**Temperature (^oC)**	**Relative Humidity (%)**
0 – 1	26.5 – 28.5	72.2 – 80.7
1 – 2	26.1 – 28.7	75.1 – 83.1
2 – 3	26.3 – 29.6	75.5 – 81.8
3 – 4	26.7 – 29.6	73.4 – 80.7
4 – 5	26.4 – 29.9	72.6 – 80.8
5 – 6	26.3 – 29.6	71.4 – 80.7
6 – 7	27.1 – 30.2	72.3 – 81.5
7 – 8	27.3 – 30.1	72.4 – 81.8
8 – 9	26.8 – 29.8	72.1 – 82.2
9 – 10	26.9 – 29.8	73.1 – 81.8
10 – 11	27.2 – 29.9	73.3 – 81.6
11 – 12	27.2 – 30.1	73.4 – 81.5

Table 2: Seed Germination at Different Packaging Materials during Storage

Packaging	Storage Period (month)						
	0	1	2	3	10	11	12
			..... %				
Sack of polypropylena	79.6	90.5 a	92.4 a	91.8 a	89.7 a	87.4 a	85.1 a
Sack of rami/jute		84.2 ab	87.7 ab	85.1 ab	80.1 b	76.8 b	71.9 b
Sack of goni/cloth		79.8 b	81.2 b	78.3 b	72.6 b	71.2 b	68.7 b
LSD 5%		7.44	6.82	7.76	8.83	7.52	9.33

Note: numbers in the column with the same letter did not differ significantly at P≤0.05

Table 3: Germination Rate at Different Packaging Materials during Storage

Packaging	Storage Period (month)						
	0	1	2	3	10	11	12
			..... days				
Sack of polypropylena	8.4	6.6	6.9	7.1	9.8 b	9.6 b	10.1 b
Sack of rami/jute		6.9	7.3	7.5	11.5 ab	12.7 a	14.2 a
Sack of goni/cloth		7.2	7.7	7.6	13.4 a	13.9 a	15.6 a
LSD 5%		ns	ns	ns	2.21	2.06	3.43

Note: Values in each column followed by similar letter are not significantly different at P≤0.05 according to Least Significant Difference Test. ns = non significant difference

Table 4: Percentage of Abnormal Seedling at Different Packaging Materials During Storage

Packaging	Storage Period (month)						
	0	1	2	3	10	11	12
			..... %				
Sack of polypropylena	13.1	8.5	9.2 a	9.6 a	9.9 b	10.8 b	10.6 b
Sack of rami/jute		10.1	12.6 b	13.8 b	14.7 a	14.8 a	14.2 a
Sack of goni/cloth		11.6	14.1 b	16.9 b	17.2 a	16.9 a	16.6 a
LSD 5%		ns	3.12	3.36	3.82	3.77	3.41

Note: Values in each column followed by similar letter are not significantly different at P≤0.05 according to Least Significant Difference Test. ns = non significant difference

Table 5. Seeds Water Content at Different Packaging Materials During Storage

Packaging	Storage Period (month)						
	0	1	2	3	10	11	12
			..... %				
Sack of polypropylena	6.15	5.62	5.77	5.86	5.77	5.62 b	5.13 b
Sack of rami/jute		5.64	5.78	5.77	6.21	6.92 a	5.86 a
Sack of goni/cloth		5.85	5.63	5.72	6.07	6.87 a	5.91 a
LSD 5%		ns	ns	ns	0.52	0.87	0.65

Note: Values in each column followed by similar letter are not significantly different at P≤0.05 according to Least Significant Difference Test. ns = non significant difference

Table 6. Kernels Oil Content at Different Packaging Materials During Storage

Packaging	Storage Period (month)						
	0	1	2	3	10	11	12
			..... %				
Sack of polypropylena	59.47	64.49	68.63 a	61.45 a	62.76 a	61.54 a	61.22 a
Sack of rami/jute		64.24	65.33 a	58.98 ab	55.17 b	53.42 b	52.13 b
Sack of goni/cloth		60.59	57.48 b	57.91 b	54.65 b	52.84 b	52.02 b
LSD 5%		ns	3.83	3.34	3.05	4.28	4.12

Note: Values in each column followed by similar letter are not significantly different at P≤0.05 according to Least Significant Difference Test. ns = non significant difference

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PAGE 1

PAGE 2

PAGE 3

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PAGE 6