QUALITATIVE AND QUANTITATIVE CHANGES IN STORED RICE

BY

GEETHA ROY

THESIS
Submitted in Partial Fulfilment of the Requirement
for the Degree
MASTER OF SCIENCE IN HOME SCIENCE
Food Science and Nutrition
Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF HOME SCIENCE
COLLEGE OF AGRICULTURE
VELLAYANI THIRUVANANTHAPURAM

1995

Dedicated to my Parents

D E C L A R A T I O N

I hereby declare that this thesis entitled **Qualitative and Quantitative changes in stored rice** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Place: Vellayani

Date:

Geetha

GEETHA ROY

C E R T I F I C A T E

Certif l tl t tl e tlc i ertitled **Qualitative and Quantitative changes in stored rice** is a rerord of arch c l ore lepnrd Ll by **Miss Geetha Roy** under y guidarr e l pe e on r l tl t it has not previously f r cd the t s s f r the w d l any legree Fellowship or Associateshl p to te

Dr (Mrs)L PREMA

Cl man Alvisory Committee

Ponfessor d Head

Dept of Ho e Science

College of Agriculture

Pl ce Vellayani

Date

AI HPI /EI I Y

CHAIRMAN Dr (Mrs) L PREMA

[ofes r d I ead

I pa tment f Home nce

MEMBERS Dr MARY UKKURU P

A ociate Professor

D pa tment of Ho e S ence

Dr GEETHA KUMARI

Associate I c esso

Dep t tment f Agrono y

Dr NASEEMA BEEVI

A so L I f s o

I p t e t I Ir to l gy

16/10/95

EXTERNAL EXAMINER

16/10/95

A C K N O W L E D G E M E N T

l l de p sense of g titu I p t down the follo ene tran es

I e p ss y tmost tit de nd i d t edres to **Dr (Mrs)L Prema** F ofesso d l e I Home Sc e ce l Ll e e o C iv y Co l t fo l e s ined r l l t l q de const er cou ge ent st ucti c riti i s r i l i i treatre towa de re du ing the course f thi i estigat o erd pr pa ation f this th esis

The alu le ggest ore a d critical sc utiny of the usc t **Dr Geethakumari** A ociate ofesso Depa t e t of Ac ny and be f Adv sory C mmittee i incer ly ul owle ged

I am g ateful to **Dr Naseema Beevi** Associate Frofesso Department of Er to ology and ember of Adviso y Comm ttee or her aluable advice and unstinted interest at all stage of wo

My immerse gratitude to **Dr Mary Ukkuru P** Associate professo Department of Home Science for the valuable help rendered d ring the course of the study

I avail myself of thi oppo tunity to pl ce in reco d y heartfelt than to **Dr P Rajendran** Associate Frofesso Department of Soil Science nd Agric lt ral Chemistry who

I r ly I I I w jl I jt tly c ri q le chem cal alysi f the ple a d Mrs Geetha Philip c lt Off ce / g nn for tl lelp endered for le stor cf p r

I n a grc t deal t Sri Ajith Kumar Junior F ogra mer Lep rtn nt of Ag icultural Statistic for the ost val ble lelp in analysi q the e p i ental data

I sincerel thank t e Dean lerala Agricultural Uni ersity fo aw rding a fellow hip for the Fo t G adu te F og me

With q at t de I remember the ti ely help and sincere co ope ation by City Computers

I greate t debt i due tc my parents b other and siste fo tl eir con t e ico agement and support th oughout the st dy and I dedicate this wo k of mine to thr

G E E T H A R O Y

C O N T E N T S

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

INTRODUCTION

In t p esent rld food s t ation eduction of crop l i o f making more ood ava lable for np I L food q r product cr te loss due t de cr o tion l i g u qu is found to be major limiting factor E lier studies conduct d had indicated lat the storage of the g ai s ay result in 6 per cent physical loss and 15 per cent q alitative loss mainly lepe di g or the ype of storage structure used (Hall 970

Rice sust ins mc e loss tha any othe cereal before it c ches consume In kerala majo portion of the rice p oduced by the fa ers are u ually stored at the farm house itself by conventional sto age methods and utilized by the f mil The influe ce of diffe ent storage conditions on ice va ieties needs to be studied so as to enable farmers a d loc l me ch ts to sell out their g ains in good condition at easo able price Rice deteriorated more readily at higher te perature a d moistu e content despite the ba ie prope ties of containe s in which it is stored (H ng *et al* (1986))

trd n l g r tir t rd g in are
I ected cont tous physio chemical changes which affect
ther cul y proper es a d nutr i l e (Fa tor 1979)
o age d mage may occur due to insect pests rodents and
mp uss lso Far tors such as g ai co stit ents
c l i g q lities nd o ganolept c q alities of rice
varieties e affecte when stored n differe t co ventional
d mode n sto age rtu es I formation on these lines
e at p esent sc ty

Hence the present study wa ndert ken to investigate
r cf t f sto g on ice g ain w th efe ence to
different storage st uctu es and storage durations by

a A sessing the change n grain constituents in raw
d cooked ice samples

b As ess ng the changes in physical characteristics

c A sessing their shelf life characteristics and

d A cessing the cooking qualities and ove all
acceptability of stored rice grains

REVIEW OF LITERATURE

REVIEW OF LITERATURE

tor g cf fo l g air a en inevitable step in the n l p ll ay of g in f o l a ect o con m tion Among gr i s rice et t a more lc than y other ce eals l ng ago c tho g sto age ensu es against fl ct ation i prod tion st ll es p a and replenishes t dep1 t d sto l (Jul ana 1931) F r a ed pu po e also or ge is ported to he a nece ity (F tsu et al 1971)

E a studie or Q alitative and quantitative losses of stored rice are prese ted in this chapter under

1 Qualitative charges in stored grain constituents

Charges in the physical characteristics of stored grains

Changes in the cooking characteristics of stored grains

4 Changes in the organoleptic qualities of stored grains

5 Sto age loss due to insect infestations and

6 Influe c of st rage structures on the quality of stored grains

R ce is stored for long term in different forms Us ally as raw rice it is stored for a ve y short period As paddy it keeps well for a pe iod of three years (Halls 196) R ce is sto ed in the form of husked p oduce as p ddy Th ee years a e upposed a optimu period of storage of ne e d a e l a f / s f nedium and roa se ty pe (H lle 1°91)

f jort l ly Gl ot 1 (1976) the mill l fo m ar h ch t ll of st ed rice ps is held ir village vould ffect elf life q ality However s paddy the grain is eported to ha e bette qual / and lo jer shelf l fe under the same co dit o According to I dl dhara sv my et al 984) ha d pounded ice wh ch has beer ve / lightly milled ight ur d rgo rap d deteriora ion during prolonged storage

Qua l tat e loss of ice i influenced by the rdi n which the g a s stor l Accordi j to Lee et al (1991) in ic packages ith rough ice and bro n ce stored urd r room conditio s for one year the stored grain decreased ig ific ntly due t germinat on

It h been ob erved th t brown (dehusl ed) ice without y pol l keep well i o nge a l contains all the utriti e materials (ICAR 1985) Paddy in storage may lose (0 to 1 5 pe cent) in weight du ing storage in hot orths due to driage loss hile rice may lose mo e (1 to 7 per cent) when storage continues to two to four months der comparatively dry condit ons (Juliano 1984)

2 1 Qualitative changes in stored grain constituents

Grai constituents such as fatty cids reduci g sugar p otein amylose sta ch rd moistu e are reported to be t r l c tc ge c d g to Gl eh et 1 (1976) rly 11 ng i J and p l tage a co e ed with r ce l et v l d storage

l i d f t y acid c por tie f stored rice (at Jn a J 70 re ce el t e t nid ly fo 1 years nd estly l r d t o rice n found tc differ in neut al l i r jtol pi d n j if ed 1 id glycolipid and ce fa a i l o tents These cont ts were found to ease on sto ge Chattopadh y 1988) Acco ding to f arath nd Kulk n (1980) stored i e varieties we e fo d to l ff i ificantly with re p ct to f tty acid eporil o like ol c a id n l 1 noleic acid

Kim t 1 (1998) had m itored the changes in the hys oche ical and senso p ope ie of ice and ice flour tored i C for i mo ths They ob ed that fatty acid ce t ation dec a ed apidly pto 60 days at room temperat re and for 45 days at 4C and thereafter increased slo ly

Lee t 1 (1991) rep r th t f t cidity ncreased in the ce r ch ri lled nd h own rice during stor ge and s four rot to produce ary notable ffe t the f ty cid co p ition c c pt that palmitic d cr ed nd linole c cid decrea ed to some e tent (Dhaliwal et al 1990) e r f l co ff c l n r trients lile bohyd le a l p le as Ir ld n to ed for twelve onths ci g s jar le el w ob e l to increase with torage t e the i c ease bei g lowest fo cold sto age and f r poli led rice Iraed by heated air (Hayakawa et al 1997 H oler e ge tempe at re lad no effect on starch a ert Christ ll 1990) Cho e and Iuta y (1977) reported that af e three months of storage of r ce ce tain physio hemical changes ir the colloidal state of rice starch makes the ric ore accept ble to Indian cons mers

Cl stal 1970) report d th t allt ough tot l p otei s did ot change d ing sto age of ice g ains at highe tempe at c re ulted ir ir eased disulphide bonds decrease in protein solubil ty and ar increase in average olecular weight of Oryzeni

Dhaliwal el al (1991) epo ted that paddy samples stored afte drying had sig ificant eduction in diastatic proteolytic and lipase activities Stored samples had increased activities of p otease and lipase A red ction n the amount of glutamic acid ir milled rice as well as decrease in atio of glut m c acid to total free amino acids both in m lled rice a d in the e terior of cooked ice du ing short and long term orage were observed by Tama i et l (1977)

(r F t (purte tnt flo three l cf rage f cr n r ph s che ical changes Lt l d l Lc of rr fa cl le tlc ı c more ep l1 lo Trd an con mr s

In to f t three t s afte t vest there is g ad a d ction ı amylose act ty of ice g a n (Ghose t 1 19L) Ch g nd Liu (1991) epo te l that ice starch g l with d fferent amounts of amylose du ing sto age at C ı c v y r c t r tes the trog adatior of the l gl ylo e was fa te th it t of lo amylose group at arly st ge of sto age The temperature was also observed to affe t he ate of ret og adation and properties of et ogr ded sta ch was al o i fl erced b rice v ety and storage cond tions Acco di g to Ch et al (1991) during storage average olecular weight of ylose dec eased but that of amylopectin increased Howe e wate insoluble protein and a ylose content were reported to show o s gnif c t change in the grains du ing short and long te m sto age i the e periments conducted by Tamaki et al (199)

Sinha and Wallace (196) repo ted that the rate of chemical and biological eactions in food materials depends o the water content losses occur in seeds and grains ainly due to th presence of e cess oistu o Qualitative loss s due to sp outing loss in viability dev lopment of cidily d o f ı t tı al t f cdıLle products a n ıeer ed to be effe ted t L ss m ı t ε ı the grain (r nha 1967)

2 2 Changes in Physical characteristics of stored grains

Fly l rl tc istı uch Lad rice yield ı crsıty J gcl ıen ı t mp are fou d to be f cted Lc ı

Acei j dL t storage l ı positive influence on the L d ice yield As eported t Sajwan et al (992) head r yı ld impr ved with the re ease r the duration of crage l we e tot l nilled ice ield remained unaffected l stor c dt tı n d co dıt o Jı d l a d Sı bu morgen (1994 l d tl eductıon n head ice yield due to ıtı t orpt o ıring t gr Moı ture t o ption by lo moıst e co te t ought ice ıs con idered as ı major use of ice bre kage Thicker kernal attained slightly lower a e ge equılıbrium moıstu e and also produced higher head rice yield th n thinner ke nals Thicker ke nels were o e susceptible to ed ction n head rice yield from ıoist e absorption ır comparison with thinner kernels

Viscc ıty can be defined e the ıbil t/ of the solution to flow d storage has a posit e effect on viscosity to the ad antage of consumers The viscosity of rice paste was observed to incre se while toring ice at ambient p lo 179 l jh L s pn ed that log pl ice cnrit t h l r r r i tency value l nct c a f c h c o th ju it ae later tsarved that l re vas co s l able a continuo s change n all ty pa le tl ja t the storage pe od (Indi d a s amy et al (19 8)

Sh et al (1 repo ted a b nt al inc ease in ne eral onte t d pea cosity t bro ic flo r tes hr rcrease s o ge pe od t rom cc rding to Hay l va et al 1992 scosity of t elve nths to ed pa l icc c eased s de te mined b amylograr cha cte istics

Mura ka anc Eun la (19) av lso reported that n tial p rtirg empe atire of r ce flour emained fa ly nch rg d du irg sto age but pcal viscos ty onsisterll incre ed v th the inc ease in storage time and tempe t

Indi u li a sw y et al (1978) epo ted that the ageing of rice g ains increased the gelatinisation temperatu e Gel obility appeared to be related only to the degree of st rch elatin sation and the gelatinisation temper atu e was fo nd to incre se with the increase in sto age period (Unni kri n nd Bhattacha ya (1988)

2 Changes in the Cooking Characteristics of Stored Grains

to age of ice affe t the cooling characteristics ucl v tc pt lo cool i g t e velling inde olume pr r l li uss

W ter plake an be defined as the amount of water absorbed by the g on cooking As stated by Hogus (1967) gei g e ulte i less ate plale ral The total wate ptal e n cool g was g erally ol ved to be more in ice stc ed at low temperature than in fresl s mple (Barbe 1977) In long t m storage st dy (th ee and a half yea s) of rougl rice and milled ice Indhudhara Swamy et al (1978) o erved an increase r the wate uptale at storage l mner t re of 96u and 80oC nd at roo tempe ature Changes in ate ptale ate cooling prope ties and gelatinisation p rpe tie were studied by Su j kon d E ja (1997) during sto age f milled ice for months at 1o to 70oC The wate ptalc L c r t t cf m lled rice we fou d to decrea e du ing st ge ard was o e p ono nced at ele ated sto age tempe at o

Coo g ti car be defi ed as the optimum time taken the gr n to co l ell

According to Villa eal et al (1976) due to decrease in solubility of stach and protein and the inc ease in storage period re ulted i the decre se of opt mal cooling time in lever months storage

A l q h l (1) n of ice grains decrease the opt l cooking t m l l Sabula e et l (1 1) l l c l ane v not significantly affected by torag Cooking time as p o onged b to 8 tes c t si r of g in become h r (Sung r and C n Ja 1997)

S elli c i de an be defi ed a th l io of length and v dth of gr in on cooking An ea n in swelling inde f opti lly cooked ice g e e en months sto ge was n ted b Ali t (1978 Villa eal et al (1976 reported at afr r g i ncy for to 1 m th swelling i dr r cool e l ice ncre sed f om 16 to 70

Volume e pansion c n be defined as t e e tent to which the g ain e pends on cook ng Bh tt charya (979) has eported at volume e pansion of cooked rice increased with sto age According to Sab la e et al (1991) an increased erd v s uled t e e ce of oluble solids in residu l cooling water and volume e pansion on storage o age of irradic ted rice al o found to produce s m lar changes as noted n those non ir adicated samples

Bhatt ch ya et al (1978) reported that stickiness of cooked i e could not be e pl ined on the basis of total ylo e c te t lone but they correlated well with the insoluble amylose content As the insoluble amylose ncr a ed storage the tic i ess of l cooked ice on

Lorag 1 r r1 1 Acco d1 j to C 1r et al (199-) aged 1cL kl ccol ed 1s le st1 ky tl ar newly harvested gr ns Th s lLe to denalL atlon of p otelr 1n rice I r3rq aq n}

2 4 Changes 1n Organoleptic qualities of stored grains

Con Lmer p eference of a prod ct depends on 1ts c ganoleptic qualit es like I rdness colour t ste te ture L j 1 1l / The l 1 1lh of Lo age 1s d1 1cult or almost 1mpossible to deter 1 e with any degree cf accura y a d 1f ascertairable the al e would probably be rf doLbtf 1 p actlcabl1lty ow1ng to he d1 e s1ties 1n one ner fo Lrce a1d tlr v1 1ab 1 t of the t1 me and ctlod lopted by consLme s Lo cereal (Jadhudl ara swamy t al 1994)

According to F1marathna d kLlka n1 (1988) dry1ng of paddy 1m r d Ll o ganoleptic quality of r1ce Grains ted high fc eat1ng quality on storage had a lower amylose and n1trogen content 1n their grain (MatsL ~~ek1~~ et al 1991) Varieties that rated low was also observed to have higher amylose and n1trogen co1tent 1n grain According to I at L Lk1 et al (1992) glutam1c and aspartic acid contents of r1ce samples were found to be responsible for 1mprov1ng eating quality of r1ce on sto age were rducted ir this e pe iment to establish whether pe ceptible differences were caused by the deg ee of milling or due to the storage conditions Simila changes occ rred in the nde milled and well milled ice during storage but they w re more pronounced ir the und r milled i e lc dinc to a p odu e of poorer storage tability and reduced preference

Taste inde of milled rice stored for 12 months at ambient temperatu e decrea ed during to age in proport on to stor ge time a d temperature For optimum quality it s recomme ded that ice be dried at ambient emperatu e polished and then stored under low temperat e condit o (Hayakawa et al 1992) N wly ha v sted rice showed a elatively high r palatability then stored ice s stored ice had a high f ee fatty acid content (Mat a et al 991)

M t e et l (1971) reported t t eati g quality f rice aft r ore e sto age t room te peratu e deterio a ed with storage pe iod Effect of short d long te m stor ge on the eating quali y of rice were i stigated by Tamai i et al (197) The t ture of cooled ri ec me rde n l less sti ky afte beirg stored at high temp at re and moisture content or 90 d y The t t f sto d under e si l l y cond t ns det o ated al d an early t ges of t age and ca e b t ch n ce tored ndc o l o t condit ns with p lo ged r ge

Parboiled rice reacts to storage somewhat differently from raw rice. They discolour and became yellowish possibly due to the greater moisture content in the grain (Bhattacharya 1984). According to Sun-Kon and Eun Ja (199) there were no significant changes in colour of milled rice grains during storage at 4oC but an increase was observed at higher temperature.

Deluccа and Oly (1987) reported that stored rice undergoes changes mostly enzyme catalysed which can affect flavour and colour of cooked rice. The hardness of cooked rice increased during the first three months of storage of all milled rice except of w y rice (International rice research Institute 1980). According to Juliano (1985) the change in texture of milled rice during storage increased with storage period. Surface defatting did not ret d changes in the texture of cooked rice but etarded retrogradative tendency.

Effect of t ge of rdermilled e c il octirg nd cooking qualities was investigated using both chemical nd sensory thods by Fiaggutyl et l (1971 Cl ge sensory properties ere eported to be related to he chemic l change t irg place. Desc iptive sen y a alysis of the cooked rice b a trained panel evealed at on ir odour teste d feel of fu l stored rd f eshly milled sample. T i ql nd p efc c ce te t by ar t ained p el

Most of the changes in texture ... occ during year one and two of storage with very little change being observed after that (Tamaki et al 1997) Fat by hydrolysis increased and pH of the cooking liquid decreased which seem to be related to deterioration in texture and taste of rice (Tamaki et al 1997)

2 5 Storage losses due to insect infestation

Stored rice is likely to be attacked by insects At temperature and moisture suitable for their growth insects gain entrance to the stored grains and grow on ... causing quantitative as well as qualitative losses ... the grains Delucca et al (1987) reported that the rates and extent of changes which the stored ... undergo ... by microbes and insect pests associated with it

According to Lin (1984) the storage fungi are consistently associated with the deterioration of stored grains There is ... a regular microbial succession in the deterioration process *Aspergillus restrictus* and *Aspergillus glaucus* almost invariably were found to appear first and was followed by *Aspergillus candidus*, *Aspergillus ochraceus*, *Aspergillus flavus* and *Penicillium* ... The microbial succession was also observed to be associated with the changes in moisture content and was primarily responsible for the discoloration and ... ing of the grain ... rise in temperature to ...oC ...

in the involvement of thermophilic bacteria and fungi which might carry the temperature upto 75°C after which the purely chemical processes were observed to take over and to carry the temperature to the point of combustion In such situations fungicide is of little value in controlling storage fungi Most agricultural seeds were found to be stored at low temperature or at low moisture content conditions to preserve grain quality

According to Pingale et al (1957) husked rice was infested to a greater extent than hand pounded rice Parboiled rice however has an advantage over raw rice during storage since it is less affected by weevil attack This is largely due to toughness imparted to the grain by parboiling treatment Those processed acquire a hard smooth and glossy surface which apparently affords a poor grip for pests (Bhattacharya 1984)

Delucca et al (1987) viewed changes caused by micro organisms mostly fungi on stored rice hence fungal contamination was found to be responsible for most of the quality deterioration in stored brown rice Avoiding optimal conditions for fungal proliferation were found to control the quality of brown and freshly milled rice on storage (Delucca et al 1987) According to a report published from Kerala Agricultural University (1995) loss of bran in the milled rice is reported to attract insects IRRF (1995) s epo ted that fully polished ice is le s susceptible to insect attack and have greater storage life

The most important insect which attacks stored paddy in India is the moth Sitotroga cerealella which lays eggs on the standing crop or in the harvested c op during thresh ng (Podival 1962)

Dakshinamurthy (1988) conducted an experime t in which freshly ha vested paddy infested by Sitotronga cerealella in the field was d ied to 12 per cent moisture nd mi ed with dried plants at 1 per cent by weight to monito insect development over 4 months In the second trial paddy wh ch was stored for 6 months and fumigated with phosphe ine was treated with 1 pe cent by eight of the plant powders placed i gunny bags and inoculated with Rhi ope tha dominica After 4 mo ths insect development in this sa nple was assessed and w s observed that eucalyptus powder was ost effe ti e

Acco ding to Verma and Utta (1990) the relative resistance of 16 varieties of ce was tested against Sitotroga Ce ealella In as essing the damaged grain percentage loss in gra n and mean ad lt population/50 grains ove a sto ge pe io l of 90 d y it o c r le that the seeds of Ashwini Jay a and IR 8 e e l ss ceptible t the pe t while CF 2 7 1] n thi /0 T T nd Pras d were mo t sucept l They l o repo d that seeds of othe v rictie wer moceratcly s ccpt ble to th i sect Sitotrga Ce ealella Seeds of no e of the co v rietie tested vere resist t to this irsect

The effectiveness of Acorus Cal m s L rhizome powder (0 1 & 0 2% /v) was investigated a g al protect nt against Sitophil r Or/ ae and Tribol m castanc n to ed milled rice (H richard or et al 1990) After c & montl s of stor je high tality was obser ed at both the level of A calamus T cast rec adults suffered negligible mortalit/ at all torage inte vals However ore tha 50 per cent reduction was achieved at 0 1 pe cent level The coo ing quality of mill d ice did not change even v e treated with 0 A C la s rhi ome nd stored for mo ~~more~~ th ight montl s

Dorahye et al (1991) ha c rried c t a trial in Sri nka on the o tdoo storage fo si mo ths of locally g u paddy i two sealed flexible liners termed trago cubes Insect infestatio s fail d to develop in the cuber rd irdica ed a 0 to 0 01 per c nt loss i dry eight due to met bolic tivity

According to Jooc et l 1799) insect nfestation by Tragoderma g na ium d Rh, opc tha dominica fab icius separatel/ rd ir mi ed popul tions recull d n s bstantial cl ge g contents of c lcium pl sph r s i i cr upper a d margare e ft the l a e t infestation le e (75 per c nt) Rhi o ha domi ic ca ed significa t (p 0 05) decrease n the propo ti of m l matte in whe t nd so gh m grai ow ng to lo of endosperm conte ts but the decrea d e to T granari m dam ge w s not si firant f domi i infest t r did ot significantly ch ge the i ral cont but gnif c t eductio we ulaced at 75 per c n nfesta on by T granar i m Mi ed population of both showed termedi t changes in m ne l contents Sto age f r infe ted gr for 1 mo ths did ot induce any appr i le ch r t levels of i min ral

U e of Ac d Activat d l olin (AAl) to crtr l infestat n of c paddy b/ l spp f teetle R oper h domina Sit phil s Ory e l ib l n ce c a l O , aeph l s ri enei t i c t op storage cond t as n tig ted ly Per m l rd P to 1 1992) Tre tme t used pr n pyrimip os m t l (pm) (l cert/+) Ak 7 5 c/) & 40 pe cen p o AA to) C ain sto ed 45 kg l r f r bu r l m fo 2 0 da d s bje ted to p iodic c t o t bee o All in th ee tr tment n c to co ol d op latic of ec e tc 00 y obsery dem ir ro l s s d l n 0 1 /5 lc p t r l l tl 2 l l

Fa boil g wa found to educe the m crobial populati n and imp ove head ice recovery or storage (Singaravadivel nd Anl r 199) Clalkin ir pa boiled paddy was also bserve o tc d to mic ob l i f c rs Fungi such e L o A f fl e Asp f nit and A p niie occu ec Jur ng comp ele y d d ying spe ially in ro oon seasc Repa boil ng was found to decrease n crobial population (A thor (1997)

Iraq and M h med (1997) st died thermitc spp of t red gr in in a total of 108 sample of wheat ba ley a d cc Highe t t bc if spp and highe t population density ob er ed r i in ice pa t c larly du ing Nove ber

According tc Lu atelli and Dadho (1997) eggs of F dom r c and matu e la vae and pupae of E inte punctella were fou d to be tolerant at 20oC and 24 and 48 hrs of e posu e to heat wa equi ed respectively to prev nt their s r i al B sed or the fi dings of the e periment a mb nation of low pressure ncreased temperature and arbordio d e pos e was found effective for the i in t on of c n gas p ckaging

2 6 Influence of storage structures on the quality of stored grains

Var ous type of indigenous storage t uct res are used in India beca se of its vastness varying climate and ff r c rp j tt r l l j ll et ed both i b ll c i t j n l r e s sto d in b a In India t ctt p ll nd a lle l rice a e stored f long tr m

In d a tl op lar r ge st l es u ed a e gunny os a silos ll sto aje structures varied with the eg on According to Ghosh et al (1966) only old bags which ave been sed ce lie for the stc age f otter fo d grains fo a yea r two a e employed for the st a age of paddy He s fur le reported that paddy when stored in open space damage by rain o st o tage by e cessive driage due to posure to sur or attacks of roderts and birds are possible

Ghosh et al (1976) reported that wooden bins of va ious dimensions are used by culti ators for storing paddy

In t insl nces the l irs are merely bo es made chiefly of local wood The type of eceptacles found in some parts has a specially constructed small safe rooms known as Arach which is made of well seasoned wood The receptacles re ge er lly located in heavy ainfall a eas

Acco d rg to Sajwan et al (1992) for short periods of three months storage gunny bags were found to be effective

As stated in a r port of ICAR (1989) ice is sto ed in gs with proper me ures to avoid damag du ing storage

P ce s requi ed to be sto ed t low tempo atu e for a long od of tor ce v thout losi g its q l ty (Shamsudin et al 1983) I I pan, c i stored bag at a temperature of 15°C without any d n ge (Sudhyadi 1981)

achr a d Dakshinamurthy (1991) repo ted that silos ade of metal or concrete with c p cit of 75 50 tonnes are bu r fr p e enti g mo sture nd pest Ce eals with moi t re lim of 10 to 12 pe cnt can store well p to C Ahmed (987) eported that bu k storage in silos i I lu t m st effectiv pres ation method as g ain m st e is ca ef lly cnt olled nd s lo fumig t d

Between s ch stor g system in a shed nd in open space used by arious rice milling companies the open m I d ie e co ted to allow more d terioration by fungi and sp taneous h at and raised concrete platforms is eco ended fo use with the oper procedu e (Ahmed 1987)

According to Krishnamu thy et al (1992) the fle ible po ches successfully disinfected were useful for storing 1 to 100 kg of g ains with varying e posu e time and was effecti e and ine pensi e These po ches a reported to be reaso able if handled carefully Pingale (1990) reported that the i po tant consideration of modern storage st ctures are the economics and suitability of a facility i a pa ticula situation and its capacity to protect g ain f om fire o th ft

In e pc i L cor l t d by b jl et 1 (1987) moisture cc tent and tempe atu e were mo itored in two 100kg teel il ore i lated rd the o he nirsulated filled with L o e du ng two months st age trials in a tropic cl m t In the fi l i L rements nd ca ed con ide able increase in mo sture content at certain l ations n the u rsulated s l about 7 per cent content at the top surfaces c the ce in both and 3 pe e t d t per c nt moisture at the south wall of the uni sulat l and i sulated bins respectively When b lk era or nd head sp ce ventil tion we pplied during the second tri l and moisture content of the stored grains ere l mited t 2 per cent

Storage structu e used for storing rice grains will also influe ce the antitativ loss in sto age Dampness d seepage through the floor a e reported to affect dve sely t e quality of the lo er po tion of the heap and the lower bags of stack if stored in bags Irdhudhara swamy e l (1978 epo ted that milled rice to ed in sacks for onths or more ffered sub tantial loss of quality According to Dorahye et al (1991) during storage of paddy gher oistu e co ent ay esult due to moisture condensation effect as revealed on the nder side of the r lure of the st age st ucture

J D l ınam l (1?9 t atn that th

l s c f g 0 13 to t r cer t l b = 79

4 8 r cc t n g / bag r l 4 l pc c t ın

tc lnc l t r g cture

A c e/ d cind CCTFI (179 a reve lc

t et paddy ept ın t l storag for a p ıod of 9 mo ths

ed r j los of 1 tc l per cc due to rodcrts

c te d f gı wt r stored t g fn thc a r od

d n g c e d a/ udents d nse ts much g e tor b t

l d maqc s lcss

MATERIALS & METHODS

3.0 MATERIALS AND METHODS

The present study on Qualitative and Quantitative Changes in stored rice is an investigation on the effects of [illegible] the rice stored for different durations in different containers. This included an assessment of changes in physical, shelflife and organoleptic properties of raw and cooked samples of high yielding as well as local variety of rice stored for 6 months.

3.1 Selection of Rice Varieties

From among the various high yielding varieties of rice evolved by KAU, Red Triveni was chosen for the study as it is the popular high yielding variety. Rice needed was procured from the Instructional Farm, Vellayani, Thiruvananthapuram. For comparison, local variety Uchuvithu known as PTB 10 was selected because this variety is popularly cultivated by local farmers.

3.2 Selection of storage structures

Storage structures selected for the study were wooden storage structure (Pathayam), gunny bags and the storage bins advocated by the Department of Agriculture. The above two rice varieties were stored for 6 months. Gunny bags or jute sacks are the ordinary storage structures in which rice is stored by the local farmers for a short period. Pathayam

3. Metalbin used for storage study

1. Gunny bag used for storage study

2. Pathayam used for storage study

is an indoor wooden st ucti e usu lly ectangular n pe The construction resembles that of box with a oof Metal bin is the modern storage structu e that p o ides ma im m possible protection from pests allows cont olled aer tion and allows smooth in and out moveme t of g ai (Fig 1 ? ? ?)

? 3 Plan of action

Storage of rice varieties

Ten kg of the two rice variet es (nh led) me t oned above were stored in e ch of the th ee s   ge st ct es Temperature and humidity of storage str ctu e t the in t a and d ring the time of sampling was recorded

? 4 Periodical withdrawal of the rice samples

The rice va eties stored n the st   g s r t res were   thdrawn every month to ascertain the i sect nfestation loss and o ganoleptic qual ties of the varieties The rice in the storage structure were sti ed or thoroughly mi ed and 100 g of the s mple we e   ndomly t ken

? 5 Parameters selected

Paramete s selected to monit r the helfl e qu l   of stored rice arieties we e

1 Grain const tuents

2 Ph s al ch r ct i ti s

3 Insect infestation loss

4 Cooking qualities

5 Organol ptic q alities ar l

6 Suitability of r re based p eparation

All the above parameters e cept nsect infestation loss and organoleptic qualities of raw rice sample ere s ertained in the initial a final ges of orage study

Grain constituents

In raw sample nder g ar cont t c ts ir tion s ch as moi ure p tein non p otein nit ogen acid minerals a d free fatty acids were attempted applying Universally accepted laborato y techniques and details pertaining to his re presented in T bl 1 T e rice mples selected are m lled and ground a d the e tr on is carried o t taking 5 10 g of the aw ric amples for e ch p rameter

Table 1 Methods used fo analysing the con tituents of rice grains

Sl No	Constituent	Methods selected
1	Mo st e	Irdh dh s am CFTRI(n h he
2	Prc e n	Ha l and Caer (96)
	Non Protc n r ogen	Rha y et al (1°7)
4	Uric d	Sel gson (1°67)
5	M re als	Jack on (97)
6	ree Fatt a ids	Co and Ferson 1962

Es im tion of C air oret tuen s ch as redu n sugars nonreducing suga s starch and total am lose ver attempted on raw and cooked rice samples

Table 2 Methods used for determining constituents in raw and cooked rice grains

Sl No	Constituents	Methods selected
1	Reducing s gars	Aminoff et al (97C)
2	Nonred cing s ga s	Aminoff et al (1970)
3	St rch	Aminoff et al (1970)
4	Total amylose	Mac card and Hase r 94

Physical characteristics

Phys cal characteristics such as thousand grain weight head rice yield total solids iscosity and gelatinisat on temperature were ascertained in the raw rice samples

a 1e Mechods sed to determ ne ph/sical character st
of rice g ains

	Tn and g n weight	rdh et al (197
	Head i e y eld	Raj c shmi 984)
	Tc l so ids	Re o n a e a
4	V sco	
	Ge c ni at on tempera o	h l a lcre 19 4)

Insert infestation losses

Periodical est ma ic o rser fe ta ion lo s ere carr ed o b determin ng osses in const tuent f ct one percent ge loss due to p et infestation microbi contam ration and insec e scept o / and percentage los due co post infestation ere determi ed in the samples T e samp e was hen milled and gro rd or the est ma on n losses in cons ituent fractions nd d e o micr b contamination by serial dilution techniq e

Cooking characteristics

Cooking ha ac eristics such a water p a e optimu cooking time at chinese vol me e pans on swel ng nde and gruel loss were de er ined ir 10 to 20 g of the milled and cooked samples using stand d techniques (Table 4)

Table 4 Methods used for estimating cooking characteristics of rice grains

1	Water upt le	Bhattacharya and Soubhagya (1971
	Opt m ocl ing t e	Il tt ch ry nd So bhagya (197)
	Sticl ines	Swam nathan (1971)
4	Volume e pansior	Das et al (1991)
5	Swell g inde	and Fe er (1764
	Grul 1	S ji a Rac t 1 (19 7)

Organoleptic characteristics

O g r leptic cl racteristic of different varieties of | l ver ne led in t c ir ti I d final stages f storag Fo the conduct of acceptability trials 10 panel memb rs were selected by t iangle Test (Jellinks 1964)

The m jr quality attrib t s scored by the Fanel members cr a 5 point hedonic scale we e colour hardness and o our in raw rice samples Appearance colour flavour te ture t ste and doneness we e evaluated n cooked rice a | les The Fanel mbers were gi en the prepared score ca d in which scores for the numbe ed va ieties were given aft r testing the samples Score sheets upto 5 scores for e ch of these cha acteristics we e used (Swaminathan 1974) D t je pert ining to the score c rds sed fr the e | riments a e presented in Appe dices 1 a d 2 o a 1it f r c on d r r r

from t e e alt ion of the o al t e of ro ted ce

4 Statistic l analysis of data

Th d ta e a te l n sti al st t e

a c the mc too igq e b c

ab) ee emen c org o ept q ali t o

core b r e a llis t t q ar Fa 198

RESULTS & DISCUSSION

RESULTS AND DISCUSSION

Tl i n ti t on c Q alit t d q ntitative large sto ed ce p e n s a co prehens ve info mat on n tl c l l f q l tie o l l J rice sa ples vi ed Thriven (RT) and lochuv thu (FTB 10) s ored n three l ffer n e gt L ct rce cl s p t yam g y bag d sto age bu cr si months th cference to changes in

) (co stitu ts

2) Ph c l characterist cs

( ) I se t fest on lo se

) Coo ng cha acterist cs

Org le c q l tie rd

) S itabi it cf re based p eparations

Ct g s i grain cor tituents a d rc noleptic q alit es vere determined in aw and cooked rice samples

The temp ratu e and hu idity of the three storage t uctures ere ecorded at pe iodical inte als du ing the to ge p iod le rate of chemic l and b ological rea t ons ir food material during storage depends on its ate c r tent The temperat c of the materi l or the su r ound ng atmosphere also influences the ate of c tions lo ses occur in to ed r ce samples mainl because of its hyg oscopic nat re The grain with safe orage mois re n also found to dete iorate due to v ι or r tempe t e th ctni n de ol ped in fl d l of tl to ng l tι r Relative l midity r l ι t t al n in l nd gr n also fo nd to ε ι eq ilibr ι vith m l re ir the g a r and is lly n l rced b the te pe atι e f the torage ι e

) ι il p taining to this a e pre ented T ble 5 l ch don es n ncrease in te t re a h m d t a the st ge per od prog es es i ll the three storage tr ctι es l d Te pe atιre r l l m d ty ere highe in ιι bag he compared to path y a d sto ge bi

Table 5 Changes in temperature and humidity in the three storage structures during storage period

Storage period (in months)	Temperature (oC) Gunny bag	Temperature (oC) Pathayam	Temperature (oC) Metal bin	Humidity (per cent) Gunny bag	Humidity (per cent) Pathayam	Humidity (per cent) Metal bin
No te 199	[illegible] 00	2[illegible] 00	22 30	65 80	65 40	6 [illegible]0
ecemb r 199	2[illegible] 50	22 00	[illegible] 00	6[illegible] 00	65 00	6[illegible] [illegible]0
Jan ary 1994	[illegible] [illegible]0	2[illegible] [illegible]0	2[illegible] 00	64 [illegible]0	64 20	6 80
Febr y 1994	25 80	25 60	[illegible] [illegible]0	64 80	64 [illegible]0	6 80
March 1994	[illegible]0 00	28 00	26 00	6[illegible] [illegible]0	65 80	64 00
April 1994	[illegible] [illegible]0	[illegible] 00	0 00	67 80	66 40	65 [illegible]0

I tle sto age strιctι es tle variations in the temperat e we e g eater tha the changes in h m dity These v riations we attributed to change in atmospheric t mperat e and h midity of the area where the storage tructure were tried Losses i moistur we e g e ter in g nny bag as it is easily infl enced by the atmos for c te per ture and humidity wher comp red to polt yen and storage bin Very little va at on n tempe atu was el er ed inside the bin as comp red to high t m p te ic fluctuations outside ir ma mum and m nim m tempe t e Moisture migration s minimi e i in met l bin p obabl because of its good i sulation prope t es

The eq ilibrium moistu e co tent of food s l linked to the ambient elative humid ty Lo relative l midities a therefore desi able The e pe iment desc ib d her e w s done in small bul of 10 kg rice nder clo ely controlled co ditions S ce the v r press of water will be ppro mat ly consta t througho t the s o ge tr ct e v iat ons in tempe t e ll aut m c l y c eate variations in elat ve humi i ty High r tempe a re ill mean lower el ti e h midity r ice ve

r ir q lit studi d i of t o lard tie o ient qu lit characte s based n pro e r rd c t g q lity r fo d prep at ons and the c r c qual charact r t a e i r n tratio and h y ical r c er e ics

4 1 Grain constituents of raw rice samples and cooked rice samples during storage

C ain constit rt st dard ere st re protein n rp otein cge ic aci n nr l nd f e fatt acids

4 1 1 Moisture level of stored rice samples

Dr f d is alwaye at less isk of poil r mo s food Mo t re lev l of ri e s mple is r p rt iler on i fl encing sto ag q al t n c r e e r o sture cor ter t of torage el tures c lted i enh nce g ain ard insec e pira ions esult ng n r r ase enar al e a d bi leterioratio

Effect o to age periods d etc e con i cn th oisture l vel cf tored rc sample re p t d Table 6

Table 6 Changes in moisture level of rice samples due to storage and storage containers

Rice Varieties	Moisture level of rice samples (g)				
	Fresh samples	Stored samples			Mean
		Gunny bag	Pathayam	Metal bin	
PTB 10	14 30	14 70	4 38	14 31	14 42
		(+0 4)	(+0 08)	(+0 01)	(0 17
Red Triveni	13 10	13 50	13 31	13 01	1 30
		(+0 4)	+0 21)	(0 07	(0 10)
Mean	13 65	14 10	1 84	3 64	
		(+0 55)	(+0 19)	(0 01)	

Number in parenthesis indicates increase in moisture

CD values

Va 0 329

Co 0 321

As revealed in the table there was variation in moisture content between varieties and among storage containers throughout the storage period. During storage average moisture level in PTB 10 was observed to increase by 0 17 per cent while for Red Triveni the increase was 0 10 per cent. This variation may probably be due to the difference in temperature of rice stored in the containers. Among the storage containers the rate of increase in moisture was minimum in metal storage bin (0 01 per cent) followed by pathayam (0 17 per cent) and gunny bag (0 5 p r cent) for the two rice sampl p ob ly bec use of the good insulation p ope ty of the metal bin

When data on moisture level was statistic ll a lysed a significant va iation was obser ed in the mean co es obtained between the two varieties of rice The i c se i moisture level for the rice samples when sto ed n the different co tainers was significa t e cupl betw en r ce samples stored in pathayam and metal b n Abstract of ano ta le is pre ented in Appendi

Accor d ng to F u c (1987) ol d id cli at ma lead o deterioratio of gr in st es rde e ch cl mates re u le d ied to 0 per ce t le l cistu e content or less are found to h ve better shelfl fe for a pe iod of n months

Sinha a d Wallace (1985) stated th t when m rked te pe atu e diffe ences e ist or de elop r d ff ent p rts f storage p ce oiste e incre es I this e per ment moistu e is t rsported f om w rm to co le reg o of sto d gr in the lo je co t i er and p il ge occur as a res lt r e cessive mo tu e n pa ts of he o ge spa e e ertlough o e f the q in init lly cont ined sufficient mo stu e to p omote spoi ce The v i ti n i moist re pr bably be ue to he iffe c ir mo t e current tio diffe nt to aie on a re

/ n ı _t_ _l_ (1978) r ported that the moist conten below 14 50 pe ce t assurer long te m sto age of rice They also indicated that when the rice cor aining 00 p r cent moisture content was packed n F ly ethylene ontairc = three months of sto age it out a n ge a allowable at 25oC

Driage loss ir the rice samples o ked out = rq the formula

M? 41 100

Where M1 moist re of ric s m lcr l fcre storage

M? roist e of rc sar ple fte torage

Dri ge loss of stored rice ampl s presented ir T bl 7

Table 7 Driage loss of stored rice samples (per cent)

Rice Varieties	Driage loss in storage containers (g)		
	Gunny bag	Pathayam	Metal bin
FTB 0	0 47	0 09	4 0
Fed Tl iveri	0 4c	0 ?4	0 10

I FTB 10 stored r gu n l g the dr age loss d e to va iat or in moist (14 0 per cent n o m ln b s w s 0 47 per cent i g n/ b g while Fed Th r i l 0 45 er cent Tr pathayam the l i je lo = c Lo a on ir i ture v s 0 09 per cent of FTB 10 while i Fed Th iveni t as 0 2? pe cert In met l bin th d iage lo = was l compa ed to the other t o stor ge ri t e 0 0 per cert for FTB 0 and 0 10 pe ort for Fed l on

4 1 2 Protein level of stored rice samples

P otc n conter t of rice a ietics u ally a ge bet ee 7 4 to 8 0g/100g Earlier studies have shown that hig yielding rice arieties were found to co tair mo e protein s compared to local varieties As sto r by e l e or the a i bility i p otein co tent of r ce var mainly due to the envi conment in which it I s bee gro r I otei i affected by denatu ation d e to age ng of ric e ples o due to ir ect attacl during rage

Eff t of sto ge on the p otein e el of rice sample re pre e ted ir T ble 8

Table 8 Changes in protein level of rice samples due to storage and storage containers (g)

Rice Varieties	Protein level of rice samples				
	Fresh samples	Stored samples			Mean
		Gunny bag	Pathayam	Metal bin	
TC 10	7 70	7 0 (0 01)	7 (0 11)	7 (0 0)	7 4 (0)
Tel T ri eri	8 05	8 40 (0 1)	9 50 0 10)	9 0	8 (14)
Mean	8 10	7 7 (0	7 0 27)	8 0 (0 01	

Numbers in pa enthe indic percentage decrease r p oteins

CD values

Va 0 71

C 0 91

Tabl 8 reveal that the was a de line ir c o otei level of rice samples due to storage A decrease of 0 14 per cert were noted in Red Thriveni while in PTB 10 the decre re was 0 72 per cent Among the storage containers changes in p otein content noted in gun y bag (0 5 per ce t) was higher when compared to pathayam (0 27 c cent) nd metal bin (0 04 pe cent)

A co pa ison between va i ties re e led th t d l n in protein level was g eater n local v riety (PTB 0) n all the three torage st ctures tried

Stati tical analysis of the data re ealed a gn fican v ri tion i the decrease in protein le l bet e the two rieties of rice

A s gnificant v riation r p otei los f r each var et hen stored in d fferert cont iners we e lso f und ce t bet een rice s mples stored g nn bag and p thayam Abst act of ano a table s presented n p di

[l i t dic c luc d l S jv L l (1) h d r eal d th st r ge d ation l conditio s did ffect th pro c n n tert cf rice gr ir Tot l f e m ar l in e decre sed with t me d ring storage f n h led to th ele ter d s h ce Da hl i 1971

According to Narayanan Rao et al (1984) storage of brown and milled rice at room temperature reduced the amount of proteins which are soluble in per cent sodium chloride as a result of protein denaturation

4 1 3 Nonprotein nitrogen level of stored rice samples

Nonprotein nitrogen includes aspartic acid ... glutamic acid ... lysine The nonprotein amino acid fraction is only ... per cent of the total amino acid ratio

Effect of storage on nonprotein nitrogen level of stored rice samples are presented in Table 9

Table 9 Changes in nonprotein nitrogen level of rice samples due to storage and storage containers (per cent)

Rice Varieties	Fresh samples	Stored samples: Gunny bag	Stored samples: Pathayam	Stored samples: Metal bin	Mean
TE 10	5 11	5 00 (0 10)	5 05 (0 05)	5 0[illegible] ( )	5 09 (0 0[illegible])
[illegible]	[illegible]70	6 64 (0 06)	[illegible]8 (0 0[illegible])	6 70 ([illegible]	6 69 (0 [illegible])
M[illegible]	5 90	5 32 (0 08)	5 84 (0 04)	5 90 ([illegible]	[illegible]

Figures in parentheses indicate decrease in nonprotein nitrogen

CD values

[illegible] 0 917

As revealed in the table nonprotein nitrogen decreased in local variety PTB 10 by 0.14 per cent while in Red Thriveni it was 0.07 per cent. Among the storage containers decrease of 0.08 per cent and 0.04 per cent were noted in gunny bag and pathayam respectively while such changes were not observed in metal bins. A decrease in nonprotein nitrogen may be due to their water soluble quality. In a high moisture level of the storage structure nonprotein nitrogen was taken up by the insects attacking the grain. As the moisture level increased there was a corresponding decrease in nonprotein nitrogen of the stored rice samples.

Stati l c l n lysis ev led a s ficant riation on the dec e of n p otein it ogen b ween th t o rice a ples. Abstract of a o a table is presented in Append ~

As st ted by C lde et al (199? c k prot in c nte t f u g cc to at 14 p cent i t c le l id no l a ge wh was no p otein nitroge in t str c pl lo e ed ddenly f om 10th to 14th onth of ge. Significant ch nges did no ccur in nonprot n t og n in l a l l t s of l j

F l d Reddy 19) et cl rge ar t o q l t f cr nd jowar sto ed in th differ t ng o i tic ion of A dhr P des Che l com o tion of l d d dc o in p ot in f mi n t ogen l l ase ci

4 1 4 Uric acid levels of stored rice samples

Uric acid = one of the major e et on r od cts of insect pe ts When u ic acid is present abo e the accept ble limits the pro lu ts e f d lc f f hum consumpt

Eff ct of ch ges in uric acid level of tored ice samples a e p esented in Table 10

Table 10 Changes in Uric acid level of rice samples due to storage and storage containers (ug/100g)

Rice Varieties	Fresh samples	Stored samples: Gunny bag	Stored samples: Pathayam	Stored samples: Metal bin	Mean
I TE 10		00	00		4 00
Red Th i ni		1 00	1 00		00
Mean		00	00		

CD values

Va 1 567

Co 417

Va C 1 417

I tored ice sample l r je c i l le el higher in local ar e PTB 16 c of orage co taine Th i rcrce r c id ele t cr nd after ge n lc al a ict PTF n 4 g l fo Fe

Tt ivEni tt inc var iug A ng tle two ariclin h gl yielding riety ac found to be less f ected by in ect nfestati n tlar tle local v ri ty and herce lcss | d ction of uric acid Amorg the sto age cont i ric r l va tecrved i sample sto ed i gunny t g (Tug) a d pathayam Tug) It wa higher in gunn l aj p ob l l d c t gh popula ior of i sects wl compa d lo oth e n ge ortainer

The difference in uric acid l el o l e n t rice n le fo l to L j ir c The r a d oduction i ice mplce i U tl t cr g t ine I ign ficantly ryinq The e ct n L n rta e in rel t o to i l l te tistic l/ l was fo to f r t tr c f c t lc i pr rted in endi

4 1 5 Mineral level of stored rice samples

I c c ce of r l e c n c nd ph erl s Cl j i U a l el o l e n l e t tr j diff t tc ju t p l Table 11

Table 11 Changes in the minerals of rice samples due to storage and storage container [mg/100g]

Minerals	Variety	Fresh	Stored Samples			Mean
			Gunny bag	Pathayam	Metal bin	
Calcium (mg)	FTB 1	9.80	9.20 (0.60)	9.48 (-0.32)	9.66 (-0.14)	9.56 (0.24)
	Red Thriveni	9.50	9.18 (-0.32)	9.35 (-0.15)	9.48 (-0.02)	9.37 (0.13)
	Mean	9.65	9.19 (0.46)	9.415 (0.27)	9.57 (0.08)	9.57
Iron (mg)	FTB 1	3.01	2.70 (-0.30)	2.80 (-0.20)	3.00 (-0.01)	2.87 (-0.14)
	Red Thriveni	4.31	4.26 (0.05)	4.27 (-0.04)	4.30 (-0.01)	4.28 (0.03)
	Mean	3.60	3.48 (0.12)	3.53 (0.07)	3.60	
Phosphorus (mg)	FTB 1	141.27	140.90 (0.37)	141.03 (0.20)	141.20 (0.07)	141.09 (0.14)
	Red Thriveni	162.00	161.00 (-1.00)	161.30 (0.70)	162	161.57 (0.47)
	Mean	151.60	150.95 (0.65)	151.50 (0.10)	151.60	

Number in parenthesis indicate the decrease in mineral content

CD Values (Phosphorus)

a 1.020

A decrease in calcium iron and phospho s were observed in the two rice samples on storage Decrea e in calcium, iron and phosphorus in PTB 10 (0 74) wa greater when compared to rat of decrease in Pa l Thriveni (0 17 p r cent) This variation in minor is ma be mainl du to rate of insect ttack Among the diffe ent storage cont rers for the two rice sa ples dec ease in alci m i on and phosphorus were obse ved to be higher gunny ba followed by pattayam and m talbin Thi may probably be due to the variation in the at ospheric temperature and moist re ithin the sto age truct re

Stati tical analysis of the data re ealed t at the los of phosph us in r ce sample was significant A stract of rova table is pres ted in Appendi

Acc ing to Adi i (1966) loss of tamins nd m ne al || to te separabl ith o ge no mal conditio h a cold sto age fo and lf yea lad no y significant loss of l

Ra j r ther t l (1987) epo ted 75 per t loss i calci r l 50 pe cent loss i phosph o s f om t stor age methods mmonl ed in India

4 1 6 Free fatty acid levels of stored rice samples

St e ice h tenden y to g p iled

Th b ought t t ll lap r of the

[illegible] samples. F[illegible] fatty acids were found to increase with the storage period due to oxidation of fats on prolonged storage.

Table 12 presents the details pertaining to the free fatty acid of stored rice samples.

Table 12 Changes in free fatty acid level of rice samples due to storage and storage containers (in per cent)

Rice Varieties	Free fatty acid level of rice samples				
	Fresh samples	Stored samples			Mean
		Gunny bag	Pathayam	Metal bin	
PTB 10	0.71	[illegible] (+0.61)	1.[illegible] (+0.61)	0.9[illegible] (+0.21)	1.08 (0.[illegible])
Red Thriveni	1.[illegible]	1.50 (+0.2[illegible])	1.37 (0.1[illegible])	1.[illegible] (+0.10)	1.[illegible] (0.1[illegible])
Mean	0.99	1.42 (0.4[illegible])	1.29 (+0.[illegible])	[illegible].1[illegible] (0.14)	

Number in parenthesis indicates increase in free fatty [illegible]

Difference in free fatty acids [illegible] (0.[illegible] per cent) for local variety PTB 10 after storage while for Red Thriveni it was only 0.1[illegible] per cent. An increase in free fatty acids was noted in the stored rice [illegible] between the two varieties [illegible] of [illegible] was increasing in PTB 10 [illegible] the Red Thriveni. Free [illegible] acid composition [illegible] the storage containe s due to moisture cortent and tempe at re As the lled rice co tains only trace amounts of natural antio idants, stability of its lipids gainst o dati e dete ioration is e pected to be poor compa ed with tha of rough rice lipids Variation among st rage co taine s vealed th t in all he to age cont ne s an e n e n n free fatt acids as observed ith highest concent at or in g ny bag (0 4) followed by pathayam (0 79) and m t l ain (0 16) Moi t e content of the torec ice sample t d a direct infl ence on the free fatty acid formation during st rage

Statistical analysis of the data re c led tl t the iatio the incre se in f ee fatt ac l levels between the two ice sar les and storage st cture not g ificant Abst act of aro a table is p se tod n Append

Acco ding to Ph lival et al 1991) dried ice s mples l l e l ce l r ele of free fatty cids F a o r d d free fatty cid cortent increa ed ir ll s mple d irg sto age

Dhali l et al (1990) repc ted that drying of padd b fo e tor ge did ot p odu e notable ffect n t fa ty cid compo ition e c pt that p lmitic id incre sed and l noleic ac d decreased to scro e tent Higher fatty c ds howed d crease t 6 month n are re ob ved after 12 months sto age

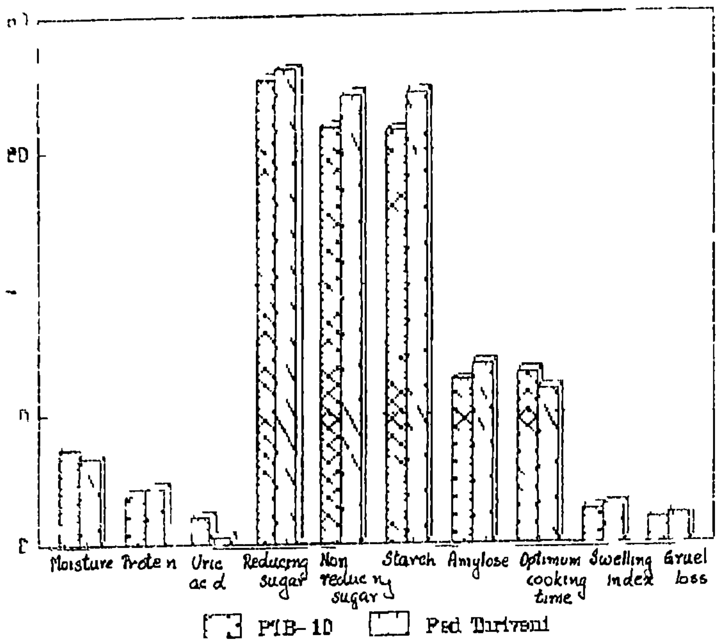
Studies conducted by Yas tel and M it h (1970) h d evealed that total fat content of milled rice remained constant either in ordinary or hermetic torage c a wide range of moistu e nd temperatu e conditions They had f rther eported that gross co positio f f t onten of stored rice nevertheless changed with an increase in free f tty acids and a decrease in n utral fats

The changes occur ing in fatty acid compos t on of ur d ice affected the fl vor of s ed rice d e to increase n lo e fatty acids during sto age (Ramaratnam Iulla i 1988)

Barber et al (1988) obse ed that th l pids of rice samples (b a re o u d and th 1 73 pe cent moi tu e containing about 60 per cent neutral fat 25 per cent free f t acid nd 15 pe cent pl o lol pid c arged c 40 per ce t ne tral fat 55 p r cent free fatt cid and 5 pe ent phosphol pi 1 n no ths st g oC se ed co taine s

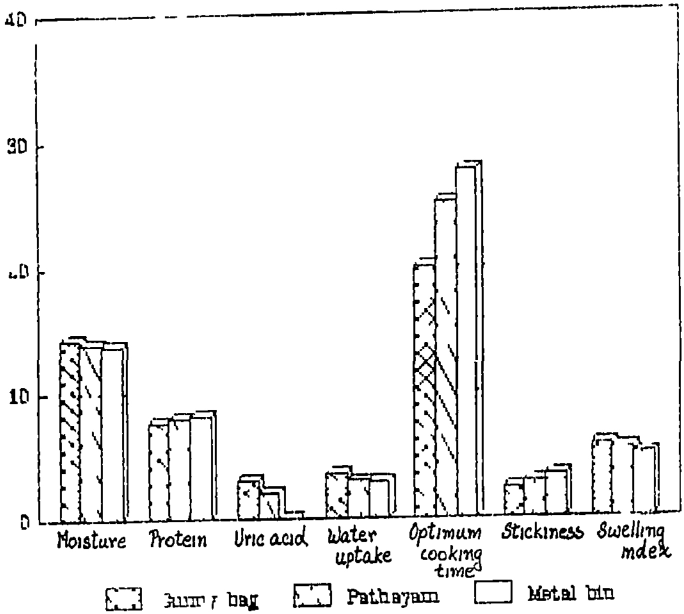
Over ll esses of ch g in j in co t ents d e to sto ge re ealed that i FTB 10 cer ain constit ents l h pr t i d re l in t ace der ed t r ter rate than in Red Thriven Increase in o st re t c acid

Fig - 1f



Changes in Grain constituents and cooking characteristics in rice samples due to storage

Fig-5



Changes in grain constituents and cooking characteristics in rice samples due to storage containers

I frer f tty cid PTT 10 v ~ nl o r sinil r rend (Fiq 4)

Amorq stor ge cort iners tricd dec ε in p ot in and ro p otein it ogen w s greate in gur y q foll d by patlayan and et l bin Simil rly inc ea L n noie ric acid and f cc fatty acids in t i c ples o d in rny bags vcre gre ter tlen tfc otle tvo tor qe container tried (Fig 5)

Effect of cooking on rice grain constituents

Among the various constituents reducing sugar, non reducing sugar, starch and total amylose in the rice grains were found to be affected by cooking. Newly harvested rice when cooked becomes a sticky or pasty mass depending on the concentration of these constituents. Upon storage the rice swells more easily resulting in more flaky and integral grain with a thin gruel because of the change in the above constituents.

4 1 7 Effect of storage on the reducing sugar level of raw and cooked rice samples

Reducing sugar in rice consists of glucose and fructose. During storage the insoluble starch is converted to soluble sugars. Reducing sugar affects the cooking quality of rice samples by taking up more water during cooking.

The cooking quality and glutinous nature of rice largely depend on its amylose/amylopectin content (Fao 1970).

Table 1 presents the reducing sugar level of rice samples on storage.

Table 13 Changes in reducing sugar level of raw and cooked rice samples due to storage and storage containers (in per cent)

Variety	Treatment	Fresh samples	Reducing sugar level of rice samples: Stored samples — Gunny bag	Pathayam	Metal bin	Mean
PTB 10	Raw	68 [illegible]0	70 60 ([illegible]2 [illegible]0)	70 [illegible]0 (+2 [illegible]0)	70 6[illegible] (+2 [illegible]0)	70 48 (+2 [illegible]0
Red Triveni	Raw	70 [illegible]0	72 [illegible]0 (+1 80)	72 10 (+1 60)	71 50 (+1 00)	71 96 [illegible]+1 46)
Mean			71 45 ([illegible] 0[illegible])	71 1[illegible] (1 7[illegible])	71 [illegible]0 (+1 [illegible])	
PTB 10	Cooked	70 10	74 00 (+[illegible] 90)	[illegible]4 [illegible]0 (+4 [illegible]0	7[illegible] 80 (+4 70)	7[illegible] [illegible]6 +4 26)
Red Triveni	Cooked	7[illegible] 00	7[illegible] [illegible]0 (+[illegible] 00)	74 [illegible] (+[illegible] [illegible]0)	74 30 ([illegible] 90)	74 [illegible]6 (+2 [illegible]6)
Mean		7[illegible] 00	74 [illegible]0 (+2 95)	74 00 (+[illegible] [illegible])	74 30 (+[illegible] [illegible]5	74 [illegible]6

[illegible] in parenthesis [illegible]dicates [illegible]

CD values (Raw)

V 0 101

During storage reducing sugar level in rice increases. Between the two rice samples the increase was greater in PTB 10 (2 0 per cent) than in Red Thiver (1 46 per cent). Among the three storage containers the increase in reducing sugar of raw rice samples was highest in gunny bag (? 0? per cent) followed by pathayam (1 7? per cent) and metal bin (1 67 per cent). Reducing sugar level in stored grain is greatly influenced by moisture and temperature of the storage structure. Among the three storage structures attempted, gunny bag had a higher level of moisture and temperature than the other two storage structures. A comparison between the stored raw rice samples revealed that the increase in reducing sugar level was greater in gunny bag followed by pathayam and metal bin.

Compared to raw rice the reducing sugar level of the cooked rice samples were higher. In fresh as well as in stored rice samples after cooking the increase in reducing sugar level was higher in PTB 10. However, variation in reducing sugar level between the two rice samples after cooking was lower in the samples stored in gunny bag (? 9? per cent) when compared to pathayam (per cent) and metal bin (7? per cent).

Increase in reducing sugar during cooking may be due to the hydrolysis of starch to sugar.

Statis cal lysis of the d re l t t variation i the mean educing gar val b a ed fo the two ice s les in w form alone was sic ficant A ract of anova t le is p e ted in Appendi 4

Earlier studie had indic ted t t tot l ars se and de t in of brown rice decre d fle l ght i r ase ring stor g An inc e i ucing of r ce sample du ing torage was observ ed by Tani et al (1990)

Acco to H a et al (939) g greatly infl en ed b e peratu and to les er c ent by isture co te t of the storage et ctu e At C o marked c ges n ugar level in sto e ce ve e f d to r

(ra et al 1978) repor that g te in inc e sed l l of acidity n r d g su ile me m co r tle of the p c t ri l

4 1 8 Nonreducing sugar level in rice

Nor e g in ric re t Ch ces i ired c suga the r e ing or yc n ile to ng i p r h t 1

Table 14 Changes in nonreducing sugar level of raw and cooked rice samples due to storage and storage containers (per cent)

Variety	Treatment	Fresh samples	Stored samples: Gunny bag	Stored samples: Pathayam	Stored samples: Metalbin	Mean
PTB 10	Raw	64 10	67 00 (1 1)	67 70 (0 9)	67 50 (0 6)	[illegible] (0 8)
Red Thriveni	Raw	68 0	68 00 (0 7)	68 00 (0)	48 10 (0)	68 [illegible] (0)
Mean			65 70 (0 7)	64 80 (0 6)	65 00 (0 1)	
PTB 10	Cooked	67 2	6 0 ([illegible] 0)	64 80 ([illegible])	65 00 ( )	65 07 ([illegible])
Red Thriveni	Cooked	70 0	68 90 (1 4)	70 00 (0 7)	70 0	69 7 (0 57)
Mean			67 10 (1 7)	67 0 (1 [illegible])	67 [illegible] (1 1)	

Number in parentheses indicates the decrease in nonreducing sugar

CD values (Raw)

V 0 080

Co 0 108

V x Co 0 15[illegible]

Amorg the raw rice samples a decrease of 0 87 pe cent in nonreducing suga level was noted in PI 10 hile the decrease ir Red Th iveni was 0 70 per cent Amo g t e storage con i e s dec ase of 0 70 pe cent 0 60 p cent and 0 40 pe ent in no educing sugar were b erved ir the g nny bag pathayam and metal bin espectively A c m i or between PTB 10 and Red Thriveni revealo that dec ease ir nonreducing s gar was greater n PTB 10 n all the three torage containers tried When compared to raw rice sample n the cooked samples the decrea e n n reducing ugar ir PTI 10 (2 79 pe cent) as well as in Red Th iveni (0 57 pe cent) was g eater

Among the storag contai er decrea of no cing s gar level was greater in PTB 10 in all th th ee torage cont iners ir the o der of gunny bag pathayam and metal bin Changes in nonreducing sugar le el in the stored rice samples may be due to temperature changes with n the storage st uctures

Statist cal anal is of the d ta revealed a s g f cant de rease in nonr du ing sugar level b tween the two va ieties of tored aw rice

A significant v r tion ir th nonreducing su l vel was also observed fo ice s mple ( ) hen sto ir different c tainers

Inte action betv.een the arieties and sto age c ntainers in relation to raw ice samples was l o fn l tc be significant Abstract of anova table is p esen ed in Appendi 4

4 1 9 Starch content of rice samples

Sta ch content of the rice dete mi e the q al ty of ice hen cooled F olonged sto age of ce under n t tebl conditions affects cooling q l ty prob bly as a esult of changes starch f action Sta ch co tent ies with different arieti depending on al ylose ylopec n content Amylose i the compo ent with which tl e sta ch granules are filled while its cove ng con tit le n lec le ol lity f myl se r l ylop c i leterm es the cl ges in st rch conte

er il perta i g to the st ch tert of r as well as coo e l ice amples sto ed difre star g contai s is pre rted r T ble 15

FTE 10 Cooled 22 78 27 90
(1 52) (+1 17) (07) +1

Inte action between the a ielios and ior ge containers ir relatio to raw rice samples was also fo nd tc be significant Absi ct of anov table p c er ed in Appendi 4

4 1 9 Starch content of rice samples

Sta ch content of the ric dete mine tl q y of rice hen coo ed Prol nged sto ge of rice rder n t ble conditions affects cook ng quality prob bly as a e lt of changes in starch f action Sta ch content varies with different a ieties d pending or its amylose amylopec n content Amylose is the componcnt with which the sta ch granules a e filled while als covering con tit tes ylopecti Sol bil ty of lose nd amy e in d te mines the hange in starch conte t

Details pertairing to the ta ch cortent of ra s ell as cooked ce samples sto ed n d ffe er to anc cc tainers is presented ir Table 15

Table 15 Changes in starch level of raw and cooked rice samples due to storage and storage containers (per cent)

Variety	Treatments	Fresh samples	Starch level of rice samples: Stored samples – Gunnybag	Pathayam	Metalbin	Mean
[illegible] 10	[illegible]	6[illegible] 50	6[illegible] [illegible]0 (1 00)	6[illegible] 70 (1 [illegible]0)	6[illegible] [illegible] ([illegible])	[illegible] ([illegible])
Red Thriveni	Raw	70 00	68 [illegible]0 (1 30)	69 10 ([illegible] 00)	[illegible]8 [illegible] (1 [illegible])	68 [illegible] ([illegible] 70)
Mean			[illegible] (1 4[illegible])	[illegible] (1 90)	[illegible] ([illegible])	
[illegible] 10	Cooked	[illegible]4 50	[illegible] [illegible]0 (1 [illegible])	6[illegible] [illegible] (1 [illegible])	[illegible] ([illegible])	[illegible] ([illegible])
Red Thriveni	Cooked	70 00	[illegible] (1 10)	[illegible] ([illegible] [illegible]0)	[illegible] ([illegible] 50)	[illegible] (1 [illegible])
Mean			[illegible] (1 [illegible])	[illegible] (1 [illegible])	65 (1 [illegible])	

Numbers in parentheses indicate the decrease in [illegible]

CD values (Raw)

Va 0 522

C 0 [illegible]7[illegible]

[illegible] 0 [illegible]

CD values (Cooked)

Va 0 508

As rev aled in the table in raw rice s ples 1 6 per cent starch decrease w s noted in PTE 10 while the dec ease in Red Thriveni was 1 70 per cent Among the storage co tainer s the dec ea e was 1 40 per cent 1 90 p nt and 1 90 per ce t in g nny bag p thayam and me l l bin espectiv ely The decrease i starch content of ice amples was greater in metal bin prob bly due o the increase i the insol ble amylose fracti n on st ge A co parison bet een the two ric arieti eve l h t decrease in starch le el was g eater r Red T ive than n PTE 10

Cooking fo lo n fl ce th t e ... led in t e tabl in coo d ampl 1 60 ent t el dec e se was noted in PTE 10 while the decre e i Red Thriv i was 1 7 per ce t Among the torage o inere lere decre e r all li th er ag co i r s t l t e compa t ile st ch t cf f e h s mp A co p rison between rice s mples r aled th t starch le vel dec eased o c in Red Th i er i r n PTE 10

The t t when s tistic ll n l sed e le t a i tion to see the decrease t e a le el f le two (raw a d co ed) rice mples o s or g was s gn fic nt

Among the three storage contair rs used the variat on in the decrease in the values obtained fo a ice samples was significart e cept betweer pathay m and metal tin Inte action between the rice samples and storage cunt iners in elation to starch co tent in raw form sl r ed a significart differen e Abstract of anova table s presented in Appendi 4

4 1 10 Amylose level of rice samples

Amylose is the li ear molecular co ponent of ice sta ch which dete mines the te tu e of cooked ce high amylose rice hen cooked is moi t and f l and do not ha den after cook ng Amylose ontent i thus t e ost i portant criterion or g ain quality Amylo amylo ectin ratio is tl efore c i ide ed as an indi t of q al ty A ylose cont nt of ice classifies rice into e y an n or w y type Total amylose comprises of both insol l le and soluble am lose Details pert ining to to l amylose content in stored i e samples is presented in T ble 16

Table 16 Changes in amylose content of raw and cooked rice samples due to storage and storage containers (per cent)

Variety	Treatment	Fresh samples	Stored samples: Gunnybag	Stored samples: Pathayam	Stored samples: Metalbin	Mean
PTB 10	Raw	[illegible]5.08	25.50 (+0.42)	[illegible]5.[illegible]0 (+0.1[illegible])	2[illegible].00 (0.09)	25.[illegible]0 (+0.1[illegible])
Red Thriveni	Raw	27.[illegible]0	27.8[illegible] (+0.[illegible])	[illegible]7.81 (+0.[illegible])	27.80 (+0.[illegible]0)	27.80 (0.[illegible]0)
Mean			26.60 (+0.41)	26.50 (0.[illegible]1)	[illegible]6.40 0.[illegible]1	
PTB 10	Cooked	2[illegible].[illegible]8	[illegible].90 (+1.5[illegible])	[illegible].[illegible]0 (+1.1[illegible])	2[illegible].47 (+1.09)	[illegible].60 +1.[illegible])
Red Thriveni	Cooked	22.[illegible]1	[illegible]4.10 (+1.[illegible])	[illegible]4.[illegible]1 (1.[illegible]0)	[illegible]4.[illegible]0 (1.[illegible])	[illegible]4.[illegible]0 (1.[illegible]0)
Mean			24.00 (+1.60)	[illegible].90 (+1.[illegible]0)	[illegible].[illegible]8 (+1.[illegible]9)	

N mber n parenthesis indicates incre se i amylose l vel

CD values (Raw) 1 5 9

CD Values (Coo ed) V[illegible] 0 [illegible]01

As revealed in the above Table 0 1 pe cert in ease in total amylose was roted in FTB 10 hile the increase in Red Thri eni was 0 50 per cent wher f st rice sample were te ted Among the storage contai e s the increase of 0 4 per cent 0 71 per cent and 0 21 per cent were obser d in gunny bag pathayam and metal bin espectively A comparison between ric samples revealed that the i se in mylose content was greater in Red Thriveni in all the sto age structures tried

In cooled samples as revealed in the table 1 22 per cent amylose inc ease was observed in FTB 10 while in Red Thriveni it was 1 80 pe cert A ong the s orage containers there was 1 60 pe cent 1 50 per cent a d 1 50 pe cent increase in gunny b g pathayam n d metal bin re pe ti ely A compariso between va ieties ealed that the increase r total amyl se content was slightly great in Red Th veni ir all the th ee sto ge containers

Statisi cal ar lysis of the dat rev aled s gr fic nt v iation n the mylose content of a and coo ed ce samples f the two arieties tored n iffere t orage containers Abstr ct of a v able s p e nted in Appendi 4

Accor di g to I dh dhara wamy *et al* (1 78) upon torage for a few months cooking of e e l n mo e welled i e nd th gruel a l amylo e co e t w l e ed to te the princip l dete min t of ε ε rrcl nq ch acte istic He also stated that conseq ently n ol tle amylose increased in stored rice

In repo t of Inte national Rice Res rl Ir= it te (~~1985~~ 1975) t has bcor stated tl t rough r ce milled rice and s rface defatted milled rice slowed s milar cnanges eg dless of the fo of storage (4oC or 8oC) in m/lo o p otein contents

Mod et al (1975) conducted studic lich re ealed an increase in mylose content of s o ed ce They also tated that in addition to lipids ncr larch ccll ll component (Polysaccharides) lso affected the am loj aph of milled ice Shit y s 1979) finding also supp ort thi study

A sal ent finding to be noted is t at rrd ir ugar d am/lo increase at a g tc r to in cooked ice amples tl in aw amples The decre ε in nor ducing ugar and sta ch c also cheerved to follo a similar t crd Th ate of change either der ea e o n c e n these constituents es gre er in [] n tt ir Pod Th iveni

Cor s ing t effect f sto gc ont riced inc ease in reducing ga a d a lose l l e gr ate j airs st l a gu ny bag th n n otler sto age c n a nc t iod n both aw l cooked samples l rl/ tl decrease in nonreducing sugar and starch level in raw and parboiled rice samples was also found to be greater when stored in gunny bag followed by pathayam and metal bin for better storage structure like metal bin ensures less disintegration of rice during storage

4 2 Physical characteristics of raw rice samples during storage

Physical characteristics of rice samples studied were thousand grain weight head rice yield total solids viscosity and gelatinisation temperature Thousand grain weight and head rice yield were estimated in raw rice samples and total solids viscosity and gelatinisation temperature were estimated while cooking

4 2 1 Thousand grain weight of stored rice samples

Thousand grain weight is the weight of thousand grains of rice samples randomly selected Effect of storage on thousand grain weight is presented in the Table 7

Among the storage container there was no change in the thousand grain weight in metal bin due to storage whereas 0 40 per cent and 0 10 per cent decrease were observed in gunny bag This may be due to moisture absorption as well as the loss of certain constituents of the g a n du irg storage

When the data on thousand grain weight of rice samples was statistically analysed the difference in the mean thousand grain weight obtained after storage was found to be significant between the two rice samples S gn f cant difference was also noted in the mean values obt ined fo the varieties in the three sto ge containers tr d

The interaction between the rice samples and containers were also found to be significant Abst act of a a table is presented in Appendix 5

Storage conditions affect thousand g ain we gh since the increase or dec ease in certa n constituents of the grain can effect the net we ght of the grains Webb a d Ste ner 1972) epo ted that thousand g n weig t of ce amples varied considerably with the moisture content But in the present study thousand grain weight did not increa e i the grains with higher moisture content This m y be d e to the l s of g i constitue t on t age

Table 17 Changes ın thousand graın weıght of rıce samples due to storage and storage containers (g)

Rice variety	Thousand grain weight of rice samples				
	Fresh samples	Stored samples			Mean
		Gunny bag	Pathayam	Metal bin	
FTB 10	28 70	27 50 (0 8)	28 00 (0 7)	28 70 (0 7)	27 90 (0 5)
Red Thriveni	25 00	24 90 (0 1)	25 00	25 00	21 55 (0 45)
Mean	26 65	26 25 (0 4)	26 50 (0 1)	26 65	

Number in pa entle sis indicates dec ease in thousand grain weight

CD Values

Va	0 115
Co	0 111
Va Co	0 200

The table eveals that thousand grain weight decreased in FTB 10 by 0 5 per cent whereas in Red Th iven the decre se was less being 0 45 per cent A comparison between ice amples evealed that the dec ease was g e ter in Red Thri eni in all the storage structu es tried E er t gh the los of grain constit ents took place in both he ce amples cast re abso ption as g e ter in FTB 10 whi might b ontrib ed to the h ghe tho s nd gra n we ght

Statistical [illegible]nalysis of the d[illegible]t[illegible] revealed that the association between thousand grain weight and mo[illegible]ture le[illegible]el of stored rice samples was not significant (r [illegible] 0 120) and details a[illegible]e p[illegible]esented in Append[illegible] 5

4 3 2 Head rice yield of stored rice samples

Head rice yield is the yield of [illegible]hole milled [illegible]ice obtained on milling of paddy [illegible]nvironmental factor[illegible] influence the milling deg[illegible]ee of sto[illegible]ed [illegible]ice samples E[illegible]fect of head rice yi[illegible]ld or stored rice [illegible] [illegible]ples a[illegible] [illegible]resented in Table 18

Table 18 Changes in head rice yield of rice samples due to storage and storage containers (per cent)

Rice variety	Head rice yield of rice samples				
	Fresh samples	Stored samples			Mean
		Gunny bag	Pathayam	Metal bin	
PTB 10	5 07	[illegible] 05 (+0 02)	[illegible] [illegible]0 (+0 17)	[illegible] [illegible] (+0 [illegible])	[illegible] 1[illegible] (+0 1[illegible])
Red Thriveri	7 00	7 [illegible]0 (0 [illegible])	7 80 (+0 8)	7 80 (0 8)	7 [illegible] (+0 [illegible])
Mean	[illegible] [illegible]0	7 00 (0 5)	7 00 (+0 [illegible]	[illegible] 40 (+[illegible] 7)	

Numbe[illegible] in parenthesis indicates in[illegible]rease [illegible]n head ri[illegible]e yield

CD Values

V[illegible] 0 710

[illegible] 0 670

As revealed in table, headrice yield was increased by 0 12 per cent in PTB 10 while in Red Thriveni the increase was 0 65 per cent A comparison between rice samples revealed that the decrease in head rice yield was greater in Red Thriveni in all the three storage structures tried This may be due to the variation in milling degree of the rice samples Among the storage containers there was 0 50 per cent increase in head rice yield in gunny bag and pathayam and 0 90 per cent increase in metal bin The rice samples stored in metal bin were harder than those stored other two storage structures which affected the milling degree of the rice samples Hardness of the grain was found to increase resistance to breakage during milling

Statistical analysis of the data revealed a significant variation in the head rice yield increase A significant increase was noted in the head rice yield of the two rice samples stored in three different containers e ce between rice samples stored in gunny bag and pathayam The interaction between rice samples and containers in relation to head rice yield was also found to be significant Abstract of anova table is presented Appendix 5

Environmental factors such as time of harvesting and moisture content was reported to be major factor influencing the milling recovery of rice (Kumar 1981)

Choudhary and Lin ı (197ﾑ) had reported that du ing storage brown rice became progressively harder resulting in an increase in total and head rice yield because of lower grain breakage on milling The a tho s had also stated that the tensile strength of the grain increased during storage Villareal et al (1976) reported that sto age of g ain for three months res lted in more resistance to breakage during milling

Breakage in milling depends on the environmental factors such as moisture level When oisture level of a sample increases the resista ce to b eakage in milli g decreases Statistical analysis revealed a positi e ssociation between moisture level and head rice yield of stored rice samples (r = 0 5?7) (Table ı Appendi 6)

4 3 ?   **Total solids in stored rice samples**

Total solids fo nd in rice samples consist of mine als vitamins protein n starch wh ch are lost n cool ed ater Storage ha dens th cell wall of rice ample which ca withstand the str of cool ing re ulti g in l   so id loss

Effect of storage on tot l solid l ls of ice samples is presented in Table 19

Table 19 Changes in total solid level of rice samples due to storage and storage containers (per cent)

Rice variety	Total solid level of rice samples				
	Fresh samples	Stored samples			Mean
		Gunny bag	Pathayam	Metal bin	
PTB 10	35 30	33 90 (-1 4)	34 50 (0 8)	34 90 (0 4)	34 65 (0 65)
Red Thriveni	33 57	32 80 (0 77)	33 00 (0 57)	33 20 (0 7)	33 14 (0 4)
Mean	34 40	33 45 (0 95)	33 75 (0 65)	34 05 (0 35)	

Number in parenthesis indicates decrease in total solid level

CD Values

Va 0 702

Co 0 50[illegible]

The table reveals a decrease in the total solids of both the rice samples A decrease of 0 65 per cent was noted in PTB 10 while the decrease in Red Thriveni was 0 40 per cent A comparison between rice samples showed that total solids decreased greatly in PTB 10 in all the three storage containers tried After storage among the varieties the Red Thriveni was harder than PTB 10 making the cell wall more resistant to breakage Among the storage containers 0 [illegible] pcr cent n pattcyn nd 0 75 per cent 1 metal hi verc noted The decrease in total solids in metal pin and pattayam may be d e to the h dness of the rice d ring ageing

When the data on total solid of the gr1 s was statistically analysed the variat on n the dec ease in the mean value of the total solids obtained for the two amples of rice was significant

The interaction between the samples and containers was also found to be significant except in the case of rice samples sto ed in gunny bag and pathay m An t ct of ova table is presented in Appendi 5

Natural ageing of ice is reported to h rden t e cell wall str ctures suff ciently to c use a smaller loss of rice solids into tle cooking water (I dhudi ra S am et l 1978)

According to A et al (1979) loss of solids n cooking water is also reported to be prog essively lo with increase in storage period t t the e of red ction in solid loss in gruel was found to be influenced by the temperat e of the to ge structu

(s stat by all iel et al 1970) the to ge of the grain for as lo g as th e montl llu 1 cd ctio 1 e t ted ol d I 1 g the oolir g loss of total solids into cooking water becomes less on storage It was found that there was eduction n solid loss in the gruel from the rice stored at higher temperatu e

Statistical analysis revealed a pos tive co elation between temperature of storage st uctures and total solid level of stored rice s mples (r 0 557)(Table in Apen i)

4 2 4 Viscosity of stored rice samples

Viscos ty is the esistance f a fluid to shea fo ce and hence to flow Viscosity is a import nt ctor in ice which is influenced by storage th t al p cess of ageing re lt in decre se r amylolytic activity o ch ge in colloidal fo m of sta ch f om sol to gel

Table 20 Changes in viscosity of rice samples due to storage and storage containers (per cent)

Rice variety	Fresh samples	Stored samples: Gunny bag	Stored samples: Pathayam	Stored samples: Metal bin	Mean
TTB 10	10 00	12 48 (+2 48)	10 40 (+0 4)	10 70 (0 7)	10 77 (0 77)
Red Th vera	9 58	14 40 (+4 82)	11 57 (+1 94)	0 08 (+0 5)	11 79 (+1 81
Mean	9 79	1 44 (+ 65)	10 7 (+1 17)	0 14 (+0 5)	

Number in pa enthesis indicates increase in viscosity

CD Values

Va 0 516

Co 0 7

V Co 0 517

The table reveals that there was 0 77 per cent increas in PTB-10 hile the increase in Red Thrivc i was 1 80 per cent Among the storage containers 7 60 per cent 1 17 per cent and 0 75 per cent increase we e not d in gu ny bag pathayam and metal bin respectively The viscosity of ice s mples depend on the solubility of amylose and amylopectin fraction of starch

Statistical analysis of the data revealed a significant var ation in the mean viscosity alues obtained for the two ice samples after storage

Variation in the mean val es for iscosity for each va iety whle stored in differe containe was also found to be significant e cept between ice sa ples stored in pathayar nd metal bin

Inte action betw en the va ieties nd cont ir r fr viscosity of sto ed samples we e also found to be significant e cept between PTB 10 stored in p th y m and metal bin

According to Indhudhara sw my et al (1978) th re was considerable and continuous change in the v scosit parameters th oughout the storage per od and the iscosit of ice paste increased at ambient tempe t re

Ragha e dra Rao a d Juliano (1970) had indic ted that ice with hig mylose content haved a d a t c drop peak viscosity upon parboiling as compa ed ith low amylo e ice

Viscosity of to d rice samples depended on the solubility of amylose fraction of starch A high amylose rice showed high iscosity value and the highest viscosity increase Indhudha a Swamy et al (1978) eported that ageing in rice is a contin ous and rathe indefinite process and a high anylose hard gel rice showed highest increase ir viscosity level

Statistical anaylsis of the data showed a positive significant association between amylose and viscosity of ice samples on storage (r 0 0) (Table n appe di 6)

4 2 5 Gelatinization temperature of stored rice samples

The range of temper ture at which th gel tini or of starch ccu e called the gelatin t on temperature G l ti i tio temp rat e i affected b the starch f action in rice Storage brings abo t hanges n starch contents of r ce Effect of sto age or gelat ni ation temperature of sto ed ice samples is presen ed in t le 21

Table 21 Changes in gelatinization temperature of rice samples due to storage and storage containers (oC)

Rice variety	Gelatinization temperature of rice samples				
	Fresh samples	Stored samples			Mean
		Gunny bag	Pathayam	Metal bin	
[illegible]TF 10	89 [illegible]0	89 60 (+0 10)	89 60 (+0 10)	89 80 (0 [illegible]0)	89 60 (+0 10)
Red Thriveni	87 00	87 20 (+0 20)	87 [illegible]0 (+0 [illegible]0)	87 [illegible]0 (+0 50)	87 25 (+0 [illegible]5)
Mean	88 25	88 40 (+0 15)	88 4[illegible] (+0 [illegible]0)	87 65 (+0 4)	

N mber in pa enthesis indicates increase n gelat n tion e perature

)

CD Values

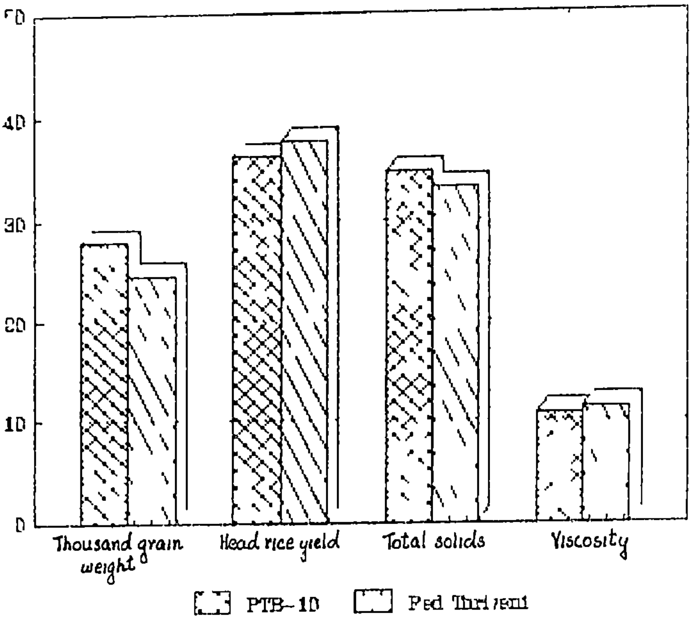
V a — 0 65[illegible]

C o 0 7[illegible]1

As re ealed ir the table gelatini tion temper ture inc eased by 0 10 per cent in PTB 10 while n Red Thriveni it was 0 [illegible] per cent Solubility of starch fraction may be possible for the increase ir gelatini ation temperature [illegible] or the stor ge cont incre [illegible] [illegible] cre [illegible] f 0 [illegible] pe cent 0 20 pe c nt and 0 10 pe cent in g nv bag pathayam nd metal bin re pecti ely The solub lit of st [illegible] [illegible] [illegible] ire s ension f [illegible] st d [illegible] s ple in [illegible] [illegible]

[illegible]

Fig-6



Changes in physical characteristics of rice samples due to storage

Stati lic l r ly is reve led c if cart v iat cn in the on set of gelat rization temperature between the two rice samples

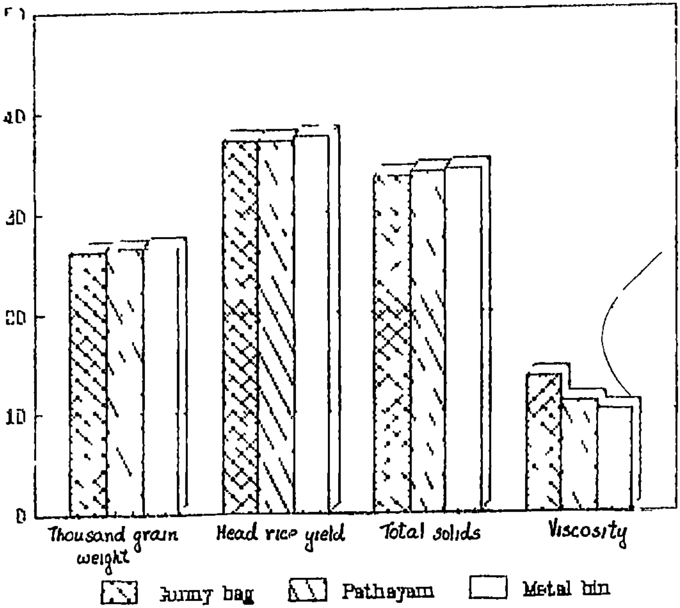
The increase i gelatini ation temperature was significantly varyi g in the ice mples sto ed n different containe s e cept between r ce mples t e l ir p thayam and gunny bag

Nala ana et al (1984) reported th t con eq ent to storage in stored rice grain gelat ni tion onset t r rature was sign ficantly effect l ly the l vel of sta ch f action in the r ce s spension

A slight incre e in gelatini tion t peratu ic amples through out the storage pe iod w s epo ted b l dhudha aw n et l 1978)

Among ll pl y l charac c istics a essed l and g ain weight nd total solid le el cf ce sampl we e fo rd to dec ease g eatly in PTE 10 than in Red Tr iv i An rease i ead rice yield i cosity o gelatini ation te pe ature w s obs v d to i c a e i l d Th v i t n co pared o PTB 10 (Fig 6) Among the stor ge cont ine s the dec ease in tho s nd grain weight and total solid le el w g eater g ny g follow t path The t of re r e fo the ie d ice cli and gelati ion te perat e was great r ir g nny b j th othe t ge

Fig--7



Changes in physical characteristics of rice samples due to storage containers

containers t ied wh le the increase in iscos tv was greater in metal bir (Fig 7)

A po itive as ociation significant was found to e i t between he d rice yield and moisture le el of elo ed rice samples s well as temperatu e of sto age struct res nd total sol d and between amylose nd iscosity

4 3 Insect infestation level of stored rice samples

Many species of insects attack stor d paddy a d rice but only a few cause serious injury a d loss of grain Nevertheless the damage caus d by th insect may be nsideral l since they not o ly cons m sto ed g ns l ts l t also co t minate them ith i sect f gmen s faec s b nj and ill smelling metabolic p oducts l q irements of opt m tempe tu e el tive h mid t nd bier t i va ies w th ins ct species The n s ct c e fo nd in the prese t st dy was totroga cre lell

The e tent of loss due to insect attack depends on the atomospheric conditions at the place of storage the ength of sto g nd the m thod and conditio f t g At 10 per cent of the loss i obse ved to t e pl ce p p dd du ng sto ge (Julier 1984)

Eff cf i se t infe t t r c ampl t t c age i e e t d Tabl 22

Table 22 Changes in insect infestation level of rice samples due to storage and storage containess (g)

Rice varieties	Fresh samples	Percentage weight of damaged grains: Stored samples			Mean
		Gunny bag	Pathayam	Metalbin	
I TE 10		0 9	0 70		0 81
Red Th iveni		0 90	0 69		0 79
M		0 91	0 69		

As th table reveals insect nfest tion n t d r FTE 10 ar d Red Thri eni Among the to age o e s j rs d ged by ecte ve e noted r FTE 10) pe ce t) ard Red Thr e i (0 09 p cent e n ed n gu n bag while insect n st t on was le e ir F R 0 0 70 p cent) d Red Th veni (0 07 p c t) stor in p m A co parison betwee ice s mpl reve le I t at FTE 10 w more affect d by in e t in t e two sto ge str ct s g n bag d path y m

A ong the ari corte s th ect tion s more r both th a iet er le l c g n b s l is i t) / I the at con l ore ar dr r g n/ b e The t p e i o d tio t ne q ha e ct diffe t due t th f i c l on I tr t th se c n d tions te I ffe or n the patta/am a d ır the metal bın F ther contınuous entry of o ganısms f om o tsıde ıs po s ble ın the gu ny b g

The ı crease ır ınsect ınfe tatıon ın FTR 10 m y be due to ıts hıgh moıstu e level Temper ture hu ıd ty and ısture levels we e hıgher ın gunny bag when compa ed to other two storage structu es Probably thı may be the e son fo the hıghe rate of ınsect ır festatıo ın thıs storage st ucture

Statıstıcal analysıs of the data re ealed no sıgnıfıcant varıatıon ın the rate of ınsect nfestatıon between the two rıce samples

Changes ır the qualıty of rıce store I upto one ar ır th ee dıffe ent agro clımatıc egıons of Andh a Pradesh were tudıed by Fu hpamma and Reddy (1970) Inse t ınfestatıon kernal damage and eıght loss ıncreased co espond ngly th the length of storage ın ll egıons Th ıce sample of coastal e had hıgher ınsect ınfestat or level th the other t c a cas

Insect ınfesta on ar recorded after sı mo h The ınfestatıo was not fo nd ın rıce samples sto ed n met l bıns Whıle ın the other two storage st uct e ınsect ınfestatıon was fo nd afte mo ths Compared to atha am r te of ır estatıon by ınsect as hıgher ır gunny b g as ıt p ov ded t e ambıe t te per tu e h ıdıty nd othe conditiors needed for the insect growth Gunny bags are neither rodent proof nor secure from fungal or insect attac while metallic structures of the bins offered better protection against insect and rodent attack as well as moisture gain

As the rate of insect infestation enhanced the protein content of the stored rice samples were found to decrease Among the two varieties the infestation level was greater in PTB 10 due to its low resistance to insect attach when compared to Red Thriveni The rate of decrease in protein level was also greater in PTB 10 Among the containers rice samples stored in gunny bag were easily affected by insects and the decrease in protein level was also greater in rice samples stored in gunny bag when compared to other two storage structures

Statistical analysis of the data showed negative significant association (r = 0.0475) between the rate of insect infestation and protein content of the stored rice samples Details are presented in Appendix 6

According to Jood et al (197) Rhizopertha dominica produced significant reduction in protein nitrogen and true protein contents of rice at 75 per cent infestation but the protein decrease was not significant at per cent and 50 per cent levels of infestation ... the contribution of nitrogenous compound lost during periodical interval of two onths at the fi t fo r mo th of sto a e we e fo d to b marginal

Insect infestatio caus d a declin in protein levels f om the first to ninth month of storage of milled rice Il s ed r ce was i fested t a greate e tent t r hand pounded milled aw and parboiled samples after two months f storage (Callibo et al 1997)

Insect infestation was ot found in rice samples stored in metal bins after si months while r gunny bag where va iation i m ist re level as 0 0 pe r t i se t infestation was greater

It w s found th t an incre e i r i t e et t inside the storage structures res lted in a highe rate of insect i festatio in th stored rice sampl s or cr ve s Moist r is nec s r y for the growth of insect nd the espiratio of insects in turn can transfer moi t e through o t the g ain torl th s in e si g ts moist level Atmospheric temperat re and h midity also controls the oist re p c d ction in the storage co taine s spec ally nside the g nny b g Among the rice a i ties t rsect infestation as well s moisture level as g eate n PTF 0 s it l orbs ore i t r f om n l r th T l The en i nny bag w s p oved to be an e cellent med a fo nsect inf station si e it al orbed more o st f om th irorm l th n m er th t o r c

Statistic l anal/sis of the data e e led a sig ificant positive association between insect infest tion and mo sture of stored ice sampl s (r 0 7) nd the det ls are r ented i Appendi 6

The pol/eth/lere packed rice stored at 25oC was found to be infested with the species of Asp glaucus and Asp e tractus group by Yanai et al (1 73) E owr rice containing less than 14 50 pe ce t of moi ture co tent did not show change in fungal population after storage for 180 days Packages made of materials with low permeabil y to gases inhibited th growth of storage f gi in the p c ed ce permitting the r pid re u ption in p ages of o ygen

T o series of samples of ough rice one at 1 40 per cent moisture and the other at 7 60 per cent were sto ed in elative h idities ranging f om 62 to 100 per cent The p valance of mold d the q al t/ ch acte istic of the r ce ere determined after 45 8 and 180 days storage Analysis of the counts of total field and sto ge molds howed that initial mois ure content, rel tive hu idity of to age t n of s age and ll the inter ct on we e highly significant so rces of v riance e dat urthe indicated that the composition of the mold flora of stored rice is e tremely variable and may ch ge rapidl nder varying to age co ditions high l v l of tabolic ctivity f the tot l mold flora rathe s ecifi g oup of f ngi, appea ed to be assoc ted wi l dete oration of tored rice (Sch oeder 196)

Insects besides onsuming the grains al o nfe ec th their metabolic products like uric ac d U ic ac d e noted only when th g ains were a tacked by nsects

Uric acid co centration increased with the rate of inc ease i the nsect infestation In PTB 10 U ic acid concentr t on was g eater than Fed Thrive i due to gre ter insect nfestation level U ic acid content was g ate in are samples stored in gunny bags follow d by st ol mple in path y

Statistical a lysis reve led a positi e s gni icant associatio (r 0 888) between ate f nsect infes ation d ur c cid leve of stored rice samples nd etai le a e p esented n Append 6

Accor ing to Wood et al (199)a significa t i c e e was reco ded in the ric acid level rice samples h ving 50 d 7 pe ent infestat on f Trogode i g ar n and Rhi o e tha do inica Both these i sect speci prod ce cceptable limit of uric acid con ents o er at 0 per c infestatio level

Insect inf st tion in the sto ed ice s ples wa estimat d by the eight of damaged o weeviled g a ns t e i festatio as fo nd to be highe n PTB 10 th in F d Thr e i

A positive significant association was found between insect infestation and grain constituents like moisture protein and uric acid of stored rice samples

4 4 Cooking characteristics of stored rice sample

The cooking characteristics of the rice varieties were assessed by determining the water uptake optimum cooking time stickiness volume expansion swelling index and gruel loss

The cooking quality and glutinous nature of rice largely depend on its amylose/amylopectin ratio (Rao 1970) Water absorption and volume expansion during cooking were directly affected by amylose content Deterioration of cooking properties of rice after storage constitutes an important cause of post harvest loss

4 4 1 Water uptake level of stored rice samples

Apparent water uptake is the weight of moisture absorbed by the grain during cooking Storage period if increased results in increased water to rice ratio

Effect of storage on water uptake level is presented in Table 27

Table 27 Changes in Water uptake level of rice samples due to storage and storage containers (g/g)

Rice Varieties	Water uptake level of rice samples				
	Fresh Sample	Stored Samples			Mean
		Gunny bag	Pathayam	Metal bin	
PTB 10	2 50	3 40 (+0 90)	3 00 (+0 50)	2 80 (+0 30)	2 90 (+0 40)
Red Triveni	2 [illegible]0	3 [illegible]0 (+1 00)	2 80 (+0 30)	2 80 (+0 [illegible]0)	2 9[illegible] (+0 4[illegible])
Mean	2 50	3 45 (+0 95)	2 90 (+0 40)	2 80 (+0 30)	

Number in parenthesis indicates increase in water uptake level

CD Values

Co 0 406

Va Co 0 427

[illegible] increase in water uptake level [illegible] in PTB 10 [illegible] 0 40 per cent while the increase in Red Triveni was noted to be 0 10 per cent Among the storage containers an increase in water uptake level was noted in all the three storage structures tried 0 95 per cent 0 40 per cent and 0 [illegible]0 per cent increase in gunny bag pathayam and metal bin respectively A comparison between rice samples revealed that increase in water uptake was almost similar in both the rice samples in all the storage structures tried Fresh rice takes up less water and is converted rapidly into a mechanical [illegible] system while stored rice [illegible] water than the fresh rice and as a result swell to elongates to a greater extent

Variation in the water uptake level between the two rice samples were found to be not significant. Variation in the water uptake level of the two rice samples stored in different containers was also found to be significant except between rice samples stored in pathayam and metal bin. The interaction between the varieties and containers were also found to be significant except between the two rice varieties stored in pathayam and metal bin

Storage of rice also revealed a reduction in stickiness and glossiness of cooked rice and increase in water absorption (Indhudhara swamy et al (1978))

Villareal et al (1970) reported that storage of the grain for as long as three months resulted in ageing and less dormancy. The change included increase in water uptake during cooking

4 4 2 Optimum cooking time of stored rice samples

Optimum cooking time is the time taken by the rice samples to be cooked more fl... ...the grain ... integral and required tenderness is obtained. Optimum cooking time is affected by ... early ... reported (Rabe et al (1976))

Eff t of st j r opt m n cool ing time wa r nted i Table

Table 24 Changes in Optimum cooking time of rice samples due to storage and storage containers (min)

Rice Varieties	Fresh Sample	Gunny bag	Pathayam	Metal bin	Mean
F TF 10	0	20 (10 10)	5 00	0	2 2 (0
F d Thriv ni		20 (00)		25	75 1)
M a	/	20 (7 0)	(5)	7	

Number in p enthes indicates decrease pl oc nc t nc

CD Values

0 0

t o 0 1

Co 0

The b e t t l r eal tl t opt m m c

i r eased t 75 1 es n F F 10 wh le e

F d T ri c e t tcs 0 o g th aq c e

There was cl a ge the opti cool g t m n tal

tor ge b whil cc ease ir g r J y n

d ty 7 7 ir t a and spo t The

cre se op ti ou i q / l cr d

water uptake which enables the ice samples to swell mo e sily t sirg t tendern of co l d ice

Statistical analysis of the data revealed significant variation in the decrease in optimum cooking time between th two to od rice samples Similarly variation in the increase of optimum cooking time taken for r ce s mpl s stored in different containers was also s gnif c nt The te actio between the v rieties and storage cont ers in relation to optimum cooking time was also fo nd o be significant e cept between Red Thrivera s mples s o ec ir i ll / l c l l l

l i t al (1979 had c rte l ll ptim l ing time c st red ce amples dec ecd f m to 95 m r e ft r ll c l s tor)

T c l g ir d medi j a n L w ice ieties r c T irradiated at 1 0 n 0 0 log m to scertain the effect of sto age on c oking time (S) larse al 1971) In l tudy ur iorr m de ar d cl ng time va ol e l ar do c lev l increased llrve e coo ing t was not significantl (P 0 05 aff c d by r jc icty al rt ih l ic l c e co l g l e in i r di ted s ples (S bula e e al 1991) Sto age of ir diated ice duced i lar l j t ll l f ro i diate l ce

irstitute l ad re eal l Flat ageing of q in decre e the

4 4 ~ Stickiness of stored rice samples

Stic| ircss of ice s mpl s depcnd on t r olubl f ctio c f the yl c ard l i n r t nt f d ase sing the eating q alit/ 1 ool ng q lity f ce tor ge ffcrts the tick i es of ic mplr tnc am lcse o t nt a with to age pe iod Dec in t cl ire is a q lity attri te p cfferd in ice by nsume

Effect of sto ge on s icl incss of rice sa pl re ented ir T ble ?

Table 25 Changes in stickiness of rice samples due to storage and storage containers (mean score)

Rice Varieties	Fresh Sample	Stickiness of rice samples: Stored Samples – Gunny bag	Pathayam	Metal bin	Mean
[TT 10	4 0	70 (00	0 1 5( )	6((0 60	0 00
Fed Tr ive	4	40)	c (1 70	20 (50	13 1
M r	1	(20)	7 (1 0)	0 (1 05)	

l nl r r onthe i dicates cr c t l ne

CD Values

(7 ?

r 0 1

In th p cent stud/ stickiness of rice samples wa ed t ene evaluation p t hed s le which obtained scores as g airy 1 not sticky 2 m d atel tic y very st r y 4 r l a y

As e alcd in the table decrease of 1 00 pe cent in the ear score obt i ed for sti iness w noted F 10 while the decrease in Red Th ivcni was 1 7 per cent A m riscr etwee ce sample evealcd that tl re se in stickiness was greater in Red Th i er wh may be due t ir e ir ir l ble yl f tio A n j the containers, decre se in st k s was ct d t e dec easc i q 2 00 r c rt j any t g 1 o p t in p thayam a d 1 0 pe cent i metal bir It is depended upon the t mper r tor je str ctu s all e the ol ble a lo f tion n s c ed r ce mple Il e decre se a greater j rr t because to tem er re 11 i oluble an/lo e ve eater th r e s mple s n ed in g y t g her comp red to the re sample score l i other t l cr jc l l the dece e te r ti rice s mples stored ir metal bi s

No sign ficant iation n the dec e n st l nes f stor d r c s n les v ct le t was st stically ral l there j a d in ll mc n i cr ase tick es f e l e s mples her to ed l ffc ent co l i e ccpt l t ecn ce rplcs eto c l ir g nn bag ard p thayam Tle intr a tion between the ice s mples and sto age containers v lso fo nd to be significant ir PTB 10 stored in pathay m and metal bin

The rc e eible bi ding of o y inir to mylopecti and am lcse educed the nteraction with sta ch du ing storage pecially t higle et rage temp r t re n l was rela ed to decreased stickine= of cooked rice Clrast l 1990) S in et l (1991) reported that stickness decreased markedly upto 10 months of sto age at 75oC M r et al (1991) h s also eported a eduction of stickirces of cooled ice du ing st ge

Desp rdc and El ltacha ya (1979) l cpc t l that stickiness was not app eciably affected by vate t rice ratio duri g cooking but was rkedly c ced b/ to ge especially ir high t | alure

Natural p oce s of agei g decrc e etic i e of co led rice samples As stated ea lier stickness of a rice s ple s lcc to tl mylose a ylcpectin compcn nt vith vhich t cl is filled Du ng trraje i olublc f ac ion f mylcse i c rases res lting r decre in etic ne

Association belw en amylose content nd stickn s of cooled icc amples afte stor g i pre t d in Appe di o

9

Stickiness is a quality parameter greatly infl   ed by amylose content as well as by the storage tempe ature of ice samples since temp ature 1 inc eases the sol bility of ylose or te ch co te t th s re ing a dec ease i sol ble fraction of amylose a d increasi g insol ble amylose

It is to be noted that tempe ature within the gu ny bag was highe and the lowest in metal bin A positive significant correlation was noted between stickness and temperature of sto ed ice samples on storage (r   0 577) and detail a e presented in Appe di 6

Indhudhara swamy et al (1978) have also repor ed that low temperatu e storage effectively retarded the decrease in stickness of rice

4 4 4   Volume expansion of stored rice samples

E pansion or the r e of i crease n the volume of ice s ples afte cooling i   desi ble t it te the co   more The volume e pansion was fo nd to be infl enced   y the app rent water uptak d ring cooking

Storage increa es the wate   ptake of r ce   a iet es whe   cooked Increase in water pt ke di ectl   influences the olume e p nsio of ice

Effect of storage on the volume e pansion of   ice samples is presented in Table 26

Table 26 Changes in volume expansion of rice samples due to storage and storage containers (per cent)

Rice varieties	Fresh sample	Volume expansion of rice samples: Stored sample			Mean
		Gunnybag	Pathayam	Metalbin	
PTB 10	240 00	244 40 (+4 00)	24[illegible] 80 ([illegible] 80)	240 00	241 9[illegible] (+1 95)
Red Thriveni	276 70	278 70 (+2 00)	277 80 (+1 [illegible]0)	276 50 (+0 [illegible]0)	277 [illegible] (+1 05)
Mean	258 1[illegible]	261 1[illegible] (+[illegible] 00)	260 90 (+[illegible] [illegible]5)	258 [illegible]5 ([illegible]0 10)	

Number in parenthesis indicates increase in volume expansion

CD values

V 0 09[illegible]

[illegible] 0 11[illegible]

Va Co 0 159

1 95 per cent inc ease in volume e p n ion in PTB 10 and 1 05 per cent inc ease in Red Thriveni were noted Among the grain stored in sto ge containers [illegible] 00 per cent [illegible] 65 per cent nd 0 10 per ent inc ease in gun y bag p hayam and metal bin were observed respecti ely The wate ptake level as greater in PTB 10 and hence the h gher volume e pansion The increa e in volume e pansion n rice s mples in gunny bag wa g eate when compa ed t o [illegible] o the two o age structu es

Statistical anrlysis of th data evealed a significart va iation in the inc ease in volume e pansior of he t o ice samples stored There was a significant increase ir the vol me fo each i e sample when sto ed in different containers The interaction between the ice samples and storage containers w s also found to be significant

Iongsree et al (1978) found that inspite of g eate volume expansion in aged rice the elongation ratio of the g ain during cooking was found to remain uncharged Similar results we e registe ed by Indh dhara swamy et al (1985) also

According to Villa ial et al (1976) storage of the g ain fo a long as th ee months resulted in ageing with an increase in volume

4 4 5 Swelling index of stored rice samples

Swelling inde is the ratio between the length and idth of cooked g air and length width of uncooked grair The swelling inde g ve an idea of the in rease in g in dimension after cooling which is a desi able t ait while estimating t e acceptability of the va ieties Storage affects the welling r le of r ce samples favourably due to i creased water uptake as well as greate vol me e pansion or cooking

Effect of storage on the swelling inde of ice samples are presented in Table 27

Table 27 Changes in swelling index of rice samples due to storage and storage containers (ratio)

Rice varieties	Swelling index of rice samples				
	Fresh sample	Stored sample			Mean
		Gunnybag	Pathayam	Metalbin	
F TF 10	4 80	5 20 (+0 20)	[illegible] 00 (+0 70)	4 80	4 95 (+0 15)
F d Thrive 1	5 0	6 0 (+1 78)	5 80 (0 78)	[illegible] 02	5 [illegible] (+0 [illegible])
M an	4 91	[illegible] 7[illegible] (+0 81)	[illegible] 10 (+0 4[illegible])	4 94 (+ 0[illegible])	

Number in parenthesis indicates ncrease i swelling index

CD values

va 0 1[illegible]

[illegible] 0 0

Va Co 0 [illegible]1?

As re ealed ir th table i c ease swelling rde wa noted ir FTF 10 (0 15) wh l in Red Th veni was 0 [illegible]1 The w ter uptake was gre te ir Red Thriveri th n in FTB 10 Amo g the storage cont i e s swell g inde metal bin did not change while 0 81 p cent n l 0 49 pe cent inc ease we noted ir g nny b g a d pat y m respec ely

Increased water uptake was noted in the rice samples stored in gunny bag and pathayam.

Statistical analysis of the data revealed variation in the mean swelling index values obtained for the two rice samples due to storage. Variation in the increase in swelling index values of the two rice samples stored in three different storage containers was also found to be significant except between the rice samples stored in gunny bag and pathayam.

The interaction between the rice samples and containers was also found to be significant except in PTB 10 stored in all the containers. Ali *et al.* (1978) had reported that the swelling index of optimally cooked rice increased from 3.6 to 7.78 after storage of paddy for 3 to 4 months.

4.4.6 Gruel loss of stored rice samples

Gruel loss is an important character in assessing the quality of rice samples. Higher the gruel loss greater will be the nutrient loss. Storage affects gruel loss as ageing affects the insect infestation in rice samples.

Effect of storage on gruel loss of rice samples is presented in Table 28.

Table 28 Changes in gruel loss of rice samples due to storage and storage containers (per cent)

Rice varieties	Gruel loss of rice samples				
	Fresh sample	Stored sample			Mean
		Gunny bag	Pathayam	Metal bin	
PTB 10	[illegible] 20	[illegible] 70 (+0 50)	[illegible] 40 (+0 20)	[illegible] (+0 0[illegible])	[illegible] 48 (+0 25)
Red Thriveni	4 10	4 60 (+0 40)	4 40 (+0 [illegible]0)	4 14 (+0 04)	4 [illegible]1 (+0 [illegible]1)
Mean	[illegible] 65	4 15 (+0 50)	[illegible] 90 (+0 25)	[illegible] 68 (-0 0[illegible])	

Number in parenthesis indicates increase in gruel loss

CD values

Va[illegible] – 0 515

As revealed in the table an increase of 0 [illegible]8 per cent was noted in gruel loss in PTB 10 while the [illegible] in Red Thriveni [illegible]s 0 21 per cent Insect infestation was greater in PTB 10 which caused damage to hard cell wall Hence gruel loss was greater in PTB 10 when compared to Red Thriveni Among the storage containers an increase of 0 [illegible]0 per cent 0 [illegible]0 per cent and 0 0[illegible] per cent were [illegible] in gunny bag pathayam and metal bin respectively A comparison between rice samples showed that gruel loss during cooking after storage [illegible] greater in PTB 10 in all the three storage structures tried The increase in gruel loss is probably due to insect infestation of rice samples

When the data on gruel loss was statistically analysed a significant increase was observed between the two rice samples Variation in increase in gruel loss for the rice samples when stored in three different containers was not significant

On assessing cooking characteristics of stored rice samples like water uptake optimum cooking time stickiness volume expansion, swelling index and gruel loss it was found that while water uptake volume expansion swelling index and gruel loss increased after storage optimum cooking time and stickiness of rice samples decreased (Fig 4)

The rate of increase in the cooking characteristics was greater in Red Thriveni stored in gunnybags except for volume expansion and gruel loss which [illegible] FTL 10 stored in gunnybag The rate of decrease in optimum cooking time and stickiness [illegible] greater in FTL 10 stored in gunnybag and Red Thriveni in gunnybag respectively A [illegible]tive association significant at 5 per cent level was found to exist between stickiness and amylose content as well as between stickiness and temperature [illegible] storage containers (Fig 5)

4 5 Organoleptic qualities of raw rice samples

Quality has been defined as degree of e cellence and is the composite of characterisL s determining acceptability Grain q ality is associated with consumer acceptarce The org noleptic quality cf r w rice samples st d ed c r colo r hardness and odou ing a point cal O the basis of acceptance each parameter was clas ified into 5 group and sco ed

4 5 1 Colour changes in stored rice samples

Colour fading is one of the negative pa amete s affecti g the over ll cceptabil ty of c luring t jo E periments cond cted at International Rice Resea ch institute ha l re calle l hat ageing f g i s decreas the s rface hite ess of the rice The c eamish white colour of the two f h ice s rples were obse r l to ch nge to b ownish wh te and to brown du ing the si months sto ge Rate of yellowing was found to increase progressively and the details e presented in Table 29

Table 29 Change in colour of raw rice samples due to storage and storage containers (Mean scores)

Rice varieties	Colour of raw rice samples: Fresh sample	Stored rice sample: Gunny bag	Pathayam	Metal bin	Mean
PTR 10	[illegible] 50	2 80 (0 70)	[illegible] 80 (0 70)	[illegible] 00 (0 50)	[illegible] 00 (0 50)
Red Thriveni	2 90	[illegible] 70 (0 60)	[illegible] 50 (0 40)	2 70 (0 [illegible]0)	[illegible] 60 (0 [illegible]0)
Mean	[illegible] 20	[illegible] (0 70)	2 65 (0 60)	2 8[illegible] (0 10)	

N mber in p enthesi indicates de rease n colour

CD Values

[illegible] 0 [illegible]

Urfavourable ch nges in colo r had esulted in lowe scores since the b r ing was less acceptable Va iation of 0 50 and 0 0 in sc es were obse ed in the mean co es obtained f r colo r in PTR 10 and Red Thriveni afte storage Amo g the sto age co tainers a decrease ir t e mear sco e of 0 70 0 60 and 0 40 we e noted n rice mples stored in gun y bag patha am a d metal bi respect vely A compa ison between the ice mples r caled that lc er cores e e awa ded fr the colou change ir PTR 10 n all the sto age containe s Colour of the g ain is gene aly irfluenced by the t mperature and oisture of stor g t u ture These c nal facto s h l g eater ffect on PTR 10 th r or Red T i eni

Statistical an lysis of the data revealed h t the va iation in the mean sco es obtained fo the colou hange of the two stored aw rice samples were sig ficant indicating less acceptability of PTB 10

The diffe ence i the mea scores obtained fo colou of the tw rice v rieties stored in th ee d fferent cont iners was found to be not significant

Lee et al (198?) had reported that grain moisture content storage temperature and storage period we e the major determinants of the ate of discolou ation The quality and economic value of rice are severely ed ced by discolourat on

According to Hempel (198) at ?5oC or below the stored ice samples with 1 to 15 per cent moistu e did not dep ct olo r f di g while at ?5oC yellow olo developo r the r ce sa pl with t e me moistu e level

Similar findings ere reported by Ho st r et l (197?) t for p bo led r ce and fo one e r torage at no mal oo tempe at re in either open or sealed container nd at higher temperatu es As obser ed in the e periment the ch ge in colour appea ed in the stored grains after three to four mo ths due to no e mic b own ng a co p n ed by losses of ug rs ami o nitroge a d free mino acid

4 5 2 Changes in hardness of raw rice samples on storage

Ageing brings about various physical changes in grain even under normal conditions During ageing brown rice becomes progressively harder varying with moisture content of the rice samples

Webb et al (1972) reported that hardness was determined by time to grind particle size index near infrared reflectance and resistance to grinding and crushing force In this experiment it was observed that hardness tests were significant but of a relatively low order There is an association between hardness and five grain quality parameters like milling yield amylose alkali spreading value gelatinisation temperature, protein and grain size and shape

Hardness of rice may also determine the cooking quality of rice Scores obtained for this quality parameter in stored rice samples presented in Table 0

Table 30 Changes in the hardness of raw rice samples due to storage and storage containers (Mean scores)

Rice varieties	Hardness of rice samples				
	Fresh sample	Stored rice sample			Mean
		Gunny bag	Pathayam	Metal bin	
FTB 10	[illegible] 00	[illegible] 50 (+0 50)	[illegible] 60 (+0 60	[illegible] 80 0 80)	[illegible] 47 (+0 40)
Red T hiveni	2 50	[illegible] 10 (+0 60)	[illegible] [illegible]0 (0 90)	[illegible] 40 (0 9[illegible])	[illegible] 00 (+0 50)
Mean	2 80	[illegible] [illegible]0 (+0 [illegible]0)	[illegible] [illegible]5 (0 60)	[illegible] [illegible]0 (0 80)	

Number ir p renthesi indicate increase in hardre s

CD Values

Va 0 278

Co 0 [illegible]60

Incr [illegible] by 0 40 and 0 50 ir he mean s es fo hardness re ob ed or FTB 10 [illegible] Red Th iveni Similarly increase of 0 50 0 60 and 0 80 in ha rre s were noted in the ice samples sto ed in gunny bag path yam and etal bin respeti ely The ha d s of r ce s mple sto ed in gunny bag was l p obably bec use of the ncre ed bsorption of moistu e co tent A comparison between the rice samples re aled that Red Thr eni was harder [illegible] all the storage contain r ir the orde of m l bin [illegible]thayam and g nny bag I Red Thri [illegible] moi [illegible] e [illegible] tent [illegible] also bs r ed t be le s than FTB 10

When the data was statistically analysed the a iation in the increase in the mean sco es bet een the two rice samples in gunny bag alone was found to be sign f cant

Variation in hardness of the t o i e amples stored in three different conta ners was significant onl bet een rice mples stored in gu ny bag and pathay

Sy thesis of itrogen containing compo nds in the cell wall of cotyledon of the grains r to age y be contrib ting facto in the inc ease r ha dness by indu ing the dissolution of the middle lamella d ing cool ing (Ro e t al 1990)

Se et l (199?) repor ed that greater grain hardnes w ohser d in to ed g in n met l l n tha gr ins tored i g nny bags o ing to greater moisture tsorptio in gunny bags Howeve the ha dness of t e grain las resulted in higher milling y eld (J l o 1995)

As the tempr of the to age ructure i ased the ha dre s of he tored rice samples i reased Among th co tl ire s increa e i tempe a re w s f rd to result in e d dr which y in c e ed o the absorptio Rice sa pl s sto ed n metal drums we e harder than those stored in g nny bag The eco omic loss d e to ardening w s e pla d in h g cool nc t me

St ti ic l a lysis revealed a p sitic as o i t on between ha dness of ice sample and temp ilt e of storage tr ct s (r 0 61) d detail e p e ted Appenc 6

Incre e in h midity resulted n a d c ease in hardne cf rice nples T e h m l ty of stored rice samples in g nny bag was highe when compared to other two storage structures the lowest being in metal bins The hardness of rice samples was al o g eater n metal bin followed by j thayam ar l gunn / l g

When statistically a alysed a positi e significant ssociatio 0 47) was fo nd betwe r ha dne of ice ples l hu i lity of sto ge str ct e (De ails in Appendi 6)

Gre t h r r f ri ple w e fo rd c offe greate re tance t breakage r mill ng and the l ad rice yield of ce e mple stored n metal bi e highe her compared tc rice samples sto ed i other t o storage tructure lar l e f r ce ple et l in g nny bag e lowe d hence the low c rice y ld a ubser ed

The ylose c te l cf stored r ce nples we e found de re ill te c ea e l d f pl s A ylose l t we j ater c ampl tored gunny l s he a th drese of e mpl to ed n gunny g al re he h r l e s of ri mple n g nn t gs was lower when compa ed to sample ored ir other torage str ctures A positi e asso iation bet e n hardne and mylose conte t of stored rice amples was found to e ist (r 0 734) (Table in Appendi 5)

As the hardness of stored rice sample increa ed the gelatini ation temperature as also found to increase H rdness of rice s mples w s greater when stored in metalbins followed by pathayam and gunnybag Gelat ni at on temperature of rice samples stored in metal bins was greate when compar d to other two stor ge st uct es hen the data was statistically analysed positi e s g ificant as ociatio (0 545) w s fou d between ha dne s of rice s mples and their gel tinisation tempe t re (T ble in Appe di 6)

4 5 3 Changes in odour of the raw rice samples on storage

The p od ction and acc mulation of volatile c bon l compo nds i he inte g an la air are epo ted to c use off odou s,

Th odo r of illed rice changes e y rapidly du ing storage Long sto ge us ally br ngs bout det r oration esulting in change in the odou i h temper ture high oist re ontent and c rtain other f ctor contr b te to th hanges cour d g stor g

Odour was ascertained by sensory evaluation o a 5 point hedonic scale A light pleasant odour was obtained in the rice samples after storage Effect of storage on the odour of raw rice samples on storage are presented in Table 31

Table 31 Changes in the odour of raw rice samples due to storage and storage containers (Mean scores)

Rice varieties	Fresh sample	Odour of rice samples: Stored rice sample – Gunnybag	Pathayam	Metalbin	Mean
PTB 10	3 10	2 50 (0 60)	2 60 (0 20)	00 (-0 10)	3 80 (0 70)
Red Thrivenni	3 70	2 70 (0 60)	3 90 (0 40)	70 (0 10)	07 (0 38)
Mean	3 02	3 60 (0 60)	2 [illegible] (0 45)	3 10 (0 10)	

Number in parentheses indicates decrease in odour

CD Values

Co 0 287

Va Co 0 364

As revealed in the table 0 30 per cent reduction in the mean scores obtained for odour was noted in PTB 10 and 0 20 per cent in Red Thrivenni The pleasant odour of the stored rice sample was changed to an unpleasant odour with torage cort iner with a degr c of v tio M r per c ntage sc re fo odo was 1c t 0 /0 c cent (per ce t and 0 0 per ce t in jum b q pall y and mcl 1 bin pectivel The d erioration of fre f tty a d was a er gl ny b e followed l p thaya nd mc 1 b n giv ng an off odou A compa on tel e th i e ample e calcd considerable variation in odo r i both t rice mples nd in all th to age e n s l ied Th change odo r i duc to t e leter r tion of at atty acids

The a nif c t i t c the l f t o ice samples sto c l i genr l j and l bar n betwee ice r ples st r p lly et l Th i terac betwee th rice ple l o ge cnta n w w e also c rd to l grific l c c t t t eer c e ple ored j / t a d patl n

Earb e l 1988) t d r ted t t high tempe t r hi the e rr d l m l j deg er lance d r fo l r

Two serie cf mple l rc j (o n l 4 p cert c l a othe o p ert e stored clatl e l di r ca j fr tr 10 Def t c w derce grc deg c lo terr l di ccl ar J lo r th c j r cack l a a t t ceder 1 4

Aseoci tion bet een odour and moisture le el of stored ice samples was found to be posit e and significant (r 0 557) (Table in Appendi)

Odour of sto ed rice sample was found to be ore npleasant with the increase in free tty acids F ee f tty acids were fo nd to increase in rice samples in g nn bag follow d by pattay n rd metal bin on ngo Hence the d terior t n of odou as grea e n g nn bag a d lower in met l bin

A positive significant a ociatio (0 / 4) was obtained between od nd f ee f tty aci l le el of stored ice samples on statis tical analysis (Table in Appe d 6)

In the present study the organoleptic q alit es a sessed reve led that the sco es for odo and colo of ice sa ples decrea ed gradu l i PTB 10 sto ed n gunny bag than in Red Thriveni (Fig 3) The q ality parameter hardness was fo nd to inc ease in Red Th iveni sto ed in etal bin th n i PTB 10 or Red Th i eni st ed in the other two torag nit i (Fig 8)

A positive a soc ation w s found to e ist between h rd ess and temperat re and humid ty o n nge str ct res I s also found that hardn s ae p si i ely a ciated ith head ri e yiel lo er l lat ion to p alu e f tored ice s pl s Odo w s found t be rela ted wi t tempe ature d umidity of o age str ct es moisture he d rice yield and free fatty cids of rice samples

4 6 Suitability of rice based preparations

Sensory evaluatio of food has med i c ea ing significance in recent years as this provide information of pr luct i p o ement n l product levelopment Ac o d ng to I r mer and Twigg (1970) food quality det ctable b our s s can te b oken down int th ee in catego ies ppearance facto to l ral factor nd fla c f ct

Sreede (1989 se ei thro gh o v l tion studies that the acceptability of cooked ice mple re nfl enced by the phy ical ch cter t c of in dual mples In the present study c ked re s selec ted as th ri t l pre io s n l ib tes c ppe ance colour fl vou t ture tast and d ness we e th p eter l ted to l m ne the accept lity of the p ep tions

Accord g to I l dh a y et al (1978) th p l t bil ty of stor d rice samples we e affected b the e col ar p ar nce

4 6 1 Appearance of cooked rice samoles

ppe r ce the q lity trait to t ch ci i es the accept bil y of product b the cons er

Effect of stor ge in the ppea arce of coolcd rice samples is p esented i Table 32

Table 32 Changes in appearance of cooked rice samples due to storage and sotrage containers (mean scores)

(maximum score 5)

Rice varieties	Appearance of cooked rice samples				
	Fresh sample	Stored rice sample			Mean
		Gunnybag	Pathayam	Metalbin	
FTr 10	50	4 00 (+0 50	70 +0 70	50	70 (0 70)
l lltri en	10	40 (0 70)	0 (0 70	70 (0 10)	) 0 70)
llc n	0	70 (0 10)	53 (0 20)	40 (0 10)	

N n c n p entire i dic crea e cores

CD Values

7a 0 272

F3 0 9

Fr 0 4

\ ri i roted n llc core fr rc c of f esh and tlo ed ice s mples of PTE 9 and F d Tl iven hen cooled cre fc d o te 0 70 A ong th torage c t nc s 0 10 0 70 d 0 10 tl e ti on l in l c r ec r s f r l d ice pl l l dr f r g nry bag aalhayen n metal i r e pec ly A compar on between th rice s mple revealed that t ppe e of ice sampl stored metal bin impo d g eatly n both the varie ie

Stati tical nalysis of t data ealed t t c ation t tween t c rice amples w s = gnif nt A g ificant diffe t a fc l fc t l rice ple stored in th ee diffe er cont rers e cept bo r r ce amples st red in pa avam a d etal Tlc i rtior between the arieti nd contr i e s c lso fo J to b g i i ar t tvee t tO ea pl = to c g g and p ll a am

Acco li g to Tar et al 1991) aci p odu ed more fl l y cool ice lc o the r r emain r tog al th no plate or idce T e p ty mas f re l r e ted r c r cooking a r ol see ice t oun sto ge for a fc m nths

4 6 2 Colour of cooked rice samples

Colo r letermine the co e t p cf rence of p oduc J it va i from g n to ec c rd f r t v d l t nothe

White d ror l cert ice p ef t ry p l in mo t pa ts t o l to gl pla t l cr ct th re cl ccl r l (c ic p) l lr the ecr l l ol f r ice m t nq t a d r e resulting in lo e scores Effect of sto age on the colo r of cooked ice samples is p esented in Table 3

Table 33 Changes in colour of cooked rice samples due to storage and storage containers (mean scores)

(ma imum score 5)

Rice varieties	Fresh sample	Colour of cooked rice samples — Stored rice sample: Gunny bag	Pathayam	Metal bin	Mean
PTB 10	4 00	3 50 (0 50)	3 70 (0 80)	3 90 (0 10)	3 65 (0 35)
Red Triveni	4 20	4 00 (0 20)	3 90 (0 0)	4 10 (0 10)	4 00 (0 20
Mean	4 10	3 75 (0 25)	3 50 (0 51	4 00 (0 10	

Numbers in parenthesis indicate decrease in scores from fresh sample

CD Values

	0 78
Cr	0 242
Va Co	0 76

The above table shows d c e of 1 5 in the mean score obtained for cooked sample of stored PTB 10 and 0 20 for Red T ive i i imila si tions f c p r n amo g sto age conta e eale d dec ea e of 0 3 0 20 nd 0 10 in the ean score fo the r t i ic e pl g y b g path y m d t l bi t c e c the q l ltrib te colour ccmp d o bclvcc tle va 1 ties c ealed l l the T 1 score ltained f I TE 10 v love n ll thc lhree storng cort 1 c t cd

St ti l cal l c lment of the d ta reve led a 1j ficart v 1 tio betv c the tvo rice aaples 1atir n the mcan cores obta ned for lle colo cf the 1c s mplce c c al o 1gnificeri vlcn st rcd in diffe ent containers The inte action betveen the 1ce sarpl s and cr taincrs lso revealcd a sig ificart v 1 tior fo the colour of co led 1cc s mples e c pt in Fec Thri en tored 1 lle tl cc cort 1 c

Colour changes du 1ng torage of c ppe red f o to 4 orths dc to no en ymatic b ov 1 ng (Fr mo e 1 1° 0)

4 6 - Flavour of cooled rice samples

Flavour cor t tutes the arc a o odc of the p oduct Fl ur 1 ul qu l t ltrib te 1cl ul l to appetile for the partic la p od t

E fecc o to ge or the fla ou cf c rice s mples p nl d ir t e 4

Table [illegible]4 Changes in flavour of cooked rice samples due to storage and storage containers (Mean scores)

(maximum Score - 5)

Rice varieties	Fresh sample	Stored rice sample: Gunny bag	Pathayam	Metal b[illegible]n	Mean
PTB 10	[illegible]	[illegible] (-0.80)	[illegible] (0.[illegible]0)	[illegible] (0.[illegible]0)	[illegible].90 (0.40)
Red Triveni	[illegible].00	[illegible].50 (0.[illegible])	[illegible] (0.[illegible])	[illegible] (0.[illegible])	[illegible] (0.[illegible])
Mean	[illegible]05	2.[illegible]0 (0.55)	[illegible].60 (0.[illegible]0)		

Column heading spanning the score columns: Flavour of cooked rice samples

Number in parenthesis indicates decrease in scores

CD Values

Va [illegible] 0.2[illegible]

Co [illegible] 0.[illegible]1[illegible]

[illegible] Co [illegible] [illegible].[illegible]8

[illegible] decrease of [illegible] 10 in [illegible] scores [illegible] flavour [illegible] cooked samples of PTB 10 (stored [illegible] and [illegible] in Red Triveni [illegible]) [illegible] noted [illegible] the storage containers [illegible] of 0.40 [illegible] 0.[illegible] and 0.[illegible] in the [illegible] [illegible] reported [illegible] [illegible] for flavour [illegible] in PTB 10 [illegible]

Statistical ar lysis of th data revealed th t the variation in the mean sco es obtain d for the fl our between the two ice sample were sign ficant Th e we a significant diffe ence in th mear sco s obtained for the flavo of the wo ice ampl w er t l n tl l ffe ent storage co t r e cept t r r amp es ed in ury t r and p thayam T r te a Lrl tl varieties and th containers were also fo nd to be significant

F a t l (970 repo ed t a d elopme t of of fl o rs ith n st t pe i l o lo ge r a ice ecially the m ll d rice l ll order c y ld nd

Acco ding to l lka ni (1970) ch ng s due to f t/ ac d d tion in stor d rice affec d th l vo of cooked ice

Free fatty ac ds the sto ed ri ample ere r highe conc t er in g ny bag follow d by palth m rd etal t ir both the rice sa ples Sco es obt ined for flavo s l e f nd to dec e e i a im r patte n Statis tic l r l sis c the d ta o ed a c iti e ignifi t as o iation (r 0 8612) between free fatty acid | od cti ro fl o r of sto ed rice samples (T ble r e di 6)

4 5 4 Texture of cooked rice samples on storage

Texture is the quality attribute tested by feeling the cooked product. Ageing was found to increase the texture quality of stored rice samples.

Effect of storage on the texture of cooked rice samples is presented in Table [illegible]

Table [illegible] Changes in texture of cooked rice samples due to storage and storage containers (Mean scores)

(maximum score 5)

Rice varieties	Texture of cooked rice samples: Fresh sample	Stored rice sample: Gunny bag	Stored rice sample: Pathayam	Stored rice sample: Metal bin	Mean
PTB 10	3 50	3 70 (+0 20)	3 80 (+0 [illegible])	4 00 (+0 50)	3 75 (+0 25)
Red Triveni	3 00	3 10 (+0 10)	3 [illegible] (+0 [illegible]1)	3 50 (+0 50)	3 [illegible] (+0 [illegible]0)
Mean	3 25	3 [illegible]0 (+0 25)	[illegible] 55 (+0 [illegible]0)	[illegible] 75 (+0 50)	

Number in parenthesis indicates increase in scores

CD Values

[illegible] 0 [illegible]10

[illegible] 0 [illegible]1

[illegible]
tc ture of the two rice sample 1 c eased by 0 25 in PTB 10 and by 0 20 in Red Thriveni Among the sto age cont iners the increase noted in gunny bag pathay m a d metal b r were 0 ? 0 30 nd 0 ?0 re pectively A co p ? ? let the rice samples revealed that te t e inc eas l in Red T r en r all the storage containers tried

The data when st tistically anal sed a s on ficant difference in the mea scores fo tr tu c between the two rice samples ere noled The ari t on in the me n c es for ice samples hen stored in three different tor ge cort ine ? e c also fo nd to be ign f c nt e cept etween s mple sto ed in gunr b g and pathay m The rte action bet een the rice samples and containers we e not ig ific t c pt between ice mples t ed in pa l y m r l metal bi with Red Thriveni

Indi udre swamy et al 19 8) epor d that the e is te dy increa e in the consistenc of oole d ri e th to ge pe i d The le ge in the te ur cf ccc rice te ls to e ma in f higt a ylo e r th h d gel co sistenc Pere ard Juliano (198?) reported change in mill g prope t e of IR ?6 and IR 42 and o gh r ce sto ed ? ??oC fc nth c nnges in t t r c i g t r e of milled rice at 28 ?0oC and te t re charges in IR ?? tored a illed or ough ice were al o erved in this nent

Te tLre of nilled rice dLring ageing is reported tr imp ove with the inc ease in amylose content (Villareal et 1 1976 Perez and liano 1982) High amylose rice ar fo nd to ha e ncreased te tLre Amylose level of ed Thri eni stored in metal bin we higher whe comp ed to rice samples s o ed ir othe sto g tructL Inc e e n te tLre was also found to be gre te among Red Thri eni sto ed in me l bin

Statistical analy is showed that th e e ists a positive significant ssociation (0 97 5 between m/lo e cor ent and te tLre quality of stored ice samples (Tabl n Appendi 6)

4 6 5 Taste of cooked rice samples on storage

Taste is a quality pa ameter w ch i hig ly depe ded or the individLal According to Mats e e al (1991) deter orat on in palatabilit, dLe to deterio ation n he taste nd stickiness of cooked ice

Effect of torage on the taste of cooked ice samples is pre ented in Table 76

Table 36 Changes in taste of cooked rice samples due to storage and storage containers (Mean scores)

(maximum score - 5)

Rice varieties	Taste of cooked rice samples				
	Fresh sample	Stored rice sample			Mean
		Gunny bag	Pathayam	Metal bin	
PTB 10	3.50	2.70 (0.80)	3.00 (0.50)	3.10 (0.40)	3.00 (0.50)
Red Triveni	3.10	2.50 (0.60)	2.90 (0.20)	3.00 (0.10)	2.80 (0.30)
Mean	3.30	2.60 (0.70)	2.95 (0.35)	3.05 (0.25)	

Number in parenthesis indicates decrease in scores

As revealed in table, in PTB 10 (fresh and stored) a decrease in mean score was obtained for taste by 0.50 and in Red Triveni (fresh and stored) a decrease of 0.30 were noted. Among the storage containers the decrease in taste noted were 0.70, 0.35 and 0.25 in gunny bag, pathayam and metal bin respectively.

There was no significant difference in the mean scores obtained for taste among the two rice samples.

A product is accepted on the taste of it, as it affects the palatability.

4 6 6 Doneness of cool ed rice samples on storage

Doneness is the quality attribute to determine whether the rice is well cooked or not. In the present study the [illegible] taken by the [illegible] samples to be cooked [illegible] on storage by 5 to 10 minutes. Doneness was measured by pressing it with finger. Effect of storage on doness of cooked rice samples is presented in Table 7

Table 37 Changes in doneness of cooked rice samples due to storage and storage containers (Mean scores)

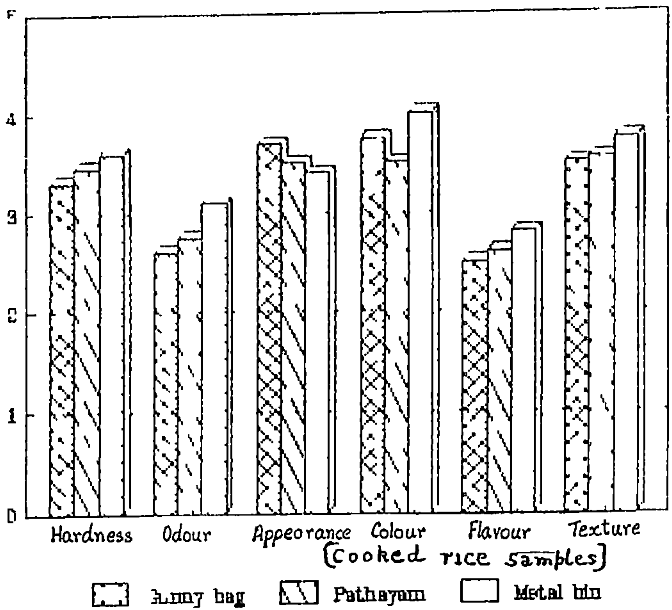
(maximum score-5)

Rice varieties	Doneness of cooked rice samples				
	Fresh sample	Stored rice sample			Mean
		Gunny bag	Pathayam	Metal bin	
FTD 10	[illegible] 50	[illegible] 20 (0 0)	[illegible] 20 (0 0)	[illegible]0 0 [illegible]0)	[illegible] [illegible]0 (0 [illegible]0)
Red Thriveni	[illegible]0	[illegible] 80 (0 50)	00 (0 0)	[illegible] [illegible]6 (0 10)	10 (0 [illegible]0)
Mean	[illegible] 40	[illegible] 05 (0 10	[illegible] 10 (0 0)	[illegible] 25 0 15)	

Number in parenthesis indicates decrease in scores

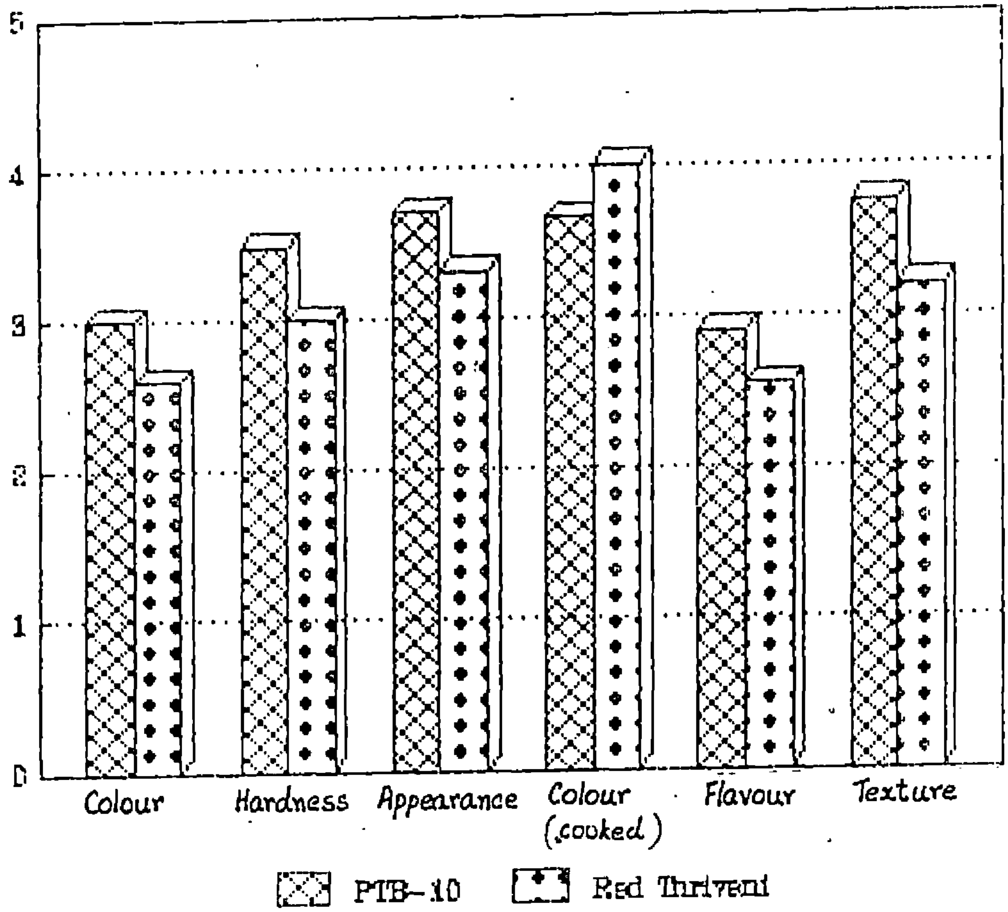
A decrease of 0 [illegible]0 in the mean score obtained for doneness was noted in FTF 10 (fresh and stored) when cooked and in Red Thriveni fresh and stored [illegible] 0 [illegible]0. Among the storage containers decrease of 0 40 [illegible] and [illegible] in gunny bag pathayam and metal [illegible] were observed respectively

Fig-8



Changes in organoleptic characteristics of rice samples due to storage containers

Fig--9



Changes in organoleptic characteristics of rice samples due to storage

A comparison between the rice samples revealed that lower mean score was observed in PTB-10 in all three storage structures tried.

Statistical analysis of the data revealed that the variation in the mean scores obtained for doneness among the two rice samples were not significant.

Organoleptic qualities of the stored rice samples revealed that appearance and texture was found to increase on storage in Red Thriveni than in PTB-10. All other factors like colour, flavour, texture, taste and doneness was found to decrease on storage. The rate of decrease was greater in PTB-10 than in Red Thriveni. (Fig - 9)

Among the storage containers the decrease in quality attributes was greater in gunny bag while metal bin proved to be more resistant to changes in quality parameters. (Fig - 8).

CONCLUSION:

The usual storage period for rice grains, in the state, is found to range from one month to one year. Generally the stored grains get exhausted by the next harvest. Among the storage structures assessed, gunny bag is found suitable for short term storage. Shelf life qualities related to grain constituents, physical, cooking and organoleptic characteristics ascertained in the stored rice samples, revealed the worthiness of metal bins as an ideal storage structure. However, the variation in the above qualities among the three structures tried were statistically not significant.

A comparison between a hybrid derivative (Red Thriveni) and local variety (PTB-10) made in this study revealed that shelf life qualities of hybrid derivatives are better than those of the local variety.

SUMMARY

SUMMARY

A six months study on "Qualitative and quantitative changes in stored rice" provides comprehensive information on the effect of different methods of storage on the various quallity parameters of stored rice grains viz. nutritional, physical, cooking and organoleptic characteristics and rate of insect infestation. For comparison, two rice samples, PTB-10 and Red Thriveni were selected for the study.

* Grain constituents like moisture, protein, non-protein nitrogen, uric acid, minerals (calciunm, iron and phosphorus) and free fatty acids were ascertained in raw rice samples.

* Storage was found to have a positive influence in increasing the moisture level in rice samples. Moisture level was greater in PTB-10. Moisture absorption was greater in samples stored in gunny bag followed by those in pathayam and metal bin.

* Storage was found to decrease the protein content of the rice samples, the decrease being greater in samples stored in gunny bag followed by those stored in pathayam and metal bin. Protein loss was higher in PTB-10.

* Nonprotein nitrogen content of the rice samples were observed to decrease, the decrease being greater in PTB-10.

Samples stored in gunny bag were found to be easily affected by such changes.

* Uric acid level was found to increase during storage in rice samples stored in gunny bag followed by those stored in pathayam while in metal bin uric acid was absent in the rice samples. Uric acid level was greater in PTB-10.

* An analysis of other components like calcium, iron and phosphorus had indicated that the rate of decrease in the mineral was greater in PTB-10. Mineral loss was lower in metal bin when compared to other two storage structures.

* Storage was found to influence the free fatty acid level in the rice samples, the increase being higher in PTB-10 than in Red Thriveni. *Rice samples stored in gunny bag had greater loss of lipids as free fatty acids when compared to the other two storage containers.

* The grain constituents studied in raw as well as in cooked samples were reducing and nonreducing sugars, starch and amylose.

* Reducing sugar was found to increase in raw and cooked samples in storage. In raw samples the increase was greater in rice samples stored in gunny bags. When compared to Red Thriveni, PTB-10 had higher reducing sugar level. A similar trend was noted in cooked samples also.

* Nonreducing sugar when assessed was found to decrease greatly in PTB-10 stored in gunny bags when compared to Red Thriveni. A comparison among the rice samples stored in three storage structures revealed that the decrease was greater in gunny bag followed by those samples stored in pathayam and metal bin.

* Starch content of rice samples decreased on storage. The rate of decrease of starch content was found to be greater in Red Thriveni than in PTB-10. Among the storage containers, rice samples stored in metal bin were found to undergo less starch hydrolysis than in gunny bag in raw as well as in cooked samples.When compared to PTB-10, amylose level in raw and cooked samples was lower in Red Thriveni. Amylose content of these to types of rice samples were found to increase at a higher rate when stored in gunny bag followed by those stored in pathayam and metal bin.

* The physical characteristics studied were thousand grain weight, head rice yield, total solids, viscosity and gelatinisation temperature. Thousand grain weight was lower in PTB-10. Storage structures were found to influence thousand grain weight significantly. Rice samples stored in gunny bags generally had a lower thousand grain weight than the rice samples stored in pathayam and metal bin.

* Compared to PTB-10, higher head rice yield was found in Red Thriveni. The percentage of head rice yield was found to

be increased in the samples in metal bin followed by those in pathayam and gunny bag. Moisture level of the stored grains and head rice yield were found to have significant association.

* Total solid level was comparitively less in stored PTB-10 and the two rice samples stored in gunny bags. A significant association was found between decrease in total solids and temperature of the storage structures.

An increase in viscosity was found in Red Thriveni stored in gunny bag when compared to other stored samples. Amylose content and viscosity of stored rice samples were also significantly associated with each other.

* A significant decrease was found in gelatinisation temperature between two rice samples. Change was more in rice samples stored in metal bins.

* Insect infestation was observed only in rice samples stored in gunny bag(0.90 per cent) and in pathayam (0.69 per cent). Insect infestation was found to be positively influenced by moisture, protein and uric acid level of stored rice samples.

* Different cooking characteristics studied were water uptake, optimum cooking time, stickiness, volume expansion, swelling index and gruel loss.

* Water uptake level during cooking was higher in Red Thriveni stored in gunny bag when compared to PTB-10.

* A significant decrease in optimum cooking time was observed in Red Thriveni. Among the storage containers, a decrease was noted in rice samples stored in gunny bag and pathayam.

* Stickiness was less in PTB-10 after storage. This quality was existing in a higher degree in samples stored in gunny bag and it was found to decrease with an increase in amylose content and temperature of storage structures.

* Volume expansion of cooked samples were directly influenced by water uptake. Volume expansion was higher in PTB-10. Among the storage containers, volume expansion was greater in samples stored in gunny bag.

Swelling index of cooked samplos increased on storage. This was found to be greater in rice samples stored in gunny bag.

Gruel loss was found to be greater in PTB-10. Among the storage containers, gruel loss was greater in the rice samples stored in gunny bag.

* Colour, hardness and odour were the major parameters tested to decide the popularity and acceptability of the rice samples. Hardness was found to increase in Red Thriveni

when stored in metal bin than the rice samples stored in other two storage structures.

Colour and odour were found to decrease on storage. Among the two rice varieties, colour and odour decreased greatly in PTB-10 when compared to Red Thriveni. Rice samples stored in gunny bag was found to be least acceptable with reference to colour and odour.

* The quality parameters studied for the acceptability of cooked rice were appearance, colour, flavour, taste, texture and doneness. Among the rice varieties, Red Thriveni was found to be more acceptable for cooked rice because of its better appearance, colour, flavour, taste and doneness than PTB-10.

* On cooking, appearance was found to improve in the two rice samples. A comparison among the storage structures revealed that the appearance of rice varieties stored in metal bin was the best.

* Lower scores were given to "colour" for PTB-10 than Red Thriveni when cooked. Among the storage containers, rice samples from metal bin had higher scores than the samples from other storage structures. Flavour was also found to decrease greatly in PTB-10 than in Red Thriveni. The deterioration was greater in gunny bag among the storage structures tried, followed by those stored in palhayam and metal bin.

Texture of the rice samples were found to improve in PTB-10 due to storage. Among the storage containers, the increase was greater in the samples stored in metal bin than those in gunny bag and pathayam. A positive significant association was found to exist between texture and amylose content as well as temperature of storage structures.

* Taste of cooked rice samples decreased greatly in PTB-10. The decrease in taste was greater in gunny bag followed by pathayam and metal bins. Doneness was also found to decrease in a similar manner.

Different parameters attempted revealed greater usefulness of metal bin as a storage structure. The study throws light on the fact that newly evolved variety viz. Red Thriveni had a better shelf life. Further studies on these aspects are warranted.

REFERENCES

REFERENCE

Adair C R (1966) Effect of storage treatment on germination of rice IRC Newslett PP 15

Ahmed E S A (1987) Assessment of stock storage of paddy rice in Egypt Alexandria Journal of Agricultural Research 32(1) PP 17 29

Ali S Z Bhattacharya K B and Narayan S (1978) Starch retrogradation and starch damage in rice Starke 13 (1) PP 31 42

Aminoff D Binkeley W W Schaffer R and Moury R W (1970) Analytical methods for carbohydrates The carbohydrates-Chemistry and Biochemistry Vol IIB PP 760 764 Academic Press III Fifth Avenue New York

Anonymous (1975) International Rice Research Institute report (1975) Los Banos Philippines PP 28

Anonymous (1976) Internatiionnal Rice Research Institute report (1976) Los Banos Philippines PP 16

Anon (1985) Report Conference paper Indian Rice Research Institute Manila PP 20

Anker C A and Gedde W F (1944) Methods in carbohydrate Chemistry-Volume IV Starch PP 115 116 Academic Press New York Sanfransisco London

Arai E Aoyana K Watanabe M(1993) Enzyme improvement of cooking quality of aged rice Bioscience Biotechnology and Biochemistry 57(6) PP 911 914

Barber S (1972) Milled rice changes during ageing Rice chemistry and Technology 3(7) pp 593

Berg W J Isly D and Schwordt H H (1982) Report on entomological work Bull Arkansas Agric Exo sta 246 PP 150 153

Baldi G Fossati G Ranghino F and Fastone G C (1992) Storage of rice changes of proteins protein fractions aminoacid composition 11 Riso 26 (3) PP 253

Barber S Benedito de Barber C and Burches J (1988) Milled rice and changes during ageing in rice Rice Chemistry and Technology 28(1) PP 215

Barber S Benedito de Barber C Guardiolo J L and Alberiola J (1967) Compsicion quimica del arroz iv Technol Alimentos 7(3) PP 346

Bhattcharya K R (1979) Rice in Food Industries Indian Institute of Technology 1 1

Bhattacharya K R Sowbhagya C M and Indhudhara Swamy Y M (1978) Importance of insoluble amylose as a determinant of rice quality Journal of science of Food and Agriculture 29(4) PP 359 364

Bhattacharya K R and Sowbhagya C M (1971) Water uptake by rice during cooking Cereal Science 16 PP 420 424

Bilgram K S Prasad T and Sinha R K (1979) Changes in nutritional components of cereals Todays and Tomorrows printers and publishers New Delhi PP 39 45

Cagampang G B Perez C M and Juliano B O (1973) A gel consistancy test for eating quality of rice Journal of Science of Food and Agriculture 24 (12) PP 1589 1594

Calliboso F M Sabio G C Tiongson R L Benigino E A (1991) Insect and mite pests and their control in commercial storage Menoz Nueva Erija [nd] PP 19

Central Food Technological Research Institute (1993) Cere No 18 Central Food Technological Research Institute Mysore India

Cox M and Pearson J (1962) Studies on the losses of stored grains due to insect pest infestation paper presented at the Action Oriented Field Workshop for Prevention of Post harvest Rice Losses Food and Agriculture Organization of the United Nations Vol 21 PP 16

Chang S M and Liw L C (1991) Retrogradation of rice starches studied by differential scanning calorimetry Journal of Food science 56 (2) PP 564 566 570

Charastil J (1991) Influence of storage on super cooling of rice starch and flour gels Journal of Agricultural and Food Chemistry 39 (10) PP 1729 1731

Chattopadhyany P K Kunze O R (1988) Fissuring Characteristics of parboiled and raw milled rice Journal of Food Science and Technology Vol 20 PP 9

Chaturvedi R N (1967) Problem of losses in marketing of food grains in Indian Agricultural marketing Indian Farming April PP 18

Chaoudhary M S and Kunzi K (1972) The effects of moisture absorption on the tensile strength of rice Ph D dissertation Texas A and University College Station Texas

Chrastil J (1990) Protein starch interactions in rice grains Influence of storage on oryzenin and starch Journal of Agricultural and Food Chemistry 38 (9) PP 1804 1809

Dakshinamurthy A (1989) Effect of certain plant products on storage pests of paddy Tropical science 28 (2) PP 119 122

Deluca A J and Ory R L (1987) Effects of microflora on the quality of stored rice Tropical science 27(3) PP 205-214

Delucca K Hall C W and Pfost H B (1987) Comparative studies on the physio chemical properties of stored rice Food Chemistry 16 pp 1 14

Desphande S S and Bhattacharya K R (1982) The texture of cooked rice Journal of texture studies 13 (1) PP 31 42

Dhaliwal Y S Sekhon K S Nagi H P S (1991) Enzymatic activities and rheological properties of stored rice Cereal chemistry 68 (1) PP 18 21

Dhaliwal Y S Sekhon K S and Nagi H P S (1990) Effect of drying and storage on the fatty acid composition of rice Journal of food Science and Technology 27 PP 107

Diruvedi K B (1989) Pest problems in rice and their control Journal of Helminthology 41, PP 61-70

Donahaye E V Navarro S Ziv A Blanschild Y and Weerasinghe D (1991) Storage of paddy in hermitically sealed plastic liners in Srilanka Tropical Science 31 (2) PP 109 121

Faure (1987) The influence of storage on quality criteria of tropical grains Proceeding of the fourth nternational working conference on stored product protection Avi Isral Sept 1986 PP 355 384

Ghose R L M (1978) Losses in storage of rice Rice economy of India Report of Ministry of Food and agriculture PP 71 73

Ghose R L M Ghatge M B and Subrahmanyan V (1976) Storage of rice Rice in India Indian council of Agricultural research PP 10

Ghose R L M and Butany W T (1973) Storage of Rice Proc Indian Acad Scie 49 B PP 287

Ghose R L M Ghatge M B and Subrahmaniyan V (1963) Rice in India Indian Council of Agricultural Research New Delhi PP 28

Gough M C Cheigh H S Kin S K and Kwon T W (1987) Physical changes in stored bulk rice Journal of Agricultural Engineering Research 37(1) PP 59-71

Hamaker B R Griffin V K andMoldenhauer K A K (1992) Potential influence of starch granule associated protein on cooked rice stickiness Journal of Food Science 56 (5) PP 1327 1329

Hampel S M (1987) Nutritional properties of Rice Food Chemistry (7) pp 6

Harish Chander Kulkurmi S G and Berny S K (1990) Acorus Calamus rhizomes as a protectant of milled rice against Sitophiles oryzac and Tribolium castaneum Journal of Food Science and Technology 27 (3) PP 171 174 Hawk and Oser (1965) In practical physiological chemistry 14th edition TATA

Hayakawa S Kawabata A Chikubu S Umeda S Tokue C Sakaguchi E and Nagashima N (1992) Storage of Paddy Journal of Agricultural Science 37 (1) PP 30 38

Hogus J T (1963) Measurement of the degree of milling of rice Rice J 68 (10) pp 10

Houstan D F Huter I r and Kester E B (1976) Storage changes in parboiled rice Journal of Agriculture and Food Chemistry 4 PP 964

Hung C S Chang T C Liao M L and Sheih D S (1980) Bulk storage of paddy rice in pouches Food industry research and development institute No E 90 PP 11

Indhudharaswamy Y M Soubhagya C M and Bhattacharya K R (1978) Changes in the physio chemical properties of rice with ageing Journal of Food Science and Agriculture 2 PP 6327

Indian Council of Agricultural Research (1985) Rice Research in India New Delhi

International Rice Research Institute (1992) Annual Report for (1991) Internatioal Rice Research Institute Los Banos Philippinnes PP 40

International Rice Research Institute (1981) Annual report for (1980) Los Banos Philippine PP 45

International Rice Research Institute (1977) Annual report for (1976) Los Banos Phillipine PP 74

International Rice Research Instiitute (1976) Annual report Los Bonnos Philippine PP 34

Iraq M Mahmood S H (1992) Mite species infesting stored products Journal of Stored Products Research 28 (3) PP 179 181 Jackson M L (1973(Sol Chem Anal practice Hall of India Pvt Ltd New Delhi

Jellinek G (1964) Introduction to and critical review of modern methods of sensory analysis (odour taste and flavour evaluation) with special emphasis on descriptive sensory analysis (flavour profile method) Journal of Nutrition and Dietetics 1 (3) PP 222 233

Jindal V K and Siebenmorgen T J (1994) Effects of rice kernel thickness on head rice yield reduction due to moisture adsorption Transactions of ASAE 37 (2) PP 487 470

Jood S Kapoor A C (1993) Protein and uric acid contents of cereal grains as affected by insect infestation Food chemistry 46 (2) PP 143 146

Jood S Kapoor A C and Singh R (1992) Mineral contents of cereal grains as affected by storage and insect infestation Journal of stored Products Research 28 (3) PP 147 151

Juliar B O Villareal R M Perez C M Villareal C P Takeda V and Hizukuri S (1987) Varietal differences in properties among high amylose rice starches Starch/Starke 39 (1) PP 390 393

Juliano B O (1985) Rice Journal of Plant food 6 (3) PP 129 145

Kachru R P and Dakshinamurthy A (1991) Improved storage technique prevent immense grain losses Indian Farming 41 (3) PP 21 24

Kim B S Park N H Jo K S Kang T S Shin D H (1989) Korean Journal of Food Science and Technology 20 (4) pp 498 503

Kongseree N Khavchaimaha L and Natesomrank K (1985) Changes in cooking and eating qualities of rice during long term storage In Research development systems and linkages for a viable grain post harvest industry in the humid tropics Asian crops post-harvest programme PP 165 187

Kramer A and Twigg B A (1970) Quality cotrol for the food industry 3rd Ed Vol 1 Avl Publishing Co West port conn

Krishnamurthy T S Muralidharan N and Muthu M (1992) Using solar heat to disinfest grain Food chain NO 7 pp 3 4

Kumar S M Sekhon R S and Vidhyad ragan R (1970) Effect of storage on nutrients of paddy Food science and Agriculture Vol 5 pp 250

Lee H J Kim T H and Jeon W B (1991) Grain ageing and sensory changes during rice storage Korean Journal of crop Science 36 (3) pp 266 270

Lee Y E and Osman E M (1991) Physio chemical factors affecting cooking and eating qualities of rice and the ultra structural changes of rice during cooking Journal of the Korean society of food and nutrition 20 (6) pp 637 645

Lii K H Gwo M S Huang C P and Lien C C (1983) Effect of moisture and temperture on storage of milled rice Food industry Research and Development Institute Vol E 81 pp 24

Lin (1986) Microflora in storage rice and control measures in post harvest prevention of paddy/Rice loss (Asian productivity organization training course) pp 158 170

Locatelli D P and Daolio E (1993) Effectiveness of carbon dioxide under reduced pressure against some insects infesting packaged rice Journal of stored Products Research 29 (1) pp 81 87

Mallick AK and Nandi B (1981) Rice (Research) Rice journal 84 (2) pp 8 13

Matsue Y Mizuta K Yoshida T (1991) Varietal difference in palatability of stored rice Japanese journal of Crop Science 60 (4) pp 537 542

Matsuzuki A Takano T Sakamoto S and Kuboyama T (1992) Relation between eating quality and chemical components in milled rice and amino acid contents in cooked rice Japanese journal of crop science 61 (4) pp 561 567

Mc Craw Cready R M and Hassil W Z (1943) The seperation and quant tative estimation of amylose American Chemical Society Journal 65 PP 1154

Mir S L Morita T and Macdonald D J (1991) Factors effecting water uptake in milled rice J Food Sc (50) 6 pp 1676

Mod J Morgan A I and Mcreal X (1975) Rice storage effect of mositure cotent temperature and head rice yield Aik Agric Exp Sta Bull pp 621

Nagawara Rao G (1983) Statistic for Agricultural Science Vol I Rg 365

Nakazava F Noguchi S Takahashi J and Takada M (1984) Gelatinization and retrogiadation of rice starch studied by differential scanning colorimetry Agricultural and Biological Chemistry 48 (1) 201 203

Naiayana Rao M Viswanatha T Mathur P B Swaminathan M and Subrahmanyan V (1984) Effect of storage on the Chemical composition of husked undermilled raw rice Journal of Food Science and Agriculture 5 pp 405

Okazak S (1991) Studies on free amino acids contained in polished rice in Japan Journal of Agriculture Chem Society Japan 35 (3) pp 34

Peiez C M and Juliano B O (1982) Physio chemical changes of the rice grain in storage A brief overview in paddy deterioration in the humid tropics Gasga seminar Bargwi Philippine Oct 1981 pp 180 191

Perumal D and Patourel G (1992) Small bin trials to deteimine the effectivenss of acid activated Kaolin against four species of beetles infesting paddy under tiopical storage conditions **Journal of Stored Products Research** 28 (3) pp 193 199

Piggotyl J R Moirison W R and Clyne J (1991) Changes in lipids and in sensory attiibutes on storage of rice milled International Journal of Food science and Technology 26 (6) pp 615 628

Pillayer P Singaravadivel K Desikachar H S and Subramaniyan V (1993) Low mositure parboiling of paddy Journal of Food Science and **Technology** India 30 (2) pp 97 99

Pillayer P (1984) A rapid test to indicate the texture of paiboiled rices without cook ng **Journal of texture** studies 15 (3) pp 263 273

P llayer P (1979) Influence of processing and storage conditions on the o ality of Rice and its by product Vol 28 (4) pp 349 357

Pi gale A A (1990) Quality of stored rice **Starke** 27 pp 69 71

Pingale S V Kadhol S B Narayana Raoth and Suaminathan M (1957) Effect of insect nfestation in stored grain Studies in husked hand pounded milled raw and parboiled milled rice Food Science and **Technology** 8 (9) pp 512 516

Poduval A B (1962) Effect of storage on thaimine protein and fat of rice J Sci Food Agric 25 pp 607-701

Primio E Barber S and Benedito de Barber C (1970) Modificationes de las protein as durante el almaconaniento alel arroz ysw influenceior sobre las zaiacteristics del grano presented at 3rd Interntional Congress of Food Science and Technology Washington D C August 1970

Pushpamma R and Reddy R (1979) Physiochemical changes in rice and jowar stored in different agro climatic regions of Andra Pradesh Bull grain Technology Vol 17 (2) pp 97 108

Raghavendra Rao S N and Juliano B O (1970) Effect of parboiling on some physiochemical properties of rice Agri Fd Chem 18 (2) pp 289 294

Rajalekshmi R (1984) Effects of cooking on the digestibility of nutritive value of foods Applied Nutrition 3rd Edition Oxford and I BH Publishing Company New Delhi Bombay Culcutta PP 259 266

Ramarathanam N and Kulkarni P R (1989) Effect of ageing on fatty acid composition of some Indian Varieties of rice Journal of food Science and Technology 26 pp 284

Ranganathan R L Rhind D and Tinu V (1987) Nututive quality of rice grains on drying and storage **Food chem** 67(8) pp 63

Roze B V Ehara Y and Juliano B O (1990) Properties of glutelin of mature and developing rice grains **Phytochem** 17 pp 177-182

Sabularse V C Liwzzo J A Rao R M and Grodner R M (1991) Cooking quality of brown rice as influenced by gamma irradication variety and storage **Journal of Food Science and Technology** V 56 (1) pp 96 98

Sajwan K S Kaplan D I Mithra B N and Pande H K (1992) Physio chemical changes in stored rice **Tropical Agriculture** 69 (3) PP 296 300

Sajwan K S Henderson M and Parsons R A (1992) Rice drying and storage **J Agric Eng Res** 13 (2) pp 87 95

Sanjiva Rao B S Vasudevamoorthy A R and Subrahmaniyam R S (1952) The amylose and amylopectin contents of rice and their influences on the cooking quality cereals Proceedings of Indian Academic Sciences 36 B PP 70 80

Schroeder H W (1963) Effects of moisture content humidity and length of storage on maintenance of quality in rough rice USDA agricultural marketing service and agricultural research service **169 Marketing research** pp 596

Ranganathan R L Rhind D and Tinu V (1987) Nututive quality of rice grains on drying and storage Food chem 67(8) pp 63

Roze B V Ehara Y and Juliano B O (1990) Properties of glutelin of mature and developing rice grains Phytochem 17 pp 177 182

Sabularse V C Liwzzo J A Rao R M and Grodner R M (1991) Cooking quality of brown rice as influenced by gamma irradication variety and storage Journal of Food Science and Technology V 56 (1) pp 96 98

Sajwan K S Kaplan D I Mithra B N and Pande H K (1992) Physio chemical changes in stored rice Tropical Agriculture 69 (3) PP 296 300

Sajwan K S Henderson M and Parsons R A (1992) Rice drying and storage J Agric Eng Res 13 (2) pp 87 95

Sanjiva Rao B S Vasudevamoorthy A R and Subrahmaniyam R S (1952) The amylose and amylopectin contents of rice and their influences on the cooking quality cereals Proceedings of Indian Academic Sciences 36 B PP 70 80

Schroeder H W (1963) Effects of moisture content humidity and length of storage on maintenance of quality in rough rice USDA agricultural marketing service and agricultural research service 169 Marketing research pp 596

Sethuraman S Nagarajan M Pilliayer P and Vidhyalingam R (1986) Storability and germination of pre harvested dessicated paddy Agricultural mechanization in Asia Africa and Latin America 17 (3) pp 23 26

Shamsudin W D Schroeder H W and Wasserman T (1981) Effect of storage on quality of rice grain J Agric Sci 6(18) pp 61 62

Shibuya s W J (1979) Effect of ageing of Rice and Rice products J Food Sc 13(7) pp 752 754

Shin M G Min B K and Kim D C (1991) changes in quality characteristics of brown rice during storage Journal of Korean society of Food and Nutrition 20 (3) pp 276 280

Sindu J S Gill M S and Bains G s (1975) Milling of paddy in relation to yield and quality of rice of different Indian Varieties J Agri Fd Chem 23 (16) PP 1983 85

Singaravadivel K and Anthoni Raj S (1992) Chalkiness in parboiled paddy due to microbial conntamination Journal of Food Science and Technology India 29 (5) pp 312 314

Singh M N and George S C (1971) Price spread of paddy Agric Situ India July 16 PP 16

Sinha S (1967) Free sugars in relation to starch accumulation in ageing rice grain Plant physiology 59 pp 417 421

Sinha R N and Wallace H A H (1985) Ecology of fungus induced hot spot in stored grain Canadian Journal of Plant Science 45 pp 48

Sood B C and Siddiq E A (1980) Studies on component quality attributes of rice Oryza Satival Z Pflenzenzuecht 84 PP 294 301

Sung Kon Kim Eun Ja Cho (1993) Effects of storage temperatures on the physio chemical properties of milled rice Journal of Korean Agricultural chemical society 36 (3) pp 146 153

Sreedevi A (1989) Quality Parameters of popular rice varieties M Sc Thesis Dept of H Sc Kerala Agricultural Univesity pp 122 123

Sudhyadi H (1981) Types of amylose in rice grain Agric Biol Chem 37 pp 2437 2438

Takeshita H and Imura O (1990) Loss assessment of stored rice infested by <u>Sitotroga cerealella</u> Applied Entomology and Zoology 25(2) pp 239 249

Tamaki M Tashiro T Ishikawa M and Ebata M (1993) Effect of storage on eating quality of rice Japanese Journal of Crop Science 62 (4) pp 540 546

Tani T Chikurbu S and Iwasaki T (1990) Changes of chemical qualities in husked rice during low temperature storage Journal of Japanese Society Food Nutrition 16 pp 436

Tomar J B (1981) Genetics and correlation studies of some physical and chemical quality traits in rice Ph D Thesis G B Pant University of Agriculture and Technology Patnagar

Unnikrishnan K R and Bhattacharya K R (1988) Application of Gel consistency test to parboiled rice Journal of Food Science and Technology 25 (3) pp 129 132

Verma R A and Uttam J R (1991) Studies on the susceptibility of rice varieties to sitotroga cerelella oliv Bulletin of Grain Technology 28n (1) pp 22 24

Villareal R Ressureccian A D Suzuki L B and Juliano B O (1976) Changes in physiochemical properties of rice during storage Starke 28 pp 88

Webb B D and sterner R A (1972) Criteria of rice quality Rice Chemistry and Technology Ed How bin D F Anm Assoc Cereal Chemistry In crop St Paul Minn PP 104

Wester J (1959) Temporary storage of high mositure rice Trans ASAE 15(2) pp 333 337

Yanai S Tsubata S and Ishitani T (1978) Storability of rice stored in various plastic pouches Nippon shokuin Kogyo Gakkaishi V 25 (10) pp 563 569

Yasumatsu K and Moritaka S (1990) Fatty acid composition of rice lipid and their changes during storage Agriculture Biology and Chemistry (Tokyo) 28 pp 257

APPENDIX 1

SCORE CARD FOR ORGANOLEPTIC EVALUATION OF DIFFERENT VARIETIES OF COOKED RICE

QUALITY ATTRIBUTES	SUB DIVISION OF ATTRIBUTES	SCORE TO EACH DIVISION	SCORE FOR SAMPLES CODE NO I	II	III	IV	V	VI
APPEARANCE	EXCELLENT							
	GOOD	4						
	SATISFACTORY	3						
	FAIR	2						
	POOR	1						
COLOUR	PURE WHITE							
	PINKISH WHITE	4						
	BROWNISH WHITE							
	CHALKY WHITE	2						
	YELLOWISH WHITE	1						
FLAVOUR	EXCELLENT	5						
	GOOD	4						
	SATISFACTORY	3						
	FAIR	2						
	GOOD	1						
TEXTURE	VERY SOFT							
	SOFT	4						
	MODERATELY SOFT	3						
	HARD	2						
	VERY HARD	1						
TASTE	EXCELLENT	5						
	GOOD	4						
	SATISFACTORY	3						
	FAIR	2						
	POOR	1						
DONENESS	WELL COOKED							
	FAIRLY COOKED	4						
	JUST COOKED							
	SLIGHTLY COOKED	2						
	UNDER COOKED	1						

APPENDIX 2

SCORE CARD FOR ORGANOLEPTIC EVALUATION OF DIFFERENT VARIETIES OF RAW RICE SAMPLES

QUALITY ATTRIBUTES	SUB DIVISIONS OF ATTRIBUTES	SCORE TO EACH DIVISION	SCORE FOR SAMPLES CODE NO I	II	III	IV	V	VI
COLOUR	PURE WHITE	5						
	PINKISH WHITE	4						
	BROWNISH WHITE							
	BROWN							
	DARK BROWN	1						
HARDNESS	VERY HARD	5						
	HARD	4						
	SLIGHTLY HARD							
	BRITTLE	2						
	SLIGHTLY BRITTLE	1						
ODOUR	VERY PLEASANT	5						
	PLEASANT	4						
	ACCEPTABLE							
	SLIGHTLY ACCEPTABLE	2						
	UNPLEASANT	1						

APPENDIX 7

EFFECT OF STORAGE ON THE DIFFERENT GRAINS CONSTITUENTS OF THE RICE SAMPLES

ABSTRACT OF ANOVA

Sources	Variety	Storage containers (Co)	Va co	Error
]|	1	?	2	6
Moisture	? 707k	?908*	1 745	1749
Protein	1 ?28	947*	1 917	11 9
Nonprotein Nitrogen	7 075*	4?08	4747NS	4165
Uricacid	? 999*	1 ???k	1 001 k	? ? ?
Calcium	7 76	228?	748?NS	1 166
Iron	2 296	1086	1 560	4 9?5
Phosphorus	?8 609**	1718	0??4NS	? ?08
Free fatty acids	? 40	6 ?92	4 175NS	1 47?

* F value significant at 1% level

** F value significant at 5% level

NS F value not significant

APPENDIX 4

EFFECT OF STORAGE ON THE DIFFERENT GRAINS CONSTITUENTS OF COOKED RICE SAMPLES

ABSTRACT OF ANOVA

	Sources	Variety	Storage containers (Co)	V x Co	Error
	DF	1	2	[illegible]	6
Mean Square	Reducing Sugar	27[illegible]**	1 707	[illegible]9 NS	1 0[illegible]
	Non reducing Sugar	66 7[illegible]8**	28 2	9 7 *	[illegible]55
	Starch	8 062**	4[illegible]7*	8 984**	5 85[illegible]
	Amylose	1 818 *	5 4[illegible]	[illegible] 61 NS	8 043

* F value significant at 1% level

** F value significant at 5% level

NS F value not significant

APPENDIX 5

EFFECT OF STORAGE ON THE PHYSICAL CHARACTERISTICS AND INSECT INFESTATION OF RICE SAMPLES

ABSTRACT OF ANOVA

	Sources	Variety	Storage conditions (Co)	Va co	Error
	DF	1	[illegible]	[illegible]	6
	Thousand grain weight	[illegible]6 40[illegible]**	[illegible]0[illegible]7	2 [illegible]9[illegible]*	6 67[illegible]
	Head rice yield	16 101 [illegible]	[illegible]7 2[illegible]	7402NS	2[illegible]2
Mean [illegible]	Total solids	7 270**	[illegible]680	9 667NS	8 2[illegible]5
	[illegible]scosity	[illegible] 876 *	1[illegible] 964**	604[illegible]	4 [illegible] 6
	Gelatinization temperature	42 9[illegible]9 [illegible]	48 641	[illegible]8 [illegible]0NS	5[illegible] 600
	Insect Infestation	4 799	4976	9 [illegible]00NS	7 [illegible]

[illegible] F value significant at 1[illegible] level

[illegible] F value significant at 5% level

NS F value not significant

APPENDIX 6

ASSOCIATION BETWEEN MOISTURE AND THOUSAND GRAIN WEIGHT OF THE RICE SAMPLES ON STORAGE

Rice Varieties	Fresh sample		Stored rice sample					
			Gunny bag		Pathayam		Metalbin	
	Moisture	T G W	Moisture	T G W	Moisture	T G W	Moisture	T G W
FTB 10	14.[illegible]0	[illegible]9.[illegible]0	[illegible]4.70	[illegible]7.50	[illegible]4.[illegible]8	[illegible]8.00	14.[illegible]1	[illegible]8.[illegible]0
Red Triveni	1[illegible].10	[illegible].00	1[illegible].50	[illegible]4.90	1[illegible].[illegible]1	[illegible]5.00	1[illegible].19	[illegible]5.00

[illegible] 0.170

T G W [illegible] Thousand grain weight

ASSOCIATION BETWEEN MOISTURE AND HEAD RICE YIELD OF RICE SAMPLES ON STORAGE

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Moisture	H R Y	Moisture	H R Y	Moisture	H R Y	Moisture	H R Y
FTB 10	14.[illegible]0	[illegible]6.0[illegible]	14.70	[illegible]6.05	14.38	[illegible]6.20	14.[illegible]1	[illegible]6.[illegible]0
Red Triveni	1[illegible].10	[illegible]7.00	1[illegible].50	[illegible].[illegible]0	1[illegible].[illegible]1	[illegible]7.80	1[illegible].19	[illegible]7.80

[illegible] 0.[illegible]

H R Y Head rice yield

ASSOCIATION BETWEEN TOTAL SOILDS AND TEMPERATURE OF STORAGE CONTAINERS

Rice varieties	Fresh samples		Stored rice samples					
			Gunny bag		Pathayam		Metal bin	
	T S	T S C	T S	T S C	T S	T S C	T S	T S C
PTB 10	[illegible]	[illegible]00	[illegible] 90	[illegible]	4 50	[illegible] 00	[illegible]4 90	[illegible]0 00
Red Triveni	[illegible]57	2[illegible] 00	[illegible] 80	[illegible]0	[illegible] 00	[illegible]2 00	[illegible] 20	[illegible]0 00

0 71

T S Total solids

T S C Temperature of Storage containers

ASSOCIATION BETWEEN VISCOSITY AND AMYLOSE CONTENT OF RICE SAMPLES ON STORAGE

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Amylose	Viscosity	Amylose	Viscosity	Amylose	Viscosity	Amylose	Viscosity
PTB 10	[illegible] 8	10 00	2[illegible] 93	1[illegible] 49	[illegible] 50	10 40	[illegible] 47	9 50
Red Triveni	[illegible]1	9 [illegible]8	24 10	14 40	[illegible]4 [illegible]1	11 [illegible]2	24 25	10 08

0 7[illegible]0[illegible]

ASSOCIATION BETWEEN MOISTURE AND INSECT INFESTATION OF RICE SAMPLES ON STORAGE

Rice Varieties	Fresh samples	Stored rice samples					
		Gunny bag		Pathayam		M[illegible]bin	
	Moisture I I	Moisture	I I	Moisture	I I	Moisture	I I
PTB 10	14.[illegible]0	14.70	0.[illegible]0	14.[illegible]8	0.60	14.[illegible]1	
Red Thriveni	1[illegible].1[illegible]	[illegible]0	[illegible]	1[illegible]	0.54	1[illegible].19	

0.[illegible]

I I   Insect Infestation

ASSOCIATION BETWEEN PROTEIN AND INSECT INFESTATION OF RICE SAMPLES ON STORAGE

Rice Varieties	Fresh Samples	Stored rice samples					
		Gunny bag		Pathayan		M[illegible]bin	
	Protein I I	Protein	I I	Protein	I I	Protein	I I
PTB 10	7.70	7.09	0.[illegible]0	7.26	0.60	7.[illegible]0	
Red Thriveni	8.50	8.[illegible]0	0.70	8.40	0.54	8.50	

r = 0.64 *

I I   Insect Infestation

ASSOCIATION BETWEEN URIC ACID AND INSECT INFESTATION OF RICE SAMPLES ON STORAGE

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Uric Acid	I.I	Uric Acid	I.I.	Uric Acid	I.I	Uric Acid	I.I
PTB 10	-	-	0.005	0.80	0.003	0.60	-	-
Red Thriveni	-	-	0.001	0.70	0.001	0.54	-	-

r = 0.888*

I.I. = Insect Infestation

ASSOCIATION BETWEEN STICKINESS OF RICE SAMPLES AND TEMPERATURE OF STORAGE STRUCTURES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Temperature	Stickiness	Temperature	Stickiness	Temperature	Stickiness	Temperature	Stickiness
PTB 10	23.00	4.20	32.30	2.30	32.00	2.70	30.00	3.60
Red Thriveni	23.00	4.50	32.30	2.40	32.00	2.80	30.00	3.00

r = 0.573*

ASSOCIATION BETWEEN STICKINESS AND AMYLOSE CONTENT OF RICE SAMPLES ON STORAGE

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Amylose	Stickiness	Amylose	Stickiness	Amylose	Stickiness	Amylose	Stickiness
PTB 10	22.38	4.20	23.90	2.30	23.50	2.70	23.47	3.50
Red Thriveni	22.51	4.50	24.10	2.40	24.31	2.60	24.50	3.00

r = 0.652*

ASSOCIATION BETWEEN HARDNESS AND TEMPERATURE OF STORAGE STRUCTURES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Hardness	Temperature	Hardness	Temperature	Hardness	Temperature	Hardness	Temperature
PTB 10	3.00	22.8	3.50	32.30	3.60	32.00	3.80	30.00
Red Thriveni	2.50	22.80	3.10	32.30	3.30	32.00	3.40	30.00

r = 0.360*

ASSOCIATION BETWEEN HARDNESS AND HUMIDITY OF STORAGE STRUCTURES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Hardness	Humidity	Hardness	Humidity	Hardness	Humidity	Hardness	Humidity
PTB 10	3.00	64.80	3.50	67.80	3.60	66.40	3.80	65.30
Red Thriveni	2.50	64.80	3.10	67.80	3.30	66.40	3.40	65.30

r = 0.547*

ASSOCIATION BETWEEN HARDNESS AND HEAD RICE YIELD OF RICE SAMPLES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Hardness	H.R.Y.	Hardness	H.R.Y.	Hardness	H.R.Y.	Hardness	H.R.Y.
PTB 10	3.00	36.30	3.50	36.05	3.60	36.20	3.80	36.30
Red Thriveni	2.50	37.00	3.10	38.00	3.30	37.80	3.40	37.80

r = 0.526*

H.R.Y. = Head rice yield

ASSOCIATION BETWEEN HARDNESS AND AMYLOSE CONTENT OF RICE SAMPLES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Hardness	Amylose	Hard ness	Amylose	Hard ness	Amylose	Hard ness	Amylose
PTB 10	3.00	22.38	3.50	23.90	3.60	23.50	3.80	23.47
Red Thriveni	2.50	22.51	3.10	24.10	3.30	24.31	3.40	24.50

r = 0.384*

ASSOCIATION BETWEEN HARDNESS AND GELATINISATION TEMPERATURE OF RICE SAMPLES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Hardness	G.T.	Hardness	G.T.	Hardness	G.T.	Hardness	G.T.
PTB 10	3.00	89.50	3.50	89.60	3.60	89.60	3.80	89.80
Red Thriveni	2.50	87.00	3.10	87.20	3.30	87.30	3.40	87.50

r = 0.545*

G.T. = Gelatinisation Temperature

ASSOCIATION BETWEEN ODOUR AND TEMPERATURE OF STORAGE STRUCTURES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Odour	Temperature	Odour	Temperature	Odour	Temperature	Odour	Temperature
PTB 10	3.10	22.8	2.50	32.30	2.60	32.00	3.00	30.00
Red Thriveni	3.30	22.80	2.70	32.30	2.90	32.00	3.20	30.00

r = 0.552*

ASSOCIATION BETWEEN ODOUR AND MOISTURE OF RICE SAMPLES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Odour	Moisture	Odour	Moisture	Odour	Moisture	Odour	Moisture
PTB 10	3.10	14.30	2.50	14.70	2.60	14.38	3.00	14.31
Red Thriveni	3.30	13.10	2.70	13.50	2.90	13.31	3.20	13.19

r = 0.558*

ASSOCIATION BETWEEN ODOUR AND FREE FATTY ACIDS OF RICE SAMPLES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Odour	F.F.A	Odour	F.F.A	Odour	F.F.A	Odour	F.F.A
PTB 10	3.10	0.74	2.50	1.35	2.60	1.30	3.00	0.95
Red Thriveni	3.30	1.25	2.70	1.50	2.90	1.37	3.20	1.35

r = 0.754*

F.F.A. = Free Fatty Acids

ASSOCIATION BETWEEN FLAVOUR AND FREE FATTY ACIDS OF RICE SAMPLES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Flavour	F.F.A	Flavour	F.F.A	Flavour	F.F.A	Flavour	F.F.A
PTB 10	3.30	0.74	2.50	1.35	2.80	1.30	3.00	0.95
Red Thriveni	2.80	1.25	2.50	1.50	2.30	1.27	2.60	1.35

r = 0.861*

F.F.A. = Free Fatty Acids

ASSOCIATION BETWEEN ODOUR AND FREE FATTY ACIDS OF RICE SAMPLES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Odour	F.F.A	Odour	F.F.A	Odour	F.F.A	Odour	F.F.A
PTB 10	3.10	0.74	2.50	1.35	2.60	1.30	3.00	0.95
Red Thriveni	3.30	1.25	2.70	1.50	2.90	1.37	3.20	1.35

r = 0.754*

F.F.A. = Free Fatty Acids

ASSOCIATION BETWEEN FLAVOUR AND FREE FATTY ACIDS OF RICE SAMPLES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Flavour	F.F.A	Flavour	F.F.A	Flavour	F.F.A	Flavour	F.F.A
PTB 10	3.30	0.74	2.50	1.35	2.80	1.30	3.00	0.95
Red Thriveni	2.80	1.25	2.50	1.50	2.30	1.27	2.60	1.35

r = 0.861*

F.F.A. = Free Fatty Acids

ASSOCIATION BETWEEN TEXTURE AND AMYLOSE CONTENT

OF RICE SAMPLES

Rice Varieties	Fresh Samples		Stored rice samples					
			Gunny bag		Pathayam		Metalbin	
	Amylose	Texture	Amylose	Texture	Amylose	Texture	Amylose	Texture
PTB 10	22.38	3.50	23.90	3.70	23.50	3.80	23.47	4.00
Red Thriveni	22.51	3.00	24.10	3.10	24.31	3.[illegible]	24.50	3.50

r = 0.923*

* Significant at 5 per cent level.

APPENDIX 7

EFFECT OF STORAGE ON COOKING CHARACTERISTICS OF RICE SAMPLES

ABSTRACT OF ANNOVA

	Sources	Variety	Storage containers (Co)	Va.co	Error
	DF	1	2	2	6
Mean Square	Water uptake	3.356NS	.4900*	2.332*	2.543
	Optimum Cooking time	3.000*	49.083**	27.750**	1.500
	Volume expansion	42.414**	10.068**	5.437**	1.041
	Stickiness	1.470NS	.7300*	.2099*	5.086
	Gruel loss	2.999*	.2099	.4300NS	1.166

* F value significant at 1% level

** F value significant at 5% level

NS F value not significant

APPENDIX 8

EFFECT OF STORAGE ON ORGANOLEPTIC QUALITIES OF RAW AND COOKED RICE SAMPLES

ABSTRACT OF ANOVA

	Sources	Variety	Storage containers (Co)	Va.co	Error
	DF	1	2	2	6
	Colour	1.470*	1.460	.4199NS	3.051
	Hardness	2.999*	.4199*	.8600NS	6.999
Mean Square	Odour	7.776NS	.4570	1.496*	7.000
	Appearance	3.860*	.3437*	.0468	.0312
	Colour	2.296*	.2172	3.120*	2.960
	Flavour	4.799*	.9952*	1.860	4.519
	Texture	1.610*	1.144	1.480NS	1.515
	Taste	7.270	.5361	.1933NS	.494
	Doneness	6.673	.5664	1.875NS	1.953

* F value significant at 1% level

** F value significant at 5% level

NS F value not significant

QUALITATIVE AND QUANTITATIVE CHANGES IN STORED RICE

BY

GEETHA ROY

ABSTRACT OF THESIS
Submitted in Partial Fulfilment of the Requirement
for the Degree
MASTER OF SCIENCE IN HOME SCIENCE
Food Science and Nutrition
Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF HOME SCIENCE
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1995

ABSTRACT

Qualitative mand quantitative changes in stored rice varieties viz. PTB-10 and Red Thriveni were determined by assuming the changes in their grain constituents, physical characteristics, insect infestation, cooking characteristics and organoleptic qualities. After six months storage effect of different storage containers such as gunny bag , pathayam and metal bin on these qualities were taken into consideration.

The grain constituents like protein, nonprotein nitrogen, calcium, iron and phosphorus were found to decrease at a greater rate in PTB-10 stored in gunny bag when compared to Red Thriveni. Similarly constituents like moisture, uric acid and freefatty acids were found to increase in PTB-10 than in Red Thriveni.

Changes in grain constituents, reducing sugars, nonreducing sugars, starch and amylose were observed both in raw as well as in cooked rice samples after storage. Increase in reducing sugar and amylose was at a greater rate in PTB-10 stored in gunny bag especially when cooked while nonreducing sugars and starch level were found to decrease in a similar order.

Compared to PTB-10 in gunny bag after storage, Red Thriveni obtained lower values for thousand grain weight and

total solid level. when stored in all the storage containers tried. Head rice yield and gelatinisation temperature of rice samples increased in Red Thriveni after storage, the rate being higher in gunny bag when compared to other two storage structures. Viscosity was found to increase greatly in Red Thriveni stored in metal bin.

Insect infestation was found to be greater in gunny bags while metal bin was found to be insect proof. PTB-10 was affected by insects more when compared to Red Thriveni.

PTB-10 obtained higher values for cooking characteristics such as volume expansion and gruel loss than Red Thriveni, when stored in gunny bag. As a result of storage water uptake level and swelling index increased at a greater rate in Red Thriveni in all the storage containers tried. The rate of decrease in optimum cooking time was greater in PTB-10 stored in gunny bag while stickiness was greatly reduced in Red Thriveni when compared to PTB-10.

Raw rice samples were more acceptable before storage as quallity parameter hardness increased after storage. Storage provided low scores for colour and odour which had a negative influence on consumer acceptance.

Red Thriveni was more acceptable for all the quality attributes than PTB-10. The quality attributes colour and appearance obtained low scores in the two rice varieties, the decrease being greater in PTB-10 than Red Thriveni. Taste, flavour and doneness was found to decrease in the two rice samples. The rate of decrease in taste. flavour and doneness was lower in Red Thriveni when compared to PTB-10. Among the storage containers, metal bin was found to be a better storage structure than pathayam and gunny bag.

The experiment threw light on the significance of metal bin as a storage structure and favourable facts in the shelf life qualities of evolved varieties like Red Thriveni.