稻米品質研討會專集 282-300 (1988)

貯藏期間稻米品質的改變[1]

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摘　要

稻米之理化性隨貯藏條件及貯藏期間之不同，而發生不同程度之改變。本文就貯藏後米粒老化的一般機制，貯藏對米粒外貌及碾米品質的影響，貯藏對米粒的烹調品質的影響，貯藏對食用品質的影響，及貯藏對米粒營養品質的影響加以檢討。

游離脂肪酸隨時間之延長而增加，並形成脂肪酸——直鏈澱粉複合物、pH降低，因而加速老化。膠化溫度隨貯藏期間之延長而升高，加熱吸水率及膨脹體積亦因溫度及貯藏時間的增加而增加。米飯之膠體軟硬度隨貯藏時間之延長而變硬，粘性則降低。貯藏時間愈長則游離胺基酸及維生素B_1之含量降低愈多，但蛋白質含量之變化不多。

前　言

近年來臺灣稻米在各有關單位的努力之下，糙米年產量一直維持在240萬公噸左右，加上國民消費型態的變變，稻米每人年消費量由1980年之105.5kg降至1982年之95kg，致使每年過剩稻米高達50萬公噸以上(3)。因消費量有限，所以稻米的貯械期大都延長了(1)，在貯藏期間，由於受到穀粒胚部本身的呼吸作用以及昆蟲、微生物的爲害，所釋放的熱及水氣，使得稻米的溫度及周圍環境的相對濕度升高(7)，而影響米粒的外貌(grain appearance)(2,1,17,21)、碾米品質(milling quality)(17)，烹調品質(cooking quality)(16,17)、食用品質(eating quality)(16,10,11)，以及營養品質(nutritional qualtiy)(8,9,20)。由於臺灣的產米過剩，稻穀倉儲期間較長，同時無冷藏設備，故經貯藏2~3年後品質變劣，即白米的透明度隨貯存期的延長而變差，黃變米率亦增加，白米之碱性擴散度(alkali spreading)膠體展流度(gel consistency)及食味品質亦降低(2)，如何改善貯藏之條件及維持稻米之品爲極需解決的問題。本文針對貯藏期間稻米品質的一些變化情形，作較深入的探討。

一、貯藏後米粒老化的一般機制

稻米米粒中成分的含量因品種及栽培環境而有所不同(10,11)。一般在水分含量爲14%時，米粒中澱粉約佔穀粒乾重的70~80%，蛋白質約佔6~9%，肪脂(lipid)約2~3%(8)（表1）。而這三種主要物質經貯藏後，由於發生水解或氧化作用，而影響米粒的外觀及烹調品質，進而更影響到米飯的香味(aroma)及質地(Texture)。Moritaka and Yasumatsu(10)提出了米粒老化的機制（表2），認爲米粒貯藏後，脂肪經水解後形成之游離脂肪酸(free fatty acid)能與澱粉中之直鏈性澱粉(amylose)結合成爲脂肪酸－直鏈性澱粉(fatty acid-amylose)的複合物，而抑制了澱

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[1] 臺中區農業改良場研究報告第 0166 號。

表一　糙米、白米和米糠之化學組成含量

Table 1. Chemical composition (dry basis) of brown rice, milled rice, and bran (Resurreccion *et al* 1979; Singh and Juliano 1977; Cagampang *et al* 1976).

Constituent	Brown rice (0-100%) [a]	Milled rice (90-100%)[a]	Bran (0-6%) [a]
Starch (% anhydronglucose)	75.9	89.8	9.7
Amylose (%)	30.8	32.7	6.7
Total sugars (% glucose)	1.3	0.4	6.4
Crude fiber (%)	0.8	0.1	9.7
Dietary fiber (%)	1.9	0.7	28.4
Crude fat (%)	3.3	0.6	22.8
Crude protein (%)	8.4	7.7	15.7
Crude ash (%)	1.5	0.56	10.6
Phosphorus (%)	0.27	0.09	1.7
Phytin phosphorus (%)	0.14	0.03	1.1
Iron (mg/100 g)	2.0	0.67	15.7
Zinc (mg/100 g)	2.1	1.3	10.9
Lysine (g/16g N)	4.1	3.8	5.6
Threonine	3.7	3.7	4.1
Methionine+cystine (g/16g N)	4.7	4.9	4.7
Tryptophan (g/16g N)	1.2	1.2	1.2

* Abrasive milling fraction of brwon ricee (%by wt).

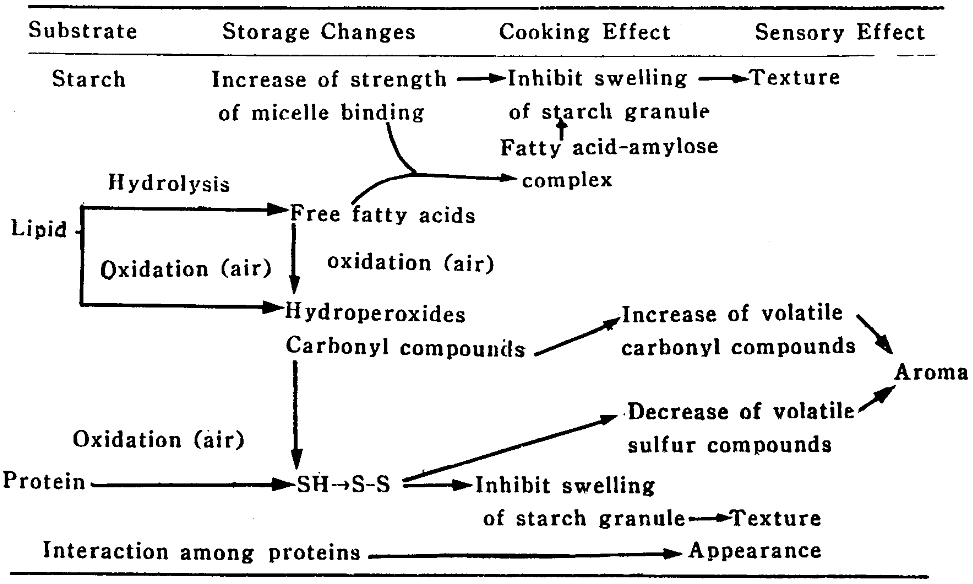
粉顆粒的膨脹(swelling)，而使米飯的質地變硬。另一方面，脂肪或是游離脂肪酸，經氧化後可產生氫過氧化物(hydroperoxides)及羰基化合物(carbonyl compouns)這二種物質可促水蛋白質的氧化，使得蛋白質中之–S–H基相互作用產生了S-S基的變硫鍵結，可影響米粒的外貌、降低揮發生硫化物的含量，另外也會抑制澱粉顆粒的膨脹，而影響米飯的香味及質地。關於澱粉的改變，可能是經過貯藏後，澱粉顆粒中之微束鍵結(micelle binding)加強了，而使米粒質地變硬。

二、貯藏對米粒外貌及碾米品質的影響

稻米採收以後，若溫度在15℃以上貯藏3~4個月後，其品質就開始發生變化(17)。其中米粒外貌的改變主要是白度(whiteness)及透明度(translucency)會隨貯藏溫度及期間的增加而降低（表3、表4）；黃米率則隨之增加(1,2,17)（圖1）。

表二　米粒老化的機制

Table 2.　Summary of Mechanisms of Aging of Rice Grain



* Source: Moritaka and Yasumatsu (1972b): used by permission.

表三　不同貯藏條件下（2℃及 29℃）貯藏 6 個月後之白米其硬度和白色度之變化

Table 3.　Changes in the hardncss index and whiteness of milied rice stored in various forms at 2℃ and 29℃ for 6 months.

Type of rice and form stored	Hardness index[a]				Whiteness[b] (%)	
	Crop season	0	6 months		6 months	
			2℃	29℃	2℃	29℃
Nonwaxy						
Milled	dry	36.6	41.7	41.7	—	—
Milled	wet	26.5	31.9	34.1	39.6	36.8
Rough	wet	26.5	40.6	45.8	37.5	35.5
Defatted milled[e]	wet	20.6	20.3	21.6	49.6	46.3
Waxy[d]						
Milled	dry	26.6	24.8	22.4	—	—
Milled	wet	26.7	26.7	25.9	—	—

[a] Percent of powder retained in 80-mesh sieve after grinding in a Wig-L-Bug amalgamator for 20 s; LSD (5%)≤2.4%

[b] LSD (5%)≤0.7%

[c] Values are mean of two rice.

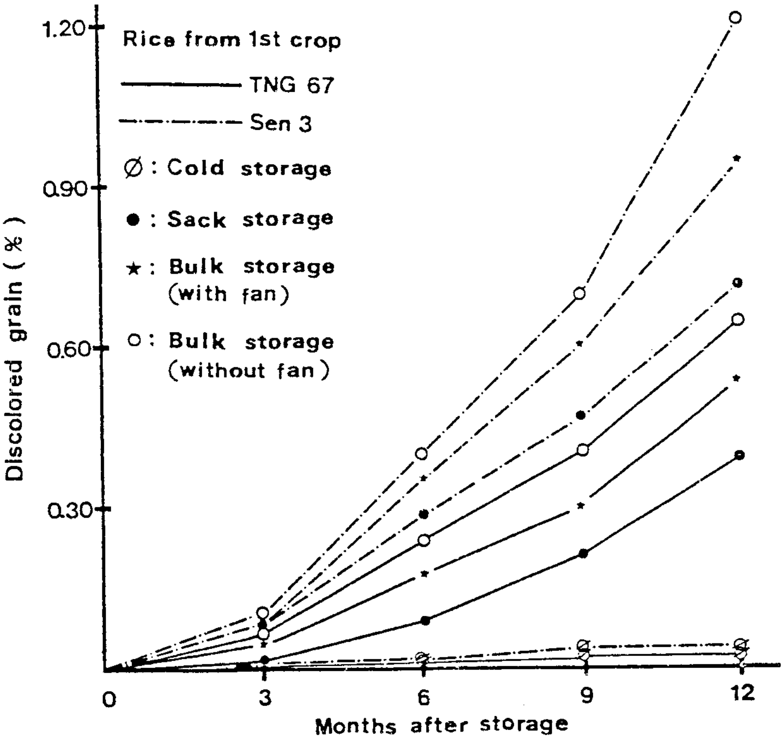
[d] One rice line at each season.

(From ref. 17)

表四　不同貯存期及貯存方式下白米透明度之平均值

Table 4.　Means of translucency udner different storage periods and storage forms (From ref. 2)

Variety	Storage period (months)	stroage form (rice from 1st crop)			
		cold storage	sack storage	bulk storage (with fan)	bulk storage (without fan)
TNT-67	0	3.0	3.0	3.0	3.0
	3	3.0	3.0	3.5	3.5
	6	3.0	3.0	4.0	4.0
	9	3.0	3.0	4.0	4.0
	12	3.0	4.0	4.0	4.0
Sen-3	0	3.0	3.0	3.0	3.0
	3	3.0	3.0	3.0	3.0
	6	3.0	3.0	3.0	3.0
	9	3.0	3.0	4.0	4.0
	12	3.0	3.5	4.0	4.0



圖一　貯藏期間白米黃變米率之變化

Fig. 1.　Change in the percentage of discolored grain as affected by different treatments during storage. (From ref. 2)

關於碾米品質的改變，主要是完整米率(head rice yield)的增加，由於貯藏後澱粉顆粒的微束鍵結增強，加上蛋白質的S-H基氧化成S-S基，使得米粒的硬度指數(hardness index)變大，故在碾米過程中有較大的抗力，避免斷裂，因此而增加了完整米率(17)（表5）。

表五　不同貯藏條件下（2℃及 29℃）貯藏 6 個月後之非糯性糙米的完整米率和硬度變變

Table 5.　Changes in head rice yield and hardness index of nonwaxy brown rice stored at 2℃ and at 29℃ for 6 months.

Rice	Head rice yield (% of milled rice)		Hardness index[a]	
	2℃	29℃	2℃	29℃
IR 1529-680-3	15	64	36.5	42.2
IR 480-5-9	28	60	44.0	50.3
IR 24	79	72	41.4	44.9

[a] Percent of powder retained in 80 mesh sieve after grinding in a Wig-L-Bug amalgamator for 20 s. LSD (5%)=1.5%. (From ref. 22)

三、貯藏對米粒烹調品質的影響

米粒貯藏後，由於脂肪的水解、氧化，其組成分含量發生變化，游離脂肪酸的含量，室溫貯藏較低溫貯藏有增加的現象(21)（表6），其中又以白米方式貯藏增加最多(14)（圖2），故浸過舊米的水其pH值會降低，且貯藏愈久pH值降低愈多，因此可利用這種方法來鑑定新舊米。

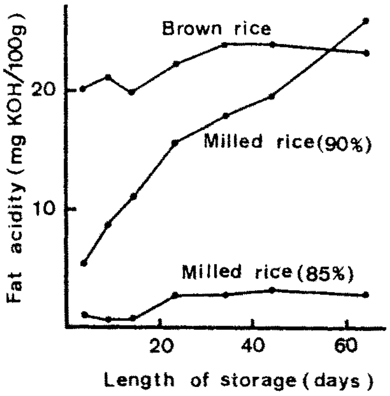
表六　貯藏期間白米之脂肪組成的變化

Table 6.　Change in lipid compositions of polished rice during storage

		g/100g of rice*		g/100g of extranseous lipid			
		Extraneous lipid	Fat-by-hydrolysis	Phosp-holipid	Free fatty acids	Neutral fat	Unsaponifiable matter
Koshiji-wase	9℃	0.35	0.53	1.5	30.6	49.9	5.7
(Niigata)	Room temp.	0.34	0.54	0.4	51.9	30.8	6.0
Asahi	9℃	0.35	0.55	1.5	32.0	54.9	5.6
(Okayama)	Room temp.	0.6	0.54	0.6	51.6	33.0	4.9

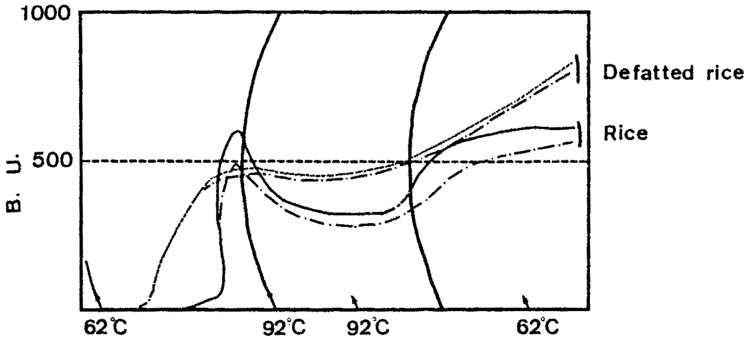
* Mosture content: 13%. (From ref. 22)

再則因游離脂肪酸的增加提高了連續粘度變化圖譜(amylogram)的最大粘度(maximum viscosity)（圖3、圖4）。此外利用X-ray繞射(diffraction)後之X-ray種類的不同，亦證明了游離脂肪酸的增加是提高最大粘度的主要因素(22)（圖5、6、7）。



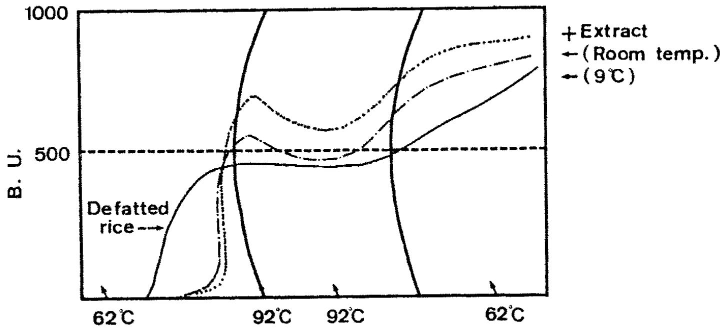
圖二　貯藏期間脂肪酸度的變化

Fig. 2.　Changes in fat acidity during storage. (Norin No. 29) (From ref. 14)



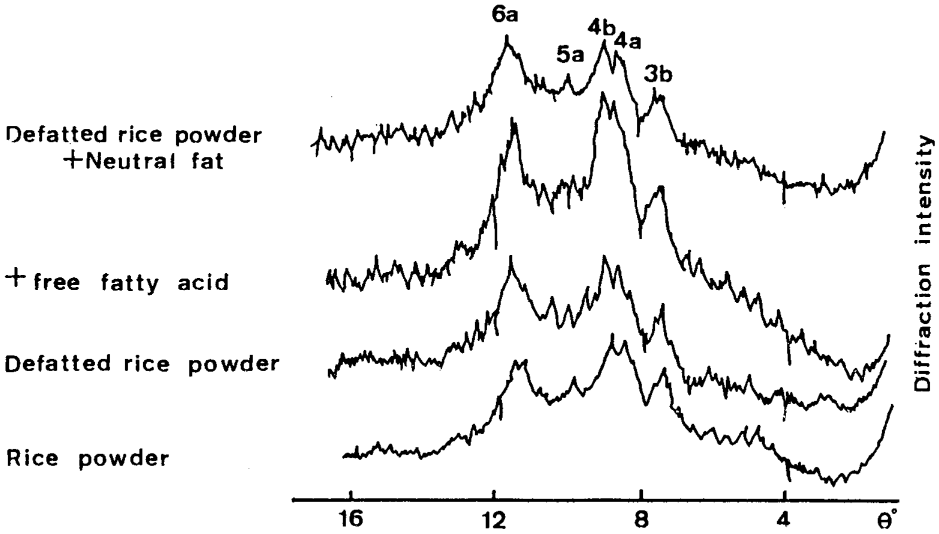
圖三　不同貯藏溫度下所得稻米之米粉和去脂米粉之連續粘度變化圖譜

Fig. 3.　Amylograms of rice powder and defatted rice powder prepared from rice grains having different storage temperatures. (From ref. 22)



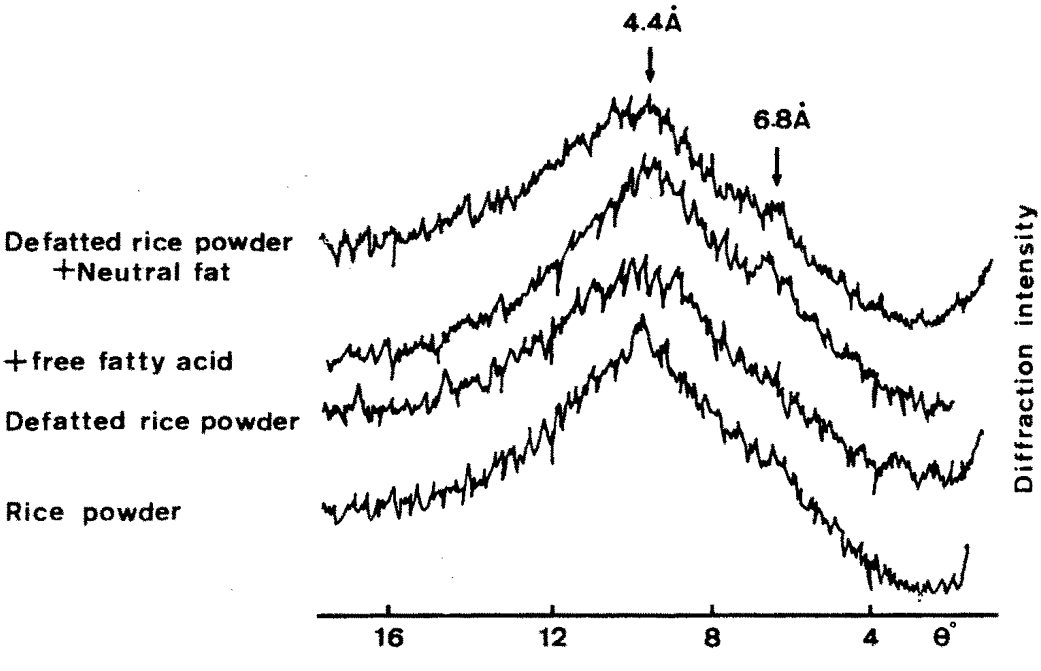
圖四　添加稻米抽出液對去脂米粉之連續粘度變化圖譜之影響

Fig. 4.　Effect of rice extract added back to defatted rice on amylogram. (From ref. 22)



圖五　31℃貯藏下米粉之 X 線模式

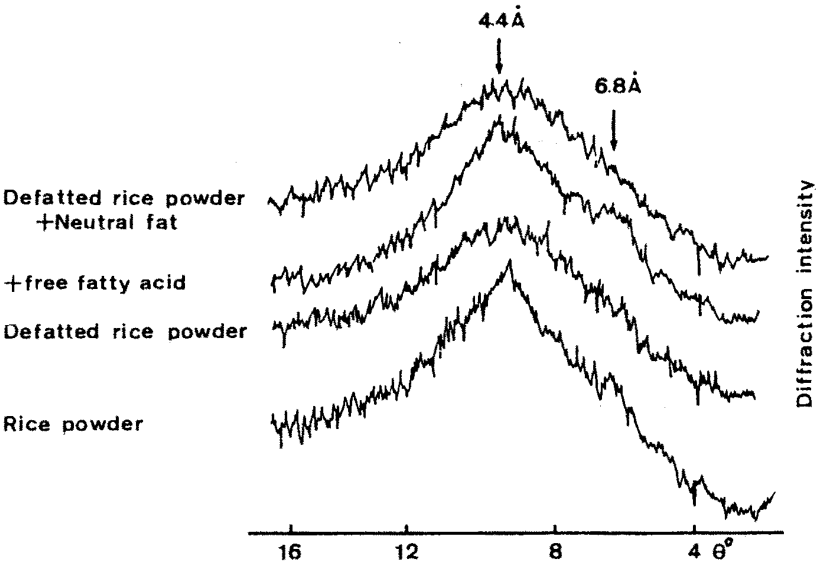
Fig. 5.　X-ray patterns of rice powders taken at 31℃. ((A….. raw starch)) (From ref. 22)



圖六　可使粘度增加之溫度下貯藏之米粉的 X 線模式

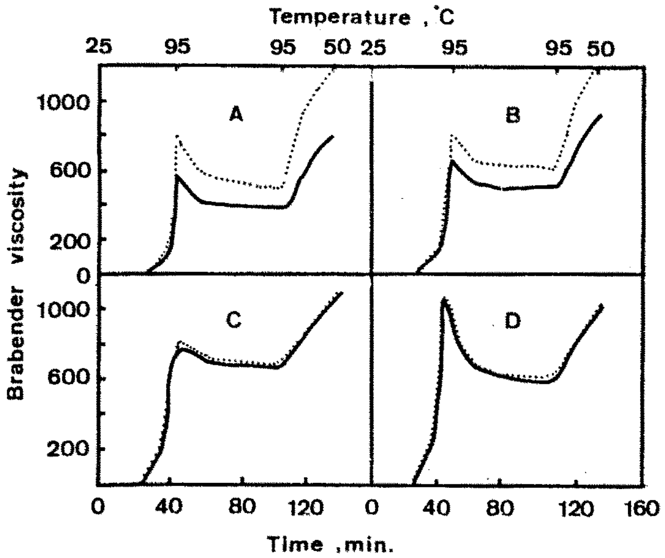
Fig. 6.　X-ray patterns of rice powders taken at temperature of viscosity increase. (From ref. 22)

但Shin et al.(15)則認爲米粒貯藏後，最大粘度的增加是由於澱粉酶(amylase)活性的降低所引起，並非由游離脂肪酸的增加所造成（圖8、表7）。



圖七　達最大粘度時之溫度下貯藏之米粉的 X 線模式

Fig. 7.　X-ray patterns of rice powders taken at temperature of miaximum viscosity. (From ref. 22)



圖八　35℃貯藏下各種糙米之連續粘度變化圖譜

Fig. 8.　Amylograms of undefatted brown rice flour (UBR) (A). ether defatted brown rice flour (EDBR) (B) methanol extracted ether-defatted brown rice flour (MEDBR) (C) and brown rice starch (D) during storage of brown rice at 35℃.——, flours or starch at storage time of 0 month ……, flours or starch at storage time of 12 months (From ref. 15)

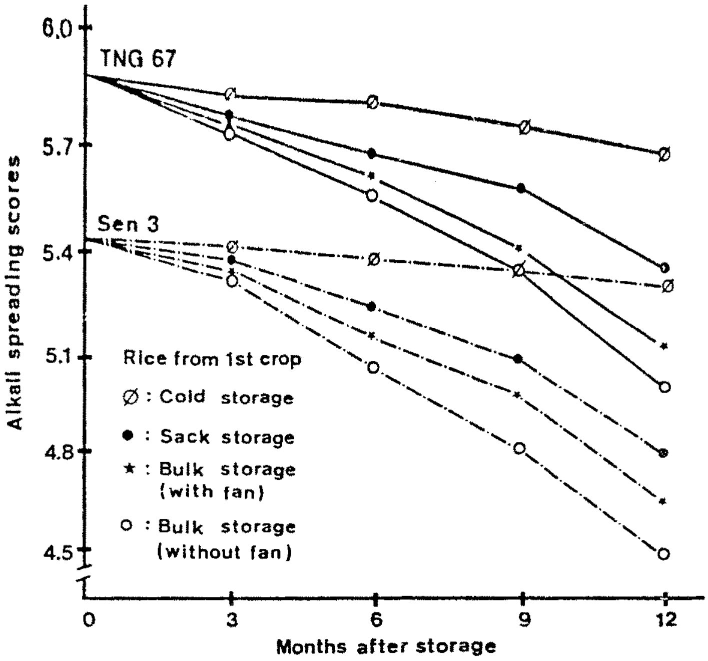
表七　35℃貯藏下各種不同糙米米粉之澱粉酶活性

Table 7.　Amylose activity in various brown rice flours during storage of brown rice aat 35℃

Type of flour[a]	Amylose activity (mg maltose/min/ml extracts)	
	Before storage	After 12 months
Undefatted brown rice flour (UBR)	0.206±0.012	0.114±0.009
Ether defatted brown rice flour (EDBR)	0.170±0.015	0.090±0.009
Methanol extracted ether defatted brown rice flour (MEDBR)	Nil	Nil

* Mean±S.D. based on 3 samples. (From ref. 15)

碱性擴散程度(alkali spreading scores)因貯藏而有降低的趨勢，此暗示膠化溫度(gelatinization temperature)可能會因貯藏而升高(2)（圖9）。加熱吸水率及膨脹容積也因溫度及貯藏時間的增加而增加，可溶性固形物則有減少的趨勢(14)（表8），所以煮飯的適當時間就加長了。Pushpamma and Reddy(10)指出貯存6個月的舊米之適當炊飯時間較新收穫的米多4~6分鐘。



圖九　貯藏期間白米碱性擴散程度之變化

Fig. 9.　Change in alkali spreading scores of milled rice during storage. (From ref. 2)

表八　貯藏稻米之炊飯品質

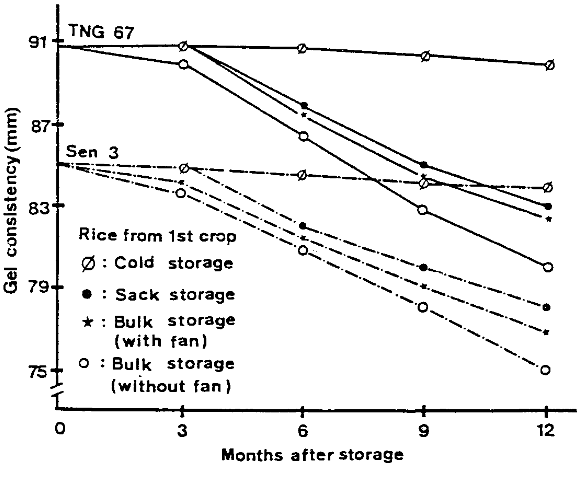
Table 8.　Cooking quality of stored rice*

Sample		Expanded volume (ml)	Water uptake ratio	pH of residual liquid
Manryo	Brown rice storage	39.6	3.08	6.72
	Milled rice storage	38.4	3.05	5.66
	Control (4℃)	36.2	2.64	6.98
Koshisakae	Brown rice storage	33.8	2.66	6.33
	Milled rice storage	35.2	2.77	5.54
	Control (4℃)	32.6	2.51	6.70
Norin No.29	Brown rice storage	33.6	2.85	6.75
	Milled rice storage	32.5	2.76	6.18
	Control (4℃)	32.2	2.54	6.85

* Milling yield, 90%, After 50 days storage. (From. ref. 14)

四、貯藏對食用品質的影響

稻米的食用品質主要受米飯的質地及香味的影響。一般直鏈性澱粉含量較高之秈稻(indica rice)，煮成米飯時較粗糙而不具粘度。直鏈性澱粉含量較低的稉稻(japonica rice)煮成米飯時乾濕度適中，粘性中等而較鬆軟，而糯稻(waxy rice)則幾乎不含直鏈性澱粉，煮成飯時較粘而濕潤(10,11)。通常貯藏後的非糯性稻米(non-waxy rice)煮成飯時，其硬度(hardness)會有增加的現象，膠體軟硬度(gel consistency)隨貯藏時間的增加而變硬，粘性(stickness)也有降低的趨勢。但糯米因幾乎不含直鏈性澱粉，故貯藏後，不論是硬度、膠體軟硬度或粘性皆無明顯的變化。(10,17,2,16)。（圖10，表9、10、11）



圖十　貯藏期間膠體軟硬度之變化

Fig. 10.　Change in gel consistency of milled rice during storage. (From ref. 2)

表九　貯藏期間不同品種白米之米飯性質的變化

Table 9. Mean changes in cooked rice properties during storage of milled rice of six nonwaxy varieties at 28-30℃

Storage Period (mo)	Cooked Rice Instron Hardness (kg)	Gel Consistency (mm)	Amylograph Viscosity (BU)		
			Peak	Final at 94℃	Cooled to 60℃
0	7.4	65	541	359	703
1	7.5	60	592	379	750
2	8.4	54	620	400	793
3	8.8	53	652	440	820
4	8.8	52	649	426	835
5	8.6	50	678	441	851
6	8.4	56	…	…	…

* source: Perez and Juliano (1982): used by permission.

表十　不同貯藏條件下米飯之質地變化

Table 10. Texture of cooked rice perpared from 4℃-stored and 40℃ stored rice samples

Property	4℃-stored rice	40℃-Stored rice	t-Test[b]
Texture of cooked rice[a]			
Hardness	2.92±0.145	3.49±0.162	*
Stickiness	0.51±0.054	0.10±0.027	**
Cohesiveness	0.681±0.0440	0.715±0.0341	

[a] Texturometer unit.

[b] *p=0.01 and **p=0.001. (From ref. 16)

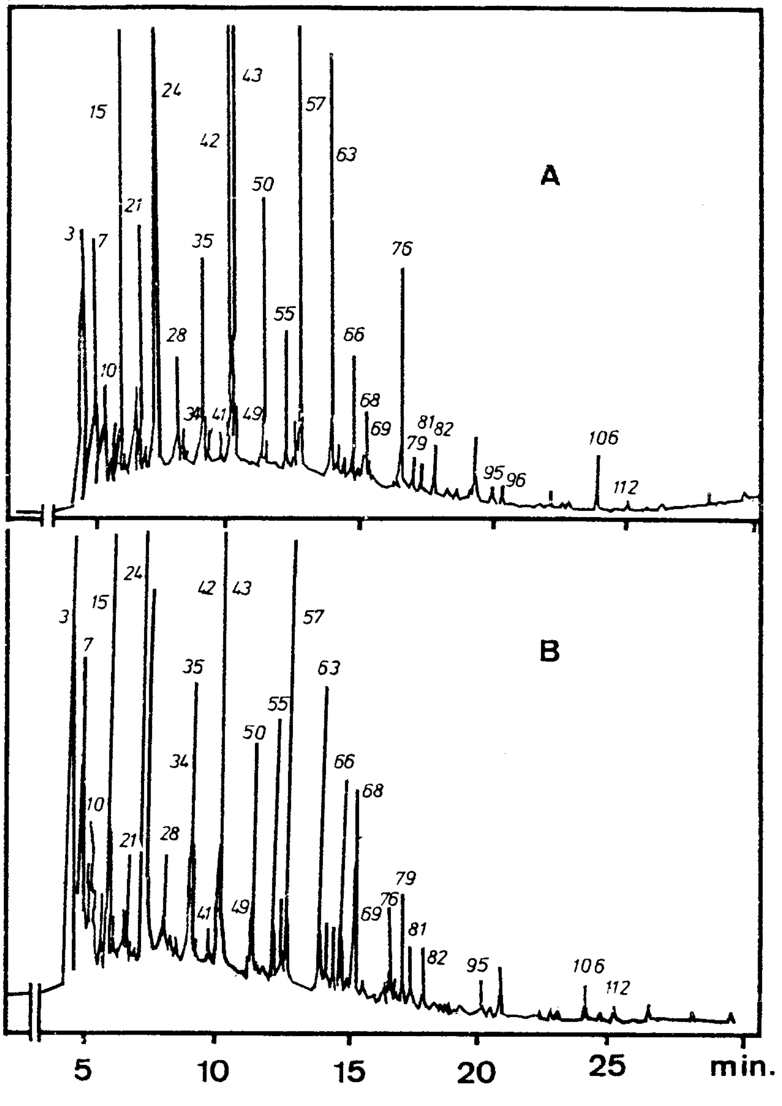
表十一　不同貯藏條件下（2℃和 29℃）貯藏 6 個月後之各種白米的粘度變化

Table 11. Stickiness of IR24, Ir29, and IR833-6-2 milled rice after storae for 6 months at 2℃ and at 29℃

Variety or line	Form of stored rice	Crop season	Stickiness (g/10 grains)[a]	
			2℃	29℃
Nonwaxy				
IR24	Milled	dry	196	96
IR24	Milled	wet	173	83
	Defatted milled	wet	168	106
	Rough	wet	128	114
Waxy				
IR29	Milled	wet	208	262
IR833-6-2	Milled (7.4% protein)	wet	168	160
	Milled (7.4% protein)	dry	127	120

[a] LSD (5%)=18. (From ref. 17)

由貯藏過的米粒煮成的米飯其蒸氣經由氣相層析儀(Gc gas chromatorgraphy)分析的結果，發現約有一百多種揮發性物質(16)（圖11），而主要是揮發性羰基化合物。又貯藏在40℃的米粒其不飽和脂肪酸：亞麻油酸(linoleic acid)及亞麻脂酸(linolenic acid)有減少的趨勢(20)（表12）。相對地，羰基化合物中之己烷醛(hexanal)有顯著的增加(16)（表13），其峰面積(peak area)由95.2增加到204.1。此意味著在貯藏期間不飽和脂肪酸自行氧化後增加了羰基化合物的含量。而且認定己烷醛是造成稻米腐敗氣味的主要因子。



圖十一　米飯之上部揮發性物質的氣相層析圖譜

Fig. 11　Gas chromatograms of headspace volatiles of cooked rice (A) 4℃-stored rice; (B) 40℃-stored ric. (From. ref. 16)

表十三　米飯之主要揮發性組成分的相對含量

Table 13.　Relative amounts of major volatile components of cooked rice

Peak no.	Compound	Relative amount of volatile component					
		Headspace analysis[a]				SDE method[b]	
		4℃-Stored		40℃-Stored		4℃-Stored	40℃-Stored
Alkanals		(A)	(B)	(A)	(B)		
15	Pentanal	13.0	(4.4)	27.0	(5.7)	4.2	12.4
24	Hexanal	95.2	(31.8)	204.1	(43.2)	65.9	226.6
35	Heptanal	5.8	(2.0)	7.9	(1.7)	7.4	16.6
50	Octanal	6.9	(2.3)	6.1	(1.3)	18.2	24.8
63	Nonanal	11.6	(3.9)	8.7	(1.8)	40.9	48.9
76	Decanal	6.6	(2.2)	3.4	(0.7)	14.4	19.7
Alkenals							
41	trans-2-Hexenal	0.6	(0.2)	1.3	(0.3)	1.3	3.6
55	trans-2-Heptenal	3.6	(1.2)	6.6	(1.4)	13.7	47.0
66	trans-2-Octenal	3.4	(1.1)	5.9	(1.2)	22.2	63.3
81	trans-2-Nonenal	1.0	(0.3)	2.0	(0.4)	12.2	38.1
106	trans-2-trnas-4Decadienal	1.9	(0.6)	1.2	(0.3)	132.5	193.4
Aromatic aldehydes							
79	Benzaidehyde	1.0	(0.3)	3.0	(0.6)	4.7	16.5
95	Phenylacetaldehyde	0.5	(0.2)	0.9	(0.2)	18.7	43.4
Ketones							
7	Acetone	12.0	(4.0)	15.3	(3.2)	—	—
34	2-Heptanone	2.3	(0.8)	6.1	(1.3)	1.7	10.8
49	2-Octanone	1.5	(0.5)	1.4	(0.3)	2.8	4.1
62	2-Nonanone	0.3	(0.1)	0.6	(0.1)	1.5	3.7
56	6-Methyl-5-hepten-2-one	1.4	(0.5)	2.3	(0.5)	2.0	11.9
Alcohols							
43	1-Pentanol	11.5	(3.8)	9.1	(1.9)	30.5	44.9
57	1-Hexanol	26.1	(8.7)	10.3	(2.2)	127.1	93.3
69	1-Heptanol	1.2	(0.4)	1.5	(0.3)	12.4	23.9
82	1-Octanol	1.5	(0.5)	1.8	(0.4)	23.0	41.4
96	1-Nonanol	0.6	(0.2)	0.3	(0.1)	12.1	14.8
68	1-Octen-3-ol	2.2	(0.7)	5.3	(1.1)	9.1	40.9
112	Benzyl alcohol	0.4	(0.1)	0.8	(0.2)	14.6	35.0
Miscellaneous							
42	2-Pentylfuran	13.0	(4.4)	18.1	(3.8)	11.5	30.3
155	4-Vinylphenol	—	—	—	—	66.3	126.7
Total peak area		299.0		472.4		—	—

[a] Relative amount of each volatile component in the headspace vapor of cooked rice: (A). Peak area on the gas chromatogram; (B). peak area % (total peak area =100).

[b] Relative amount of each volatile component in the extract obtained by simultaneous distillation-extraction of boiled rice (peak area of each volatile component×100/peak area of internal standard). (From ref. 16)

表十二　貯藏稻米之脂肪組成

Table 12.　Lipid composition of stored rice (From ref. 20)

Storage temperatures		% Composition of total lipid	
		5℃	40℃
	Myristic acid	0.6	0.6
	Palmitic acid	17.0	17.9
	Stearic acid	0.6	1.5
Fatty acids	Oleic acid	30.4	33.2
	Linoleic arid	47.1	44.8
	Linolenic acid	4.3	2.0
Total lipid (mg% of rice)		390	310

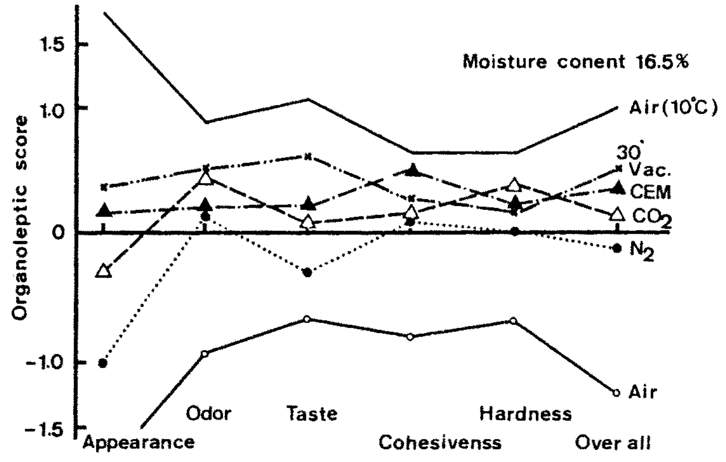
遠藤等人(4)指出由米飯質地分析儀(texturometer)測出之硬度、粘性及附著性(cohensiveness)與官能檢定(sensory test)的綜合評價有密切的關係，其中硬度與綜合評價呈顯著負相關，而粘性與附著性則與之有顯著正相關。（表14）

表十四　米飯質地分析儀所測定的特性值和官能品評之間的相關係數

Table 14.　Correlation coefficients between texturometer measurements and sensory score (From ref. 4)

	Hardness	Cohens-iveness	Hardness/ cohensiveness	Stic-kness	Hardness/ stickness	Mean stickness
Sensory score	–0.50*	0.82**	–0.77**	0.81**	–0.73**	0.81**

由以上的結果，貯藏後米飯質地變硬，粘性變差，加上腐敗的氣味，可知舊米的食用品質降低，在食用上較不為品評員所接受(19,6,20)（圖12），當然也較不受大眾歡迎。



圖十二　貯藏 3 個月後稻米之官能評價

Fig. 12.　Organoleptic evaluation of rice stored for 3 months (From ref. 19)

五、貯藏對營養品質的影響

稻米的營養品質，主要決定於蛋白質的含量，尤其是離胺酸(Lysine)含量的多寡。米粒經貯藏後，游離胺基酸(free amino acid)中除胺基丙酸(alanine)外，其他的胺基酸如：離胺酸、甲硫胺酸(methionine)、麩胺酸(glutamic acid)等皆有降低的現象，而且隨貯藏溫度及時間而異，溫度愈高、時間愈長則游離胺基酸含量降低愈多(5)（表15）。但水溶性及鹽溶性蛋白質的含量則幾乎沒有太大的改變(17,9)（表16）。

表十五　貯藏期間米粒之游離胺基酸含量的變化

Table 15.　Change in free amino acids of rice grains (Nippon bare) during storage under air (mg/100g dry wt.) (From ref. 15)

Amino acid	Before storage	1 year		3 year	
		Paddy 30℃	Paddy 4℃	Paddy 4℃	Brown 4℃
Lysine	16.5	10.1	13.4	1.8	1.9
Histidine	4.8	3.2	4.7	0.7	0.9
Arginine	14.9	10.5	14.0	3.8	4.4
Aspartic acid	32.6	23.8	21.9	7.4	8.3
Threonine	10.5	5.1	7.2	2.0	2.0
Serine	15.9	10.2	12.3	7.1	9.2
Glutamic acid	58.3	36.8	45.4	7.2	10.3
Proline	10.6	7.2	8.1	1.9	1.9
Glycine	5.6	3.7	3.9	2.0	1.7
Alanine	10.0	12.2	10.9	14.4	10.8
Valine	8.2	4.8	5.7	2.5	2.4
Methionine	8.1	5.1	6.1	1.5	1.3
Isoleucine	4.6	2.7	3.0	0.7	0.6
Leucine	9.0	5.1	5.9	1.1	0.9
Tyrosine	5.7	3.3	3.7	1.0	0.8
Phenylalanine	4.5	2.6	3.0	0.7	0.7
Total	219.8	146.4	169.2	55.8	58.1

表十六　用 MAES 法所抽出 albumin 與 globulin 量

Table 16.　The amount of albumin and globulin by maes method (From ref. 9)

Meterial	Albumin % of total N	Globulin $ of total N
Check	3.80	6.92
Storaged rice	3.35	6.68
Heated rice	3.17	6.56

至於維生素B_1（即thiamine）的含量則因貯藏漏失而含量降低(21)（表17），且其降低速率較核黃素(riboflavin)及菸鹼酸(niacin)快(10)。由於離胺酸及維生素B_1含量的降低而降低了米粒的營養品質。除此之外，稻米在貯藏期間，由於微生物的滋長，產生黴菌毒素(mycotoxins)（由真菌類(fungi)所產生），其中之黃麴毒素(aflatoxin)（由黴菌(mold)所產生）對人類或是動物更是爲害很大(7)。

表十七　貯藏溫度對於白米中維生素 B_1 含量的影響

Table 17.　Effect of storage Temperature on thiamine content of polished rice.

Variety	treatment	(r-%) Thiamin content
	Before storage	66.2
Koshijiwase (Niigata)	9℃	58.3
	Room Temp.	33.2
	Before storage	98.6
Asahi (Okayama)	9℃	68.0
	Room Temp.	57.7

(From ref. 21)

六、結論

由以上各點的說明可知；因爲貯藏的關係，在米粒外貌、烹調、食用及營養品質上都有不良的變化，同時在貯藏期間易受微生物代謝物的污染，國民食用後易有礙健康，故貯藏後稻米品質劣化是不爭的事實。要解決這個問題，收穫後的處理要特別小心，如乾燥機之選別、乾燥溫度之調整及乾燥後穀粒之含水量均要在規定之範圍內。本省農會及碾米廠之稻米貯藏，以袋裝及散裝兩種方式盥主。根據宋及洪(2)之研究，散裝者之品質劣化程度較袋裝者大，尤以無通風設備之散裝稻穀爲甚。稻穀本身爲有生命的種子，故在貯藏中亦進行呼吸作用並消耗能源。在空氣不流通而高溫的地方，則呼吸率增加，ATP的消耗增加，種子之老化也增快。因此，如何降低溫度，增加空氣的流通，以減緩種子之老化，乃爲保持稻穀新鮮度之要訣。目前臺灣各碾米廠使用加入CO_2於包裝袋內之作法，可以維持稻米新鮮度相當久的時間，故值得大力推廣。日本的穀倉大部份有冷藏設備，故可以保持良質米的時間相當長，但在本省大規模的稻穀冷藏倉庫不多。政府大力推廣良質米行銷之際，興建新米倉時，應把冷藏設備考慮在內，如此才能長期保鮮本省的良質米。

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Changes in Rice Grain Quality During Storage

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ABSTRACT

Physico-chemical properties of rice is known to change during the storage period. The mechanism of aging during storage and the effect of storage time on grain appearance, milling quality, cooking and eating qualities as well as nutritional value are reviewed and evaluated.

Free fatty acid is increased in parallel with the increase of pH value. Free fatty acid and amylose are then forming the fatty acid-amylose complex which contributed very much to agin of rice grains. Gelatinizaton temperature, Water absorption rate and expansion volume are increassed with the prolongation of storage period. Harder gel consistency and reduced stickiness of rice grains are resulted due to storage. Free amino acid and vitamin B_1 contents are reduced with the prolongation of storage period. However, no change in the rate of water and alkali soluble proteins occurred during the storage period.