

STORAGE STUDIES ON PACKAGED PADDY AND RICE

INTRODUCTION

Rice is one of the major crops and is a staple food for a large section of the population in India in particular and Asia in general. In India, paddy is grown in 44.6 Million hectares and the annual production is around 135 million tons of paddy and around 95 millions tons of milled rice. Generally paddy is harvested at a moisture of around 22%, and dried up to 18%. It is then tempered by keeping in the form of a heap or by covering with tarpaulin for 1 to 3 hrs. During this step, the moisture moves through out the grain uniformly and afterwards it is dried either in shade or in sun. Dried paddy is packed in jute sacks and stored. The present study was undertaken to assess the suitability of storing paddy and raw rice in plastic woven sacks of HDPE (High Density Polyethylene) and PP (Polypropylene). Paddy and rice were also packed and stored in Jute sacks for comparative evaluation.

MATERIALS AND METHODS

Paddy variety viz., Sona – Mahsuri (harvested during Dec. 2003) as well as Sona – Mahsuri rice were procured from a local mill.

Woven sacks of HDPE, PP and Jute sacks were supplied by the Sponsor.

Paddy was packed in all the three type of sacks, each containing 35 kgs and the bags were stitched by a machine, and there were six numbers each. These sacks were placed one above the other, vertically, and in each column, six sacks were placed (Fig 1).



Fig 1. Bulk storage of paddy and rice in different types of sacks

Rice was also packed in similar way, but in this case 50 kg was the quantity in each sack, because of its higher bulk density.

These sacks were placed under ambient conditions at room temperature.

Accelerated Storage

The above paddy as well as rice samples were also stored in 1 kg pack of respective HDPE, PP and Jute sacks whose dimensions were 16.5 x 27 cms. Paddy or rice were filled and the sacks were closed by machine stitching and stored at 38° C and at 90 % RH (Fig 2).

Sample withdrawal

Under accelerated conditions, the samples were withdrawn at the end of 15 as well as 30 days. However in the case of Jute sack, the samples were withdrawn at the end of 8, 15 and 30 days.

In the case of ambient or room temperature stored samples, paddy as well as rice were withdrawn every month. Each sack was opened, and the sample was poured on to an aluminium tray of 3 x 6 x 1 feet, mixed thoroughly, representative samples were taken for the physico – chemical and other analysis like fungal count, DNA finger print and odour pick up from the packaging material. Vibration studies on 50 kg bags of rice in each type of sacks were carried out.

The paddy samples were milled by simultaneous shelling and milling in a McGill sheller cum polisher. The following physico-chemical properties were analysed.

1. Moisture
2. Volume expansion
3. Hydration
4. Swelling & solubility
5. Amylose content
6. Pasting profile or viscography of rice

The details of the analytical procedures are provided in the Annexure.

RESULTS AND DISCUSSIONS

Physical appearance and condition of grains during accelerated studies

I. **Paddy in HDPE Sacks:** After 15 days, initial withdrawal was made and found that the sample was good. But after 30 days, the grains appeared to be spoiled and were not good. The moisture was around 15 %.

Rice in HDPE sacks: As above, after 15 days the rice was good with respect to smell, appearance. But after 30 days musty odour developed, colour of the rice was not normal. There were black spot on the HDPE sack, even rhizopartha insects were noticed and the moisture content was around 17%.

II. **Paddy in PP Sacks:** During the initial 15 days the sample was good. But after 30 days musty odour developed, some grains were whitish in colour, indicating initiation of mold growth. On an average the sample got spoiled.

Rice in PP sacks: After 30 days, there was musty odour, original colour had lost, moisture was around 16 %.

III. **Paddy in Jute sacks:** It is well known that jute absorbs more moisture (R H 90%). Hence, arrangements were made to withdraw samples after 8 days and the moisture was around 15%.

The above explanations are clear from the photographs of accelerated stored sacks as well as the grains (figures 2 & 3).

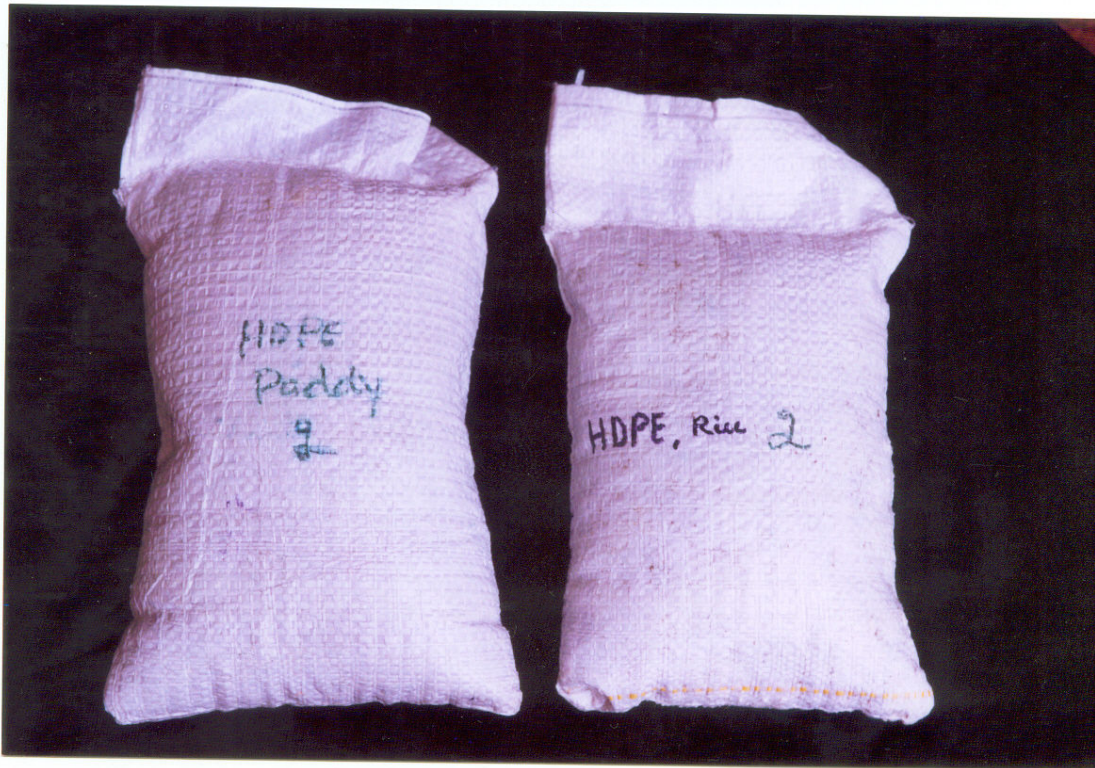


Figure 2. Accelerated stored samples of paddy and rice

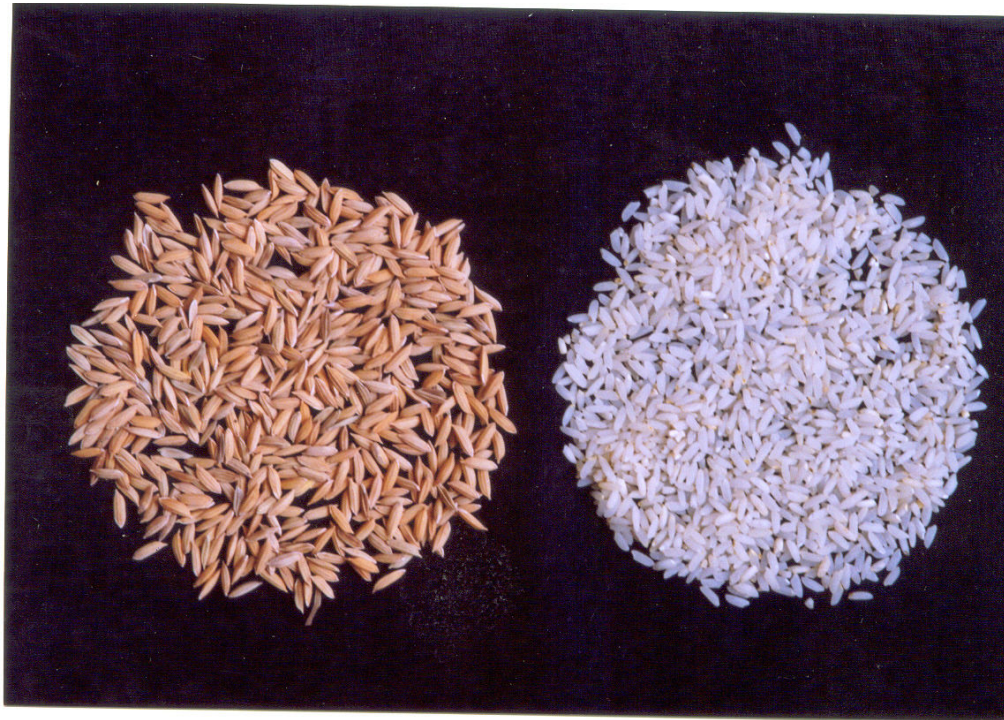


Figure 3. Samples of paddy and rice after accelerated storage

Physical Condition of grains during bulk storage

Initial samples were withdrawn from the surface as well as after opening the sack, making a heap of the stored grains, mixing thoroughly and representative samples were taken and their initial physical condition was noted down. During first month withdrawal, the samples were good and from second month onwards- following observations were made.

Rice in Jute sack : Tribolium , carcera, paddy moth on outside.

Rice in P P sack : Tribolium young insects

Paddy in Jute sack : Paddy moth on outside but no moth inside

Rice in Jute sack : Tribolium population reduced.

Fourth month

Paddy in Jute sack : Flying moth

Rice in P P sack : Different type of insects

Rice In Jute Sack : Tribolium, sitophilus, carcera as indicated by lumps
Formulation

Fifth month

Rice in HDPE sack : Young insects (Sitophilus)

Paddy in HDPE sack : No insects

Rice in P P sack : Young insects (Sitophilus)

Paddy in P P sack : No insects

Rice in Jute sack : Young insects (Sitophilus)

Paddy in Jute sack : No insects

Sixth month

Rice in H D P E Sack :	No insects
Paddy in H D P E sack :	No insects
Rice in P P sack :	Large number of young insects (Sitophilus)
Paddy in P P sack :	Paddy moth
Rice in Jute sack :	Carcera inside, large number of insects (Sitophilus)
Paddy in Jute sack :	Paddy moth

Above data indicate that worst among the sacks are Jute, followed by improvement in the case of PP and the best performance is by HDPE sack. Hence it can be concluded that HDPE is the best sack among the studies made on sacks supplied by the Sponsor.

Volume expansion

Generally on cooking of rice with water, it absorbs water and expands. When old rice is stored, it expands to a greater extent compared to the new rice.

After 15 days of storage in HDPE sacks, the volume expansion of the grains on cooking was 450 ml / 100g which was almost same as initial (Initial value was 448 ml) and rose to 480 ml after 30 days. The corresponding values for PP sacks were 448 and 453 respectively.

However, in Jute sacks the volume expansion did not change much, as the values remained almost same i.e. around 448 ml / 100g after 8 days and remained unchanged after 15 days, inferring no significant changes.

It was observed that volume expansion was always high when the grains were stored as paddy rather than as rice. In these experiments it is seen that HDPE performed better compared to other two types of sacks.

These values are clear from the following Table 1.

Table 1. Volume expansion of rice on cooking of accelerated stored samples

VOL. EXPANSION ON COOKING (ACCELERATED)
 INITIAL: RICE →448ml/100g, PADDY →443ml/ 100g

RICE			PADDY	
SACK/ DURATION	15 DAYS	30 DAYS	15 DAYS	30 DAYS
H D P E	450	480	481	-
PP	453	475	475	-
AFTER 30 DAYS EXPERIMENTS WERE STOPPED				
WITH JUTE SACKS (1KG EACH)				
SACK/ DURATION	8 DAYS	15 DAYS	30 DAYS	
JUTE - RICE	455	455	SPOILED	
JUTE - PADDY	459	466	460	

It is seen that the expansion is more when stored as paddy.

Hydration studies at room temperature

Generally hydration of rice is fast in the first sixty minutes. The initial moisture content of 10% increased to 15%, 19%, 26.8 % and 26.8% in 3, 10, 20 and 30 minutes respectively. It stabilized after 30 minutes. At the end of 24 hours, the moisture was around 27%. This behaviour was found to be common for rice packed in all three types of sacks, viz., HDPE, PP and Jute. It was observed that there were no significant differences in the hydration power of samples stored in three types of sacks. These data are seen clearly from Figure 4.

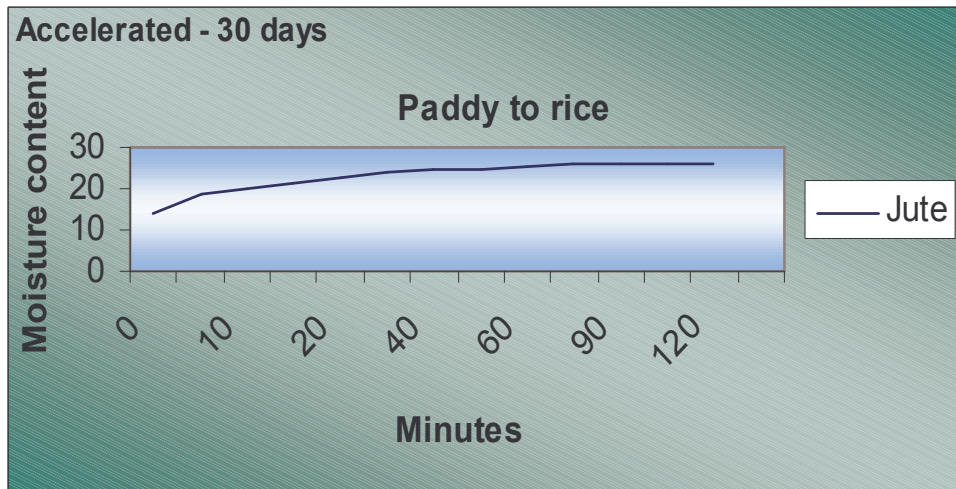
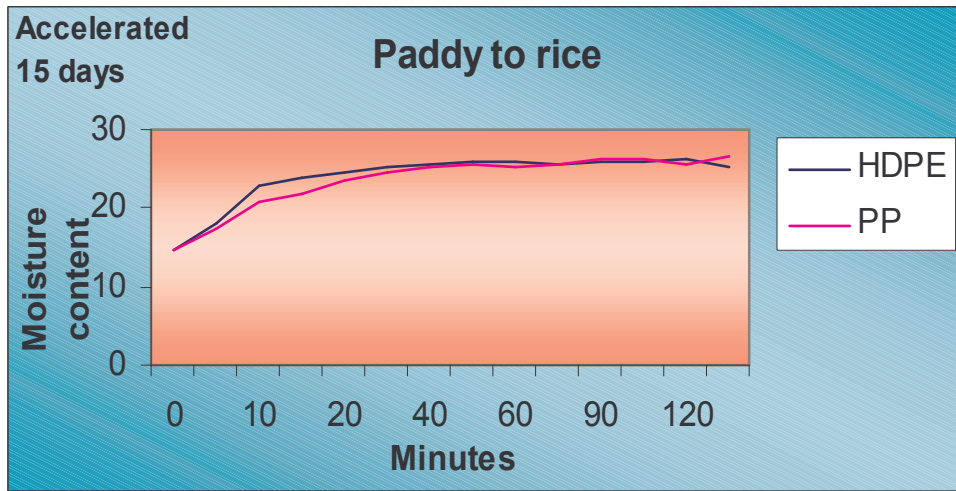
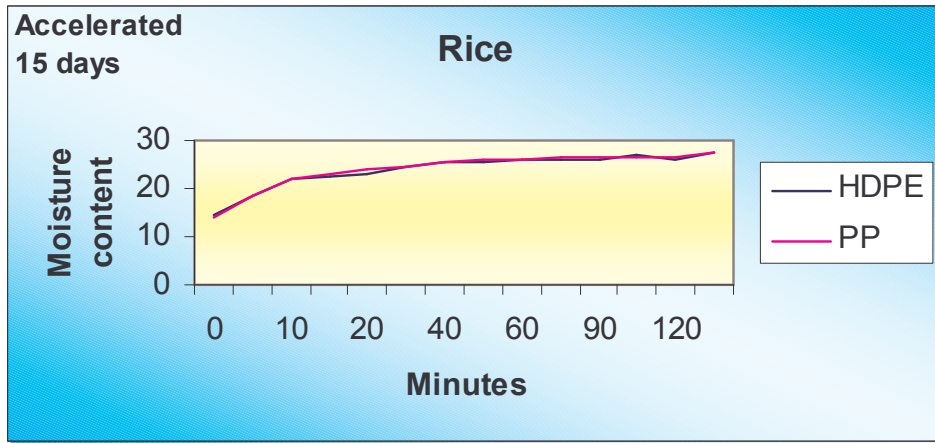


Fig 4. Hydration of rice, paddy to rice at room temperature in different sacks

Swelling and solubility

When rice grains are cooked, they slowly absorb water and swell and at the same time some leaching of starchy materials takes place, which is termed as solubles from the cooked grains. In other words it is called as the gruel. This gruel may be thick or thin depending on the age of the rice. This phenomenon is expressed as swelling and solubility of the grains on cooking.

Initially the swelling powers of rice samples were observed to be 4 at 60⁰ C and rose to 18 at around boiling. Similarly, the solubility was observed to be 2 at 60⁰C and increased to 16 at boiling water temperature (Fig 5).

Rice samples stored for 15 days in HDPE sacks showed that the swelling power increased from 4.5 at 60⁰ C to 19 at ~98⁰ C, solubility from 0.3 % at 60⁰C to 16 % at ~98⁰ C.

Swelling power of rice samples stored in PP sacks for 15 days was found to be 5 at 60⁰ C and increased to 17 at boiling water temperature. The corresponding values for solubility were around 2 % and 15 % respectively. This pattern was found to be similar to that of paddy samples stored in PP sacks.

These results have shown that no significant differences in swelling and solubility were observed amongst PP and HDPE woven sacks. Similar trend was observed in rice samples packed in jute sacks (Fig 5).

After 15 days of storage in Jute sacks the experiment was stopped as the samples got spoiled. After 30 days, rice in HDPE and PP sacks also got spoiled because of high humidity and high temperature. Hence studies were stopped after one-month storage under accelerated conditions.

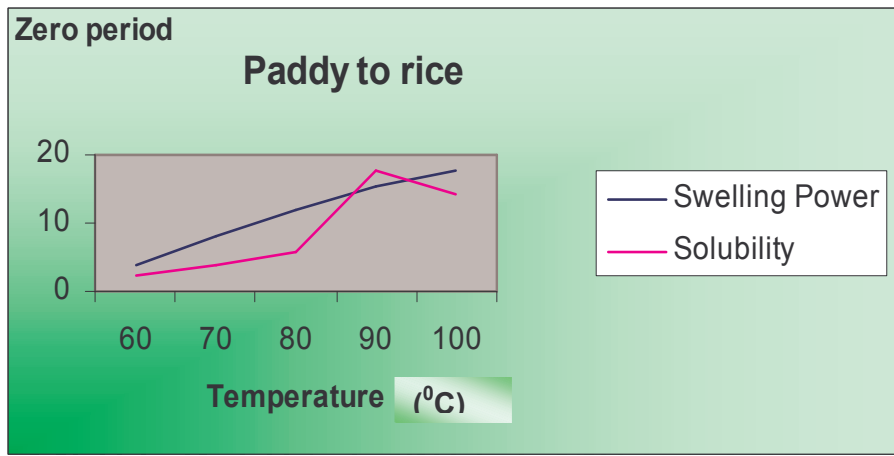
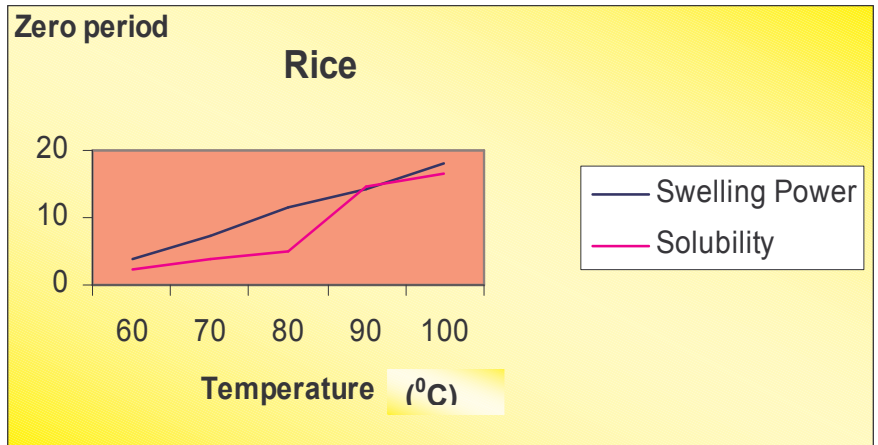


Fig 5. Swelling and solubility of rice, paddy to rice at different temperatures

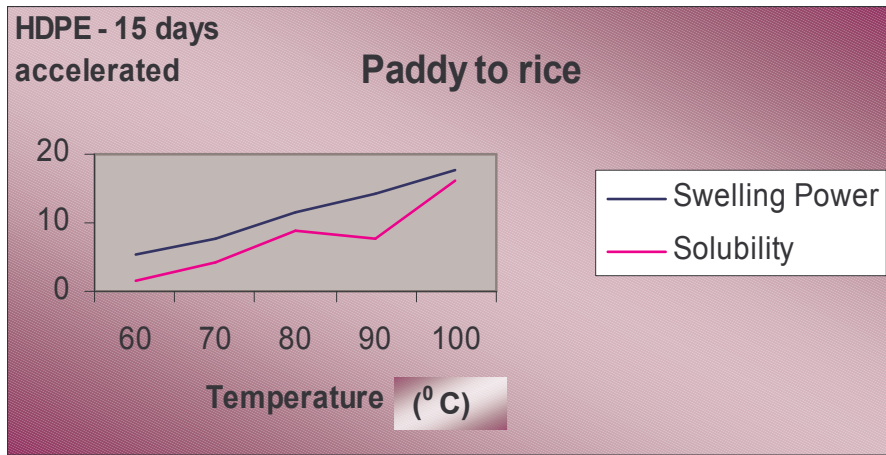
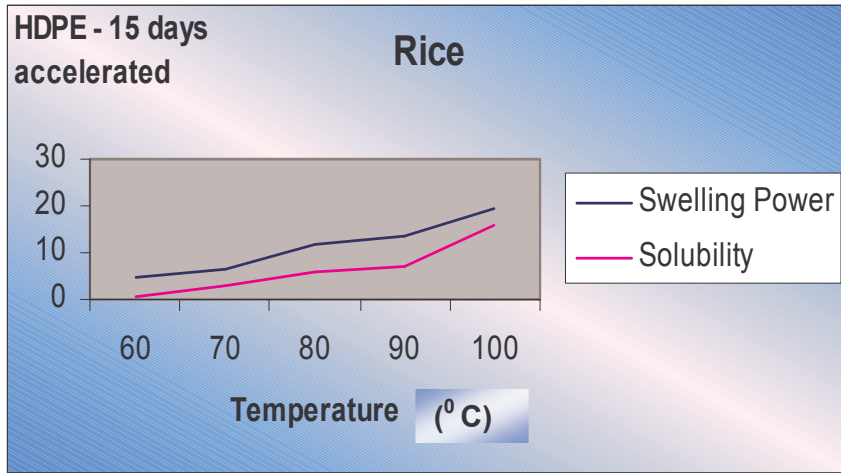


Fig 5. Swelling and solubility of rice, paddy to rice at different temperatures

Physico-chemical properties of bulk packed rice stored under ambient (Room temperature) conditions.

Moisture content of the representative samples

At the end of 30 days of storage, the surface paddy (close to the surface of sack) showed a moisture content of around 9%, representative sample had shown an average 10% in all the three types of sacks (Table 2). After 60 days both surface and representative samples showed around 10% moisture. After 3rd and 4th month the moisture rose to $11.5 \pm 0.3\%$ in surface and $11.3 \pm 0.2\%$ in the representative samples and $11.7 \pm 0.3\%$ and 11.5% respectively. At the end of six months the surface sample showed $12.3 \pm 0.2\%$ and $\sim 12.5\%$ moisture content in representative samples. Results indicate that in all types of sacks the moisture of grains varied from 11 to 12.5%, showing differences in the first month of storage. Later on the differences came down indicating the attaining of equilibration by the sample with the environment.

Table 2: Moisture content in % (w.b) of surface and representative paddy and rice samples when stored in different types of sacks

		SURFACE		REPRESENTATIVES	
PERIOD	SACK	RICE	PADDY	RICE	PADDY
30 DAYS	HDPE	9.3	8.6	9.4	10.2
	PP	8.8	9.0	9.9	9.2
	JUTE	9.3	8.7	9.8	10.2
60 DAYS	HDPE	11.8	10.0	10.0	10.0
	PP	10.7	10.4	10.2	9.8
	JUTE	10.8	9.8	10.4	10.3
90 DAYS	HDPE	12.0	11.0	11.5	11.4
	PP	12.0	11.0	11.3	11.3
	JUTE	12.2	12.0	12.1	-
120 DAYS	HDPE	12.9	12.6	12.1	-
	PP	12.9	11.4	11.5	11.5
	JUTE	13.6	11.1	-	-
150 DAYS	HDPE	12.5	11.9	11.4	11.6
	PP	12.7	12.2	12.0	11.6
	JUTE	12.9	11.4	12.5	11.9
180 DAYS	HDPE	12.9	12.4	12.7	12.2
	PP	12.8	12.6	12.4	12.4
	JUTE	13.9	11.9	13.5	11.5

Hydration studies

In the case of rice obtained by milling of stored paddy the value at zero period increased from 11% to 19%, (in which about 8% increase in moisture was noticed) in 3 to 10 minutes duration. Afterwards the increase was nearly 4%, which almost stabilized with the increase in hydration period.

Generally the hydration of rice is fast in the first hour. The initial moisture content of 10%, increased to 15%, 19%, 26.8% after 3, 10, 20 and 30 minutes respectively. Afterwards it stabilized at 30 minutes. At the end of 24 hours, the moisture rice was only 0.2% reaching final moisture to 27%.

The pattern was almost same in different types of sacks, as there were no significant differences in hydration. Significant differences were noticed only from zero to 3 and 10 min. Very little increase was seen at the end of 6 months, and the pattern remained almost same.

Almost same values were observed in stored paddy. The result indicates the type of packaging materials did not affect hydration properties. These data are clear from the following Figure 6, where the hydration curves remains same for all types of sacks.

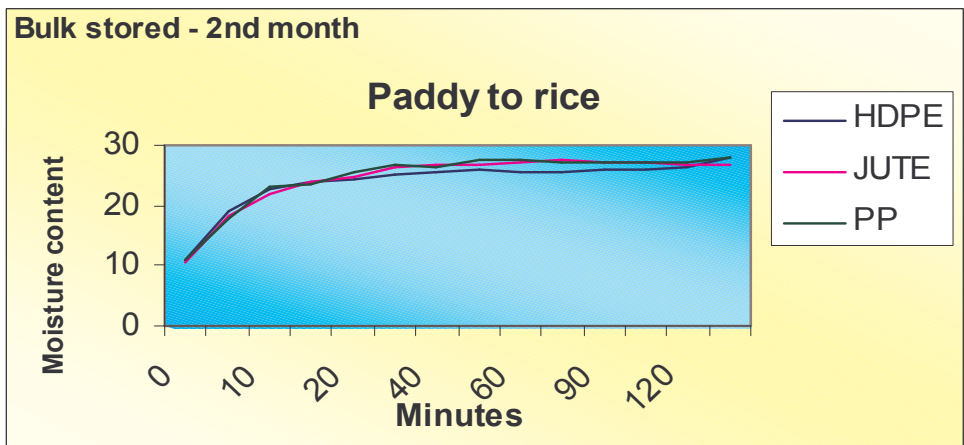
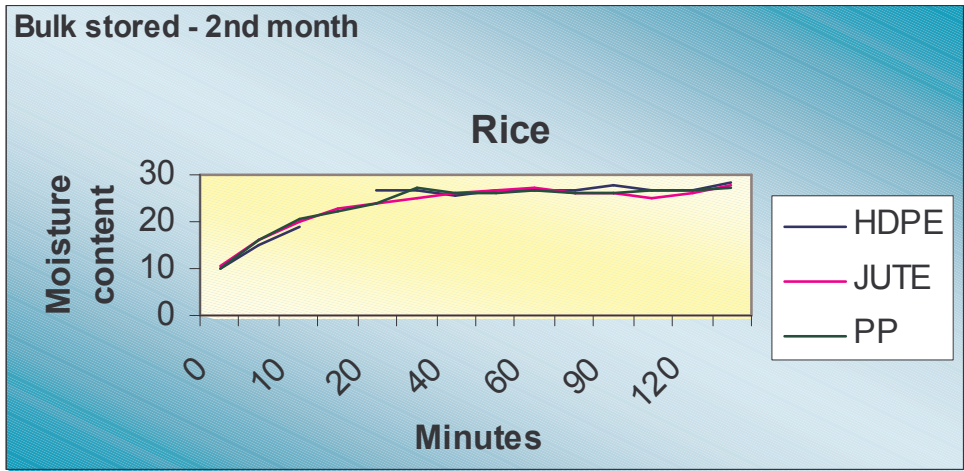


Figure6: Hydration of grains of bulk stored one

Volume expansion

Generally on cooking of rice with water, rice grains attempts to swell and expand. When old rice is cooked, it swells more and expands more compared to the new rice.

When paddy was stored in HDPE sack, during first month the value was similar to the initial. The volume increased gradually and at the end of six months the volume was 471, which is an indication of ageing phenomenon. Similarly in the case of PP sack the volume increased from 440 ml/100 g to 470 ml/100g at the end of six months. The storage effect was seen only up to second month, and subsequently the effect was less pronounced. However in the case of jute sack, the volume after a month was 435 ml/100g, which enhanced to 460 ml/100g after 2 months and slowly rose to 468 ml/100g after six months storage (Table 3).

Rice packed in HDPE sacks and stored for one month was found to have a volume expansion of 455 ml / 100g, and it was 465 ml / 100g after storing for six months. Corresponding values for rice in PP and Jute sacks were found to be 448, 465; 453 and 450 ml / 100 g. respectively. The results indicate the good performance by HDPE followed by PP woven sacks and in Jute sack much differences were not noticed. It was also observed that volume expansion was always high when the grains were stored as paddy rather than as rice.

Table 3: Volume expansion of rice on cooking of bulk rice samples

VOLUME EXPANSION IN BULK STORED SAMPLES

INITIAL VOLUME EXPANSION: 450 ml / 100 g

RICE						
SACK/PERIOD	I	II	III	IV	V	VI MONTHS
HDPE	455	450	458	459	457	465
PP	448	453	461	465	456	465
JUTE	453	453	449	453	450	450
PADDY						
HDPE	440	458	458	459	464	471
P P	440	460	468	468	470	470
JUTE	435	460	465	474	462	468

Volume appears to be little high when rice is stored as paddy and used. Volume is high in HDPE as well as PP compared to jute

Swelling & solubility

Swelling and solubility are important properties of starch in specific, flour in general. Swelling power is always less at 70°C and it slowly rises as the temperature increases. From 70°C to 80°C, the swelling power changed from 6.7 to 10.3 in HDPE, PP and Jute sacks. This further increased to 10.34 and then slowly up to 12 or 15. This behaviour was same for paddy in all the three types of sacks. At boiling water temperature the swelling power was 15.16. These values increased with storage; after 4th month the value at boiling water temperature was 18 and the same trend was followed till six months.

Solubility was minimum at 70°C, it rose to 4 to 5% at 80°C, 7 to 9% at 90°C and 18 to 20% at boiling water temperature at the end of six months. Here also we could not point out the exact differences between different sacks. Samples in all the three sacks had almost same solubility. The studies have shown that swelling and solubility were not influenced by HDPE or PP woven sacks.

Type of packaging did not exert any effect on swelling power up to a storage period of six months. Similarly, changes in solubility during storage was not influenced by the packaging material.

These observations are clear from the following figures 7 & 8, which are shown for initial two months. In the later stage the values are almost similar and hence graphs for 3rd to 6th month are not shown.

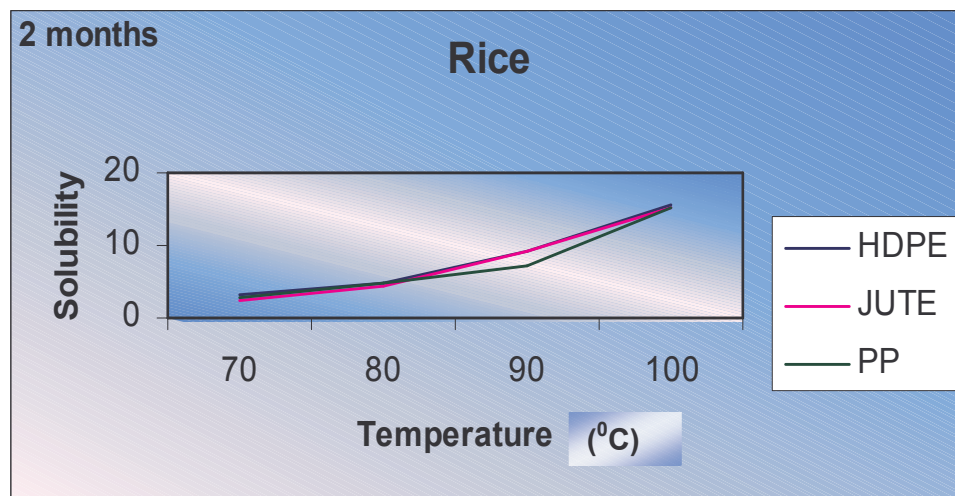
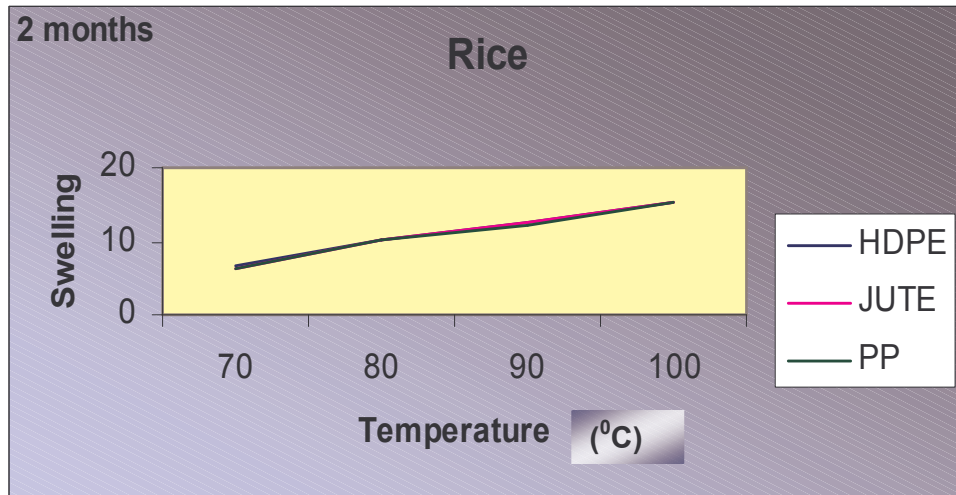


Figure 7: Swelling and solubility of rice

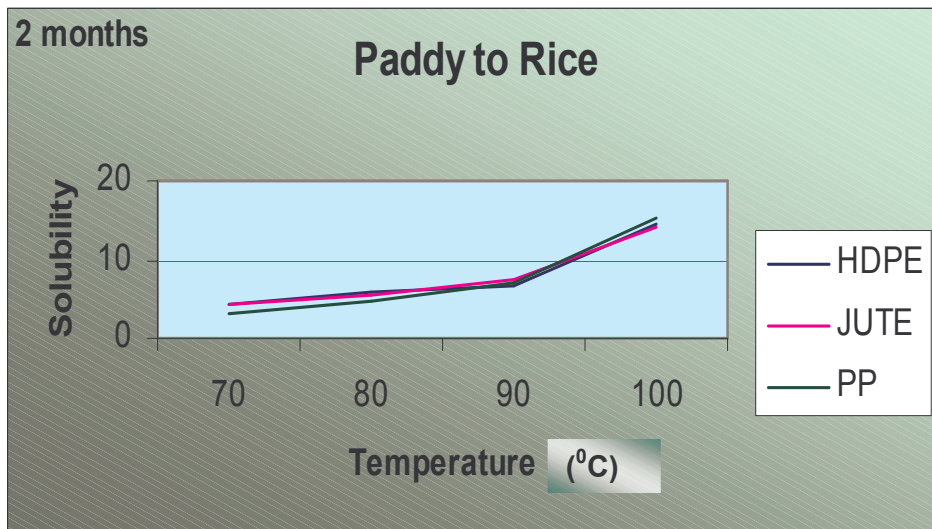
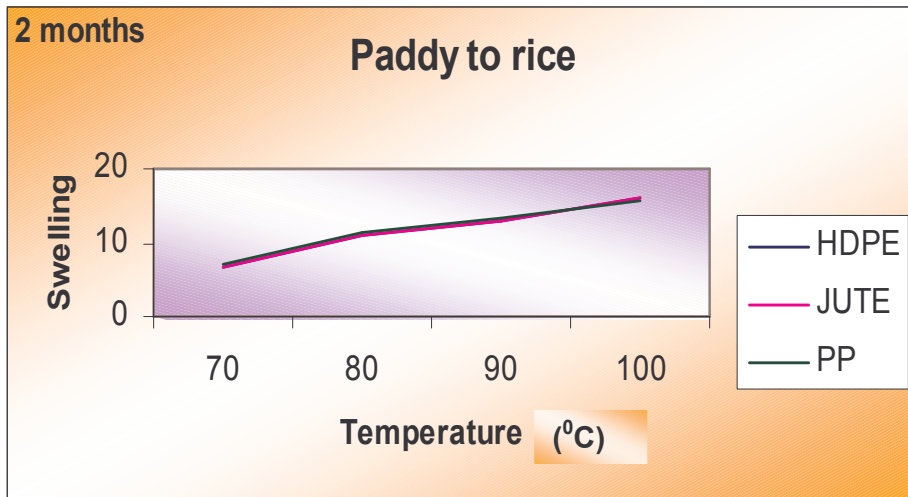
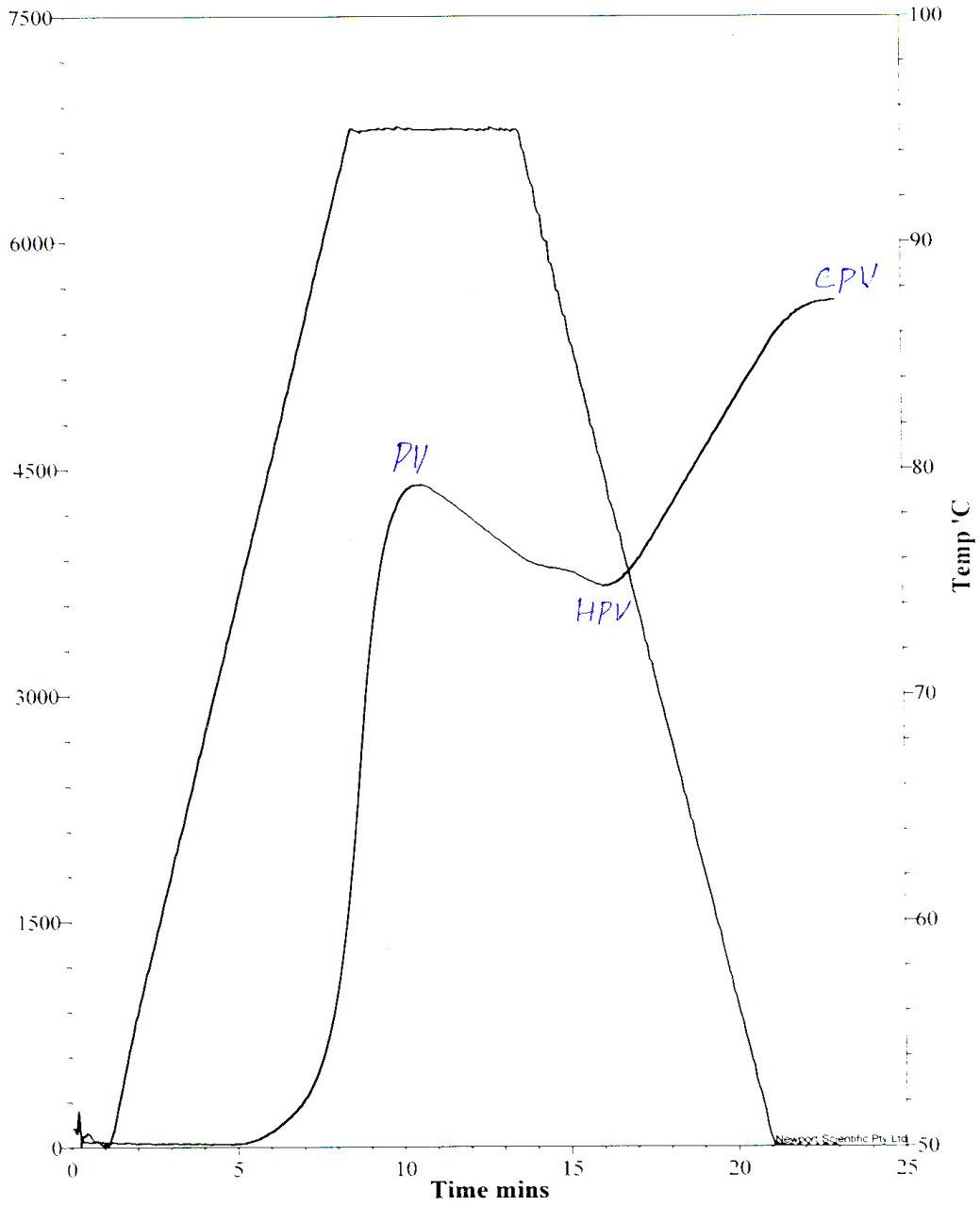


Figure 8: Swelling and solubility of paddy to rice grains

Viscography or Pasting profile of rice

Generally when rice is cooked, initially the starch granules present in the system, absorbs water and attempts to swell. As the temperature of cooking increases, absorption of water will also increase and the starch granules attain gelatinization and again increase in size by taking more and more water and correspondingly the viscosity increases. When the cooking continues, the granules continue to swell and reach peak viscosity (PV). As the cooking continues, space becomes less in the vessel, and the swollen granules of starch cannot swell further, and they bombard with the surrounding swollen starch granules and hence the shape of the swollen granules changes and attempts to break and hence the viscosity decreases. The end of decrease in viscosity is named as Hot Paste Viscosity (HPV). The difference between the Peak Viscosity and the Hot Paste Viscosity is named as Break Down of the swollen starch granules. Afterwards the sol will be allowed to cool uniformly and hence the sol joins together and formation of gel takes place which becomes hard and viscous and hence the viscosity increases. This is named as Cold Paste Viscosity (CPV). The difference between Cold Paste Viscosity and the Hot Paste Viscosity indicates retrogradation, and this is named as total Set Back (SB_t). These explanations are clear from the following viscogram of rapid visco analyzer (RVA).

The viscosity is expressed in the following discussion in centipoises units.



RVA VISCOGRAM

Discussions will be made, initially on the paddy stored in different sacks followed by rice stored in different sacks.

Viscography of rice, when stored as paddy under ambient conditions

Peak Viscosity

Table 4: Peak viscosity of rice, when stored as paddy

Period (days)	Peak viscosity		
	Type of packaging		
	HDPE	PP	Jute
0	4046	4046	4046
30	4166	4106	4067
60	4211	4238	4076
90	4314	4211	4093
120	4399	4251	4113
150	4163	4261	4116
180	4102	4294	4143

Table 4 indicates PV of rice when stored as paddy. In the case of paddy in HDPE sack the peak viscosity increased slowly from 4046 CPS to 4399 up to four months and afterwards it decreased. For paddy in PP sack the value increased continuously from 4046 to 4294 and similar trend was seen for paddy in jute sack where the value increased up to 4143. The values were high in HDPE sack and least in jute sack. The increase in peak viscosity indicates that the starch granules of stored rice are more resistant to swelling than those of fresh rice.

After 4 months the value decreases in HDPE, but in P P and Jute the values continues to rise indicating the positive effect of HDPE compared to other two types of sacks, however, as per literature the peak viscosity increases initially and then decreases with storage and this is observed only in HDPE.

Break Down (BD)

Break Down value is defined as the difference between peak and hot paste viscosity. The following table indicates the BD values of rice when stored as paddy in different sacks.

Table 5: Break Down values of rice when stored as paddy

Storage period (days)	Break Down		
	Type of packaging		
	HDPE	PP	Jute
0	708	708	708
30	745	683	657
60	651	670	551
90	592	425	533
120	660	581	540
150	550	744	496
180	524	805	459

From the Table 5 it is clear that the BD values generally decreases in HDPE and Jute sack which is the general trend observed when grains are stored as per the literature reports. The fall in BD shows that the rice substance becomes more and more organized as time goes on. This process never seems to cease, although

it does progressively taper off. However in PP sack, after 4 months the BD values starts increasing. This data needs further in depth studies. However, in Jute sacks, the value decreased continuously even after six months of storage. The decrease in break down values indicates that the capacity of the starch granules to rupture after cooking was reduced significantly by ageing of the granules. With ageing, the decrease in break down never seems to cease although it does progressively taper off. Again the observation is HDPE follows the usual storage effect of rice compared to PP sack, once again proving the efficiency of the HDPE sack compared to other two sacks.

Set back (sb)

Table 6: Set back values of rice when stored as paddy

Storage period (days)	Set Back		
	Type of packaging		
	HDPE	PP	Jute
0	1370	1370	1370
30	1313	1408	1368
60	1304	1412	1096
90	1237	1368	1293
120	1217	1332	1351
150	1290	1378	1373
180	1266	1396	1360

From the Table 6 it is clear that the SB values decreases continuously in HDPE, however in PP and Jute the values are not following a particular trend, and in the case of Jute, the value suddenly decreases to 1096 and again increases, indicating the ups and down in these values.

The above table indicates the set back values of rice flour on cooking or while running a viscogram. Set back indicates the rise in viscosity of the gel after covering the peak viscosity . It indirectly reflects the break down, in the sense that the greater the break down, the smaller is the set back or vice versa.

Paddy in HDPE, PP and Jute sacks, showed a continuous decrease in the set back value up to four months and later it increased gradually indicating the phenomenon of retrogradation.

Again we observe that HDPE stored grains behave as per the literature reports, giving strength to the fact that HDPE sack is better in all respects.

Viscography of rice

Peak viscosity (PV)

The viscosity reaches the highest value (peak viscosity) when the rice flour slurry is cooked in RVA during cooking phase. The initial value of PV was 3054 CPS. It then slowly increased with period of storage up to four months, for all the three types of sacks viz., HDPE, PP and Jute. This indicates more resistance to swelling by the starch granules of rice in these sacks compared to fresh rice starch granules. However, after four months, the PV decreased slowly indicating the reverse phenomenon i.e. easy swelling of starch granules. This phenomenon is clear from the data presented in the following Table 7.

From the data it is seen that the viscosity values were found to be higher in rice stored in Jute sacks compared to the other two types of sacks, indicating the resistance to swelling of the starch is high when rice is stored in jute sacks. In jute, the PV rises up to 4 months by 600 CPS, however in other two types of sacks the rise is only by 300 CPS.

Table 7: Peak viscosity of rice on cooking in Rapid Viscosity Analyser during ambient storage

Period (days)	Peak Viscosity		
	Type of packaging		
	HDPE	PP	Jute
0	3054	3054	3054
30	3069	3094	3165
60	3124	3189	3226
90	3175	3210	3438
120	3278	3319	3650
150	3126	3008	3407
180	3074	2885	3185

Break down (BD)

The break down value is the difference between peak viscosity and hot paste viscosity i.e (P – H). The break down values are presented in the following Table 8. Generally the BD values decreases upon increase in storage period. In the present study the break down values are decreasing, but not in an orderly way. It is observed that the break down values is similar in case of HDPE and PP sacks. More fluctuations were observed in Jute sacks. The decrease in the break down values indicates that the capacity of starch granules to rupture after cooking is reduced significantly by ageing of the granules. The results obtained from the experiments are presented in the following table, from which definite conclusions could not be drawn. Probably as per the reports, minimum period of 4 to 5 years storage aspects are to be studied, in order to draw concrete conclusions. The differences between

the rice samples in three types of packaging materials could not be ascertained clearly in this experiment.

Table 8: Breakdown value of rice during ambient storage

Storage period (days)	Break Down		
	Type of packaging		
	HDPE	PP	Jute
0	1	0	0
30	- 2	3	11
60	13	0	- 13
90	0	0	- 3
120	0	- 3	52
150	3	21	39
180	5	7	15

Set back (SB)

Set back value is the difference between cold paste viscosity and peak viscosity. Indirectly, the set back values indicate the retrogradation of the gel while cooling the sol obtained after cooking in the Brabender or Rapid Visco Analyser vessel. The data on set back values are presented in the following Table 9. It was observed that the increase in set back value were marginal with respect to HDPE sacks after 30 days of storage compared to jute sacks, where in the increase was quite significant. The increase was from 1547 CPS to 1890 CPS. The increasing trend was observed in all three types of sacks, with some exceptions. The degree of

increase was comparatively high in Jute sacks and least in case of HDPE sacks. Unless a detailed studies of long period storage, are not carried out, the results could not be explained at present. The paste break down is the primary index in a viscogram, the set back being largely a mirror image of the former, greater the break down smaller is the set back and vice versa. The increasing trend was observed in all three types of sacks, with some exceptions, indicating that HDPE and PP behaves almost similar on par with Jute sacks.

Table 9: Set back value of rice under ambient storage

Storage period (days)	Set Back		
	Type of packaging		
	HDPE	PP	Jute
0	1547	1547	1547
30	1590	1521	1890
60	1577	1512	1876
90	1650	1601	1818
120	1581	1610	1894
150	1695	1964	2094
180	1681	2017	2188

It is seen that (Table 9) the values of set back is very high in jute sacks compared to other two sacks. The values are least in HDPE sack. A clear picture can be seen, if the grains are stored in these sacks for a longer period instead of only six months. Even at the end of six months the values are highest in jute sack compared to other two, which cannot be explained at present.

Total Set back

The total set back value is the difference between the cold paste and the hot paste viscosity. It indicates the rise in viscosity while cooling the sol to form gel, which indirectly measures the retrogradation phenomenon. The values are comparatively higher for rice samples in Jute sack compared to HDPE and PP sacks. The total set back values are presented in the following Table 10.

Table 10: Total set back value of rice during ambient storage

Storage period (days)	Total Set Back		
	Type of packaging		
	HDPE	PP	Jute
0	1547	1547	1547
30	1588	1524	1902
60	1590	1513	1863
90	1650	1557	1815
120	1577	1607	1956
150	1698	1985	2133
180	1686	2024	2203

It is observed from the above table that the gel formation was higher in Jute sacks. Also, the grains became hard when stored in Jute sacks, even though hardness parameter was not measured. Degree of formation of gel in other two sacks observed to be comparatively less.

By looking to the data it can be concluded that generally the viscographic parameters are high in jute-stored grains, when grain is stored as rice. The values are different when grains are stored as paddy and generally the values are less. In order to get a clear picture, a detailed in depth studies are needed to draw conclusions.

Amylose content in paddy and rice:

Table 10 shows the amylose content of rice flour and defatted rice flours when stored in these three different types of sacks.

In the case of paddy, the amylose content of rice flour was between 22.9 & 23.6% in HDPE & PP sacks. The corresponding value for Jute sacks was 21.2%, which is less compared to the other two sacks. In defatted rice flour, the values were same in HDPE & PP i.e. 26.8% as against the value of 25.4% for Jute sacks. This indicates the linear component is less by 1.4% in Jute sacks.

When rice was stored in these sacks, between HDPE & PP the value was 1% less in PP. In jute the value were similar, as in the case of PP. On defatting the values were almost similar in HDPE & PP. However the value was less in jute sack by 2%.

It is well known that the lipid present in rice flour forms a complex with iodine, and hence the values are less in undefatted flour. However, in defatted flour the values are high indicating the fact that the absence of lipid makes the system to develop deep blue colour and hence the values are high. Even helics formation where iodine interacts and development of blue colour is less.

It is also observed that, the value of amylose is less in jute sack, which may probably be due to degradation of amylose which may be taking place in the jute sack. Both in the case of paddy and rice, degradation appears to occur only in jute sack to a greater extent.

Table 11: Amylose content in paddy and rice during ambient storage

Paddy		
Type of packaging	Undefatted	Defatted
HDPE	22.9	26.8
PP	23.6	26.8
Jute	21.2	25.4
Rice		
HDPE	22.7	26.9
PP	21.7	26.3
Jute	21.5	24.6

CONCLUSIONS

- ◆ Generally paddy stores better in HDPE compared to PP and Jute.
- ◆ Volume expansion is always high when stored as paddy rather than as rice.
- ◆ Pasting profile properties indicates HDPE is better sack compare to PP as well as Jute.
- ◆ Amylose content value indicates that the material undergoes faster degradation in Jute compared to HDPE or PP.
- ◆ The studies need minimum storage period of 3-4 years to draw a concrete conclusion.