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Effect of Modified Atmosphere Storage on Seed Quality Parameters of Paddy

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ABSTRACT Development of insect resistance against chemical fumigants is posing problem in the use of fumigants. Modified atmosphere (MA) or controlled atmosphere (CA) storage are one of the alternatives to toxic residue building chemical fumigants to protect stored seed from insect pest infestations. Seed moisture content is most important factor determining storage life of seed. Paddy seeds with 11, 13 and 15 per cent moisture level were stored under 20, 40, 60 and 80 per cent CO_2 concentrations for 4, 8 and 12 months storage periods to protect it from storage pests. Seeds with 11 per cent moisture content can safely be stored up to one year under MA conditions.

Key words: Rice seed, CO_2, modified atmosphere storage, germination

Storage of seed is critical in view of maintenance of its quality parameters like viability, vigour and seed health. Insect infestation is one of the several factors that cause seed deterioration in storage. Drying of seeds to safe moisture level and storing them in drier atmosphere is difficult due to higher relative humidity prevailing during their harvest time. Besides insects, fungal infection is also favoured by high moisture content. Thus prevention of insect and fungal infestation needs attention from the view point of both seed and food. Chemical fumigation, and modified atmosphere (MA) are some of the technologies available to protect grain from insect attack in storage. Chemical fumigants like methyl bromide and phosphine are used to protect stored product. However, both of these chemicals are toxic and hazardous to handle. It is already reported that phosphine is having xenotoxic effect on human [1].

Methyl bromide has been listed as a ozone depleting substance at the Copenhagen meeting of the parties to the Montreal Protocol on substances that deplete the ozone layer (Montreal Protocol 1992). It is also referred as carcinogenic [2]. Development of insect resistance towards phosphine is also posing problem [3, 4]. Therefore, there is worldwide concern over replacement of Methyl bromide and Phosphine with other suitable technology to kill storage insect pests. Alternatively, carbon dioxide treatment is residue free and approved by Environmental Protection Agency, USA. Carbon dioxide treated grains or seeds are also accepted in the organic market. Carbon dioxide based MA system involving CO_2 concentrations ranging from 20-80 per cent is usually used for disinfecting stored products [5, 6]. In case of paddy carbon dioxide concentration ranging from 20-80 per cent can effectively control rice weevil and lesser grain borer whereas, 60-80 per cent CO_2 was capable of reducing fungal infestation in paddy seeds with higher moisture content (11, 13 & 15 % mc) [7].

However information regarding effect of CO_2 rich atmosphere on seed quality parameters of paddy seeds with high moisture content is not

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available. This study was undertaken to see whether MA with higher carbon dioxide concentration had any beneficial or adverse effect on seed quality parameters of paddy with higher moisture content.

MATERIALS AND METHODS

Rice seed variety BTC was used in the present study. Seed was temporarily stored at 5°C before start of experiment.

Effect of storage period and carbon dioxide seed quality

a. *Storage structure* - Specially designed plastic containers (1 kg capacity) were used as storage structure. Lid of each container was fitted with one inlet port, one outlet port (made of silicone tube) and one rubber septum. Gas mixture from gas blender was introduced through inlet port and replaced gas came out through outlet port Concentration of CO_2 inside the container was checked by using gas chromatograph taking gas sample through rubber septum.

b. Seed conditioning of different required moisture levels - Matthew and Powell [8] method was used to raise seed moisture content to a pre-determined level. Moisture content of seed was checked by hot air oven method.

c. Grain storage and insect inoculation - Six hundred grams of seed of specific moisture content (three moisture levels; 11, 13 and 15%) was taken randomly after thorough mixing of whole bulk of seed. Before keeping, moisture content of seed was confirmed following ISTA [9] oven drying method. Twenty adult insects (*S. oryzae*) were released in each container. Gas mixture from gas blender was introduced through inlet port. The carbon dioxide concentration inside the container was checked using a 1ml gas sample in gas chromatograph.

For each moisture level (*viz.* 11, 13 and 15%) four treatments of carbon dioxide (20, 40, 60 and 80% CO_2 concentrations) were given in three replications each along with control (normal atmosphere, unsealed but with provision of restricting insect movement). Three different sets were prepared to take observation after three successive durations (4, 8 and 12 months) of storage. After giving treatments, containers were kept in a room under ambient condition.

Effect of carbon dioxide on seed viability, vigour and biochemical parameters: After completion of each exposure period CO_2 concentration inside the container was checked. Then seal of container was opened and observations on seed viability, vigour and biochemical parameters were taken. Seed viability and vigour index were measured taking pure seed fraction from all treatments separately after completion of each period of storage. Germination tests were conducted according to ISTA rules [9].

On fourteenth day of germination, data on seedling dry weight were taken for determination of vigour. Dry weight was taken after drying seedlings at 80 ± 1 °C for 24h and expressed as mg/10 seedlings. Vigour index was computed as Vigour index-II = Seedling dry weight, (in mg) x Germination (%) adopting the method of Abdul Baki and Anderson [10].

(a) Dehydrogenase activity

Dehydrogenase activity was measured as the intensity of formazan at 480nm following Kittock and Law's [11] procedure. 25 seeds in 3 replications were used for the study.

Relative quantification of the malondialdehyde (MDA) content was done on the basis of the intensity of the reaction mixture read as the change in OD value at 535 and 600 nm. Twenty dry whole seeds were randomly taken for each replication and all treatments were taken in 3 replication.

Statistical Analysis

Statistical analysis for all the parameters studied was carried out using the Factorial Design [12]. Data were transformed into $\sqrt{(x+0.5)}$ values for vigour indices or Arc Sin values for per cent germination for purpose of analysis.

RESULTS AND DISCUSSION

Effect of modified atmosphere (MA) storage on germination

The study revealed that germination percentage of rice seed with 15 per cent moisture content reduced below 20 per cent even within 8 months of storage

Table 1. Effect of modified atmosphere storage on the germination of rice seeds

Treatments		Storage durations			Mean
		*D_1 (4 months)	D_2 (8 months)	D_3 (12 months)	
M_1 (MC 11%)	C_0 (ambient)	91.67 (73.31)	90.67 (72.28)	86.00 (68.06)	89.44 (71.22)
	C_1 (20%CO_2)	91.00 (72.61)	90.67 (72.28)	81.67 (64.66)	87.78 (69.85)
	C_2 (40%CO_2)	91.33 (73.00)	90.33 (71.99)	80.67 (63.93)	87.44 (69.64)
	C_3 (60%CO_2)	92.00 (73.65)	91.33 (72.95)	81.33 (64.41)	88.22 (70.34)
	C_4 (80%CO_2)	92.33 (73.98)	91.00 (72.65)	82.00 (64.92)	88.44 (70.52)
M_2 (MC 13%)	C_0 (ambient)	90.67 (72.28)	90.33 (71.99)	85.00 (67.24)	88.67 (70.50)
	C_1 (20%CO_2)	90.67 (72.25)	88.33 (70.05)	68.00 (55.56)	82.33 (65.95)
	C_2 (40%CO_2)	91.00 (7Z65)	88.67 (70.38)	68.67 (55.97)	82.78 (66.33)
	C_3 (60%CO_2)	91.33 (7Z92)	88.00 (69.81)	69.33 (56.39)	82.89 (66.37)
	C_4 (80%CO_2)	90.33 (71.92)	89.00 (70.64)	69.67 (56.59)	83.00 (66.38)
M_3 (MC15%)	C_0 (ambient)	90.33 (71.92)	89.33 (71.02)	84.67 (66.96)	88.11 (69.97)
	C_1 (20%CO_2)	89.00 (70.68)	18.67 (25.58)	0.00 (2.87)	35.89 (33.04)
	C_2 (40%CO_2)	88.67 (70.35)	19.00 (25.82)	0.00 (2.87)	35.89 (33.01)
	C_3 (60%CO_2)	88.33 (70.05)	18.33 (25.32)	0.00 (2.87)	35.56 (32.75)
	C_4 (80%CO_2)	89.33 (70.97)	19.33 (26.05)	0.00 (2.87)	36.22 (33.30)
Mean	C_0 (ambient)	90.89 (72.51)	90.11 (71.76)	85.22 (67.42)	88.74a (70.56)
	C_1 (20%CO_2)	90.22 (71.85)	65.89 (55.97)	49.89 (41.03)	68.67b (56.28)
	C_2 (40%CO_2)	90.33 (72.00)	66.00 (56.06)	49.78 (40.92)	68.70b (56.33)
	C_3 (60%CO_2)	90.56 (72.21)	65.89 (56.03)	50.22 (41.22)	68.89b (56.49)
	C_4 (80%CO_2)	90.67 (72.29)	66.44 (56.45)	50.56 (41.46)	69.22b (56.73)
Mean	M_1	91.67 (73.31)	90.80 (72.43)	82.33 (65.20)	88.27a (70.31)
	M_2	90.80 (72.41)	88.87 (70.57)	72.13 (58.35)	83.93b (67.11)
	M_3	89.13 (70.80)	32.93 (34.76)	16.93 (15.69)	46.33c (40.41)
Mean		(72.17a) 90.53	70.87b (59.26)	57.13c (46.41)	

Means with the same letter are not significantly different.

Values in the parentheses are transformed (Arc Sin values). MC = Moisture content

	CD value at 5%		CD value at 5%
Moistures (M)	= 0.724	CM	= 1.618
CO_2 concentrations(C)	= 0.934	CD	= 1.618
Durations (D)	= 0.724	CDM	= 2.803
MD	= 1.254		

*Germination (%) before starting storage = 92

which rendered it unfit for planting. None of the CO_2 treatments could slow down the process of seed deterioration. The seed stored under ambient storage (control), irrespective of initial moisture content, recorded higher germination than MA storage after 12 months. However, the germination remained above 80 per cent in seeds having 11 per cent moisture content in MA storage. As the moisture levels in control seeds under ambient storage got equilibrated to equilibrium moisture content, no significant difference was found in germination. Ambient conditions in Delhi is usually conducive to good storage [13]. That is why ambient storage was advantageous over MA storage in respect of maintenance of seed viability. But in poor storer regions MA storage at 11 per cent seed moisture level will definitely be advantageous over ambient storage.

Though it appears from the results that CO_2 treatments were deteriorative for seed viability, actually it was perhaps the high moisture content of the seed in airtight storage which was responsible for faster deterioration. Moisture content of seed is the most important factor responsible for seed deterioration. It is known that moisture vapour proof (airtight) storage is not safe for seeds with higher moisture content. For rice seed, maximum 8 per cent moisture content is recommended for airtight storage under Indian Minimum Seed Certification Standards [14]. Previous workers also indicated quicker loss of viability of high moisture containing seed of paddy and wheat under air tight storage [15, 16]. Paddy with 14 per cent moisture showed no significant reduction in germination percentage and maintained germination above 80 per cent after 30 days storage whereas seeds with 18 per cent moisture content reflected rapid loss of viability. Incase of paddy containing 18 per cent moisture, germination reduced to below 50 per cent within 30 days of storage. However, from the present study we infer that modified atmospheres as such were not having adverse effect on seed viability, as there was no significant difference in seed germination among CO_2 treatments within any particular moisture level after any particular period of storage.

Thus, under MA storage (up to 80% CO_2) paddy seed with 11 per cent moisture content can be stored safely at least up to 12 month without much reduction in seed viability. These results supports previous findings of White *et al.* [17] and White and Jayas [18], who reported that germination percentage of wheat seed (13% moisture content) remained unaffected upto 12 weeks of storage in storage under 20-46 per cent CO_2 concentrations.

Rathi *et al.* [19] arrived at similar conclusions by subjecting sorghum and soybean seeds (8, 12 and 16% moisture content) to 8-month storage at 20, 55 and 90 per cent CO_2 concentration. They concluded that MA storage cannot ensure minimum seed quality desired when seed moisture and storage temperature are higher in sorghum. CO_2 kept the environment sterile but did not have detrimental effect on germination. They also reported 50 per cent drop in germination percentage in control while under CA storage it was only 25 per cent showing beneficial effect of modified atmosphere (MA) storage on soyabean. Fleurat-Lessard *et al.* [20] reported that storage of wheat in 60 per cent and 100 per cent CO_2 could not limit either decrease in germination capacity or increase in average time for germination of wheat seed with high moisture content (even inside legal tolerances). They concluded that high temperature was most important parameter, followed by high moisture content, affecting germination in MA.

Bera *et al.* [6] reported that CO_2 rich atmospheres (5, 10 and 20% CO_2) had no adverse effect on germinability of wheat seed when stored for 6 months with 12 per cent moisture content.

Effect of MA storage on vigour index

Vigour index-II (Table 2) followed the same pattern as germination. Seed moisture content and storage duration had negative effect on vigour index which was evident from decrease in vigour indices with the increase of moisture content and storage duration. MA storage did not exert any significant effect on vigour indices of rice seed with 11 per cent moisture content upto 8 months of storage. But at higher moisture levels difference was observed between ambient storage and MA storage. It is known that in airtight storage deterioration is rapid [15, 16]. If moisture content of seed is higher than the permissible level (in case of rice, 8% mc as per Indian Minimum Seed Certification Standard, 1988). Therefore, it can be inferred that the CO_2 concentration did not affect the rate of seed deterioration at given moisture content of seed.

Seed with 15 per cent moisture could not be stored even upto 8 months because vigour indices of the surviving seeds were too low (VG-II = 1057) as compared to ambient storage (VG-II = 6736). Seeds with 13 per cent moisture content can be stored upto 8 months without affecting vigour, too much, as germination percentage was also above 88 per cent. Moreover, paddy with 11 per cent moisture content can be stored upto 12 months as with little difference in vigour of seed between ambient (VG-II = 6249) and MA storage (VG-II = 5719).

Table 2. Effect of modified atmosphere storage on vigour index-II

Treatments		Storage durations			Mean
		*D_1 (4 months)	D_2 (8 months)	D_3 (12 months)	
M_1 (MC 11%)	C_0 (ambient)	6988.1 (83.60)	6854.4 (82.79)	6249.3 (79.05)	6697.3 (81.81)
	C_1 (20%CO_2)	6946.3 (83.34)	6848.4 (82.76)	5735.7 (75.74)	6510.1 (80.61)
	C_2 (40%CO_2)	6965.7 (83.46)	6829.2 (82.64)	5670.9 (75.31)	6488.6 (80.47)
	C_3 (60%CO_2)	7001.2 (83.67)	6901.8 (83.08)	5709.6 (75.56)	6537.5 (80.77)
	C_4 (80%CO_2)	7032.7 (83.86)	6888.7 (83.00)	5750.9 (75.83)	6557.4 (80.90)
M_2 (MC 13%)	C_0 (ambient)	6908.8 (83.12)	6832.2 (82.66)	6173.8 (78.58)	6638.3 (81.45)
	C_1 (20%CO_2)	6872.5 (82.90)	6557.3 (80.98)	4610.4 (67.90)	6013.4 (77.26)
	C_2 (40%CO_2)	6909.9 (83.13)	6590.9 (81.18)	4664.8 (68.30)	6055.2 (77.54)
	C_3 (60%CO_2)	6932.2 (83.26)	6523.7 (80.76)	4705.4 (68.60)	6053.8 (77.54)
	C_4 (80%CO_2)	6841.2 (82.71)	6609.7 (81.30)	4721.1 (68.71)	6057.3 (77.57)
M_3 (MC 15%)	C_0 (ambient)	6874.4 (82.91)	6735.7 (82.07)	6146.8 (78.40)	6585.6 (81.13)
	C_1 (20%CO_2)	6633.5 (81.45)	1050.9 (32.42)	0.0 (0.71)	2561.5 (38.19)
	C_2 (40%CO_2)	6596.8 (81.22)	1065.3 (32.64)	0.0 (0.71)	2554.0 (38.19)
	C_3 (60%CO_2)	6595.6 (81.22)	1028.5 (32.08)	0.0 (0.71)	2541.3 (38.00)
	C_4 (80%CO_2)	6652.4 (81.56)	1085.9 (32.%)	0.00 (0.71)	2579.4 (38.41)
Mean	C_0 (ambient)	6923.7 (83.21)	6807.4 (82.51)	6190.0 (78.68)	6640.4a (81.47)
	C_1 (20%CO_2)	6817.4 (82.57)	4818.9 (65.39)	3448.7 (48.11)	5028.3b (65.36)
	C_2 (40%CO_2)	6824.1 (82.60)	4828.4 (65.49)	3445.2 (48.10)	5032.6b (65.40)
	C_3 (60%CO_2)	6843.0 (82.72)	4818.0 (65.30)	3471.7 (48.29)	5044.2b (65.44)
	C_4 (80%CO_2)	6842.1 (8Z71)	4861.4 (65.75)	3490.7 (48.42)	5064.7b (65.63)
Mean	M_1	6986.8 (83.59)	6864.5 (82.85)	5823.3 (76.30)	6558.2a (80.91)
	M_2	6892.9 (83.03)	6622.8 (81.38)	4975.1 (70.42)	6163.6b (78.27)
	M_3	6670.5 (81.67)	2193.3 (42.43)	1229.4 (16.25)	3364.4c (46.78)
Mean		6850.1a (82.76)	5226.8b (68.89)	4009.2c (54.32)	

MC = Moisture content. Means with the same letter are not significantly different.

Values in parentheses are transformed values $\ddot{O}(x+0.5)$.

	CD value at 5%		CD value at 5%
Moistures (M)	0.286	CM	0.639
CO_2 concentrations (C)	0.369	CD	0.639
Durations (D)	0.286	CDM	1.106
MD 0.495			

*Vigour index-II before starting storage = 7038

Effect of MA storage on biochemical parameters

Dehydrogenase activity: TZ test, an indicator of respiratory efficiency, is a well accepted biochemical test to assess seed quality. In present investigation dehydrogenase activity was not affected in seeds having 11 per cent moisture content by any of the CO_2 concentrations (20, 40, 60 and 80%) in MA storage upto 8 months of storage (Table 3). After 12 months of storage there was slight difference in dehydrogenase activity. Decrease in OD values (deterioration of seed quality) with the increasing storage duration was solely a response to natural ageing process. At particular moisture level none of CO_2 concentrations showed differential effect after particular storage duration. In case of higher

Table 3. Effect of modified atmospheric storage on DOD values (DOD/10 seed/7 ml) for Malondialdehyde content

Treatments		Storage durations			Mean
		*D_1 (4 months)	D_2 (8 months)	D_3 (12 months)	
M_1 (MC 11%)	C_0 (ambient)	0.0286	0.0304	0.0344	0.0312
	C_1 (20%CO_2)	0.0276	0.0313	0.0386	0.0325
	C_2 (40%CO_2)	0.0273	0.0320	0.0397	0.0330
	C_3 (60%CO_2)	0.0283	0.0328	0.0401	0.0337
	C_4 (80%CO_2)	0.0270	0.0325	0.0392	0.0329
M_2 (MC 13%)	C_0 (ambient)	0.0292	0.0310	0.0342	0.0315
	C_1 (20%CO_2)	0.0285	0.0358	0.0459	0.0367
	C_2 (40%CO_2)	0.0291	0.0364	0.0449	0.0368
	C_3 (60%CO_2)	0.0287	0.0354	0.0454	0.0365
	C_2 (80%CO_2)	0.0275	0.0377	0.0460	0.0371
M_3 (MC 15%)	C_0 (ambient)	0.0284	0.0313	0.0332	0.0310
	C_1 (20%CO_2)	0.0342	0.0580	0.0682	0.0535
	C_2 (40%CO_2)	0.0330	0.0566	0.0692	0.0529
	C_3 (60%CO_2)	0.0327	0.0560	0.0678	0.0521
	C_4 (80%CO_2)	0.0333	0.0555	0.0670	0.0519
Mean	C_0 (ambient)	0.0288	0.0309	0.0339	0.0312a
	C_1 (20%CO_2)	0.0301	0.0417	0.0509	0.0409b
	C_2 (40%CO_2)	0.0298	0.0417	0.0513	0.0409b
	C_3 (60%CO_2)	0.0299	0.0414	0.0511	0.0408b
	C_4 (80%CO_2)	0.0293	0.0419	0.0507	0.0406b
Mean	M_1	0.0278	0.0318	0.0384	0.0327a
	M_2	0.0286	0.0353	0.0433	0.0357b
	M_3	0.0323	0.0515	0.0611	0.0483c
Mean		0.0296a	0.0395b	0.0476c	

MC = Moisture content. Means with the same letter are not significantly different.

	CD value at 5%		CD value at 5%
Moistures (M)	= 0.001	C*M	= 0.0022
CO_2 concentrations(C)	= 0.0013	C*D	= 0.0022
Durations (D)	= 0.001	C*D*M	= 0.0038
M*D	= 0.0017		

*DOD values for Malondialdehyde content before starting storage = 0.0262.

moisture levels rapid decrease in dehydrogenase activity under MA than ambient storage, is perhaps due to faster ageing under hermetic storage. Therefore, for rice seed, MA storage could not be regarded as a control measure against decrease in dehydrogenase activity *vis-a-vis* seed deterioration.

Fleurat-Lessard *et al.* [20] also reported that 40 and 100 per cent CO_2 in MA storage could not modify dehydrogenase activity in seed after 4 month storage.

Bera *et al.* [6] also reported that CO_2 rich atmospheres (5, 10 and 20% CO_2) had no adverse or beneficial effect on dehydrogenase activity of wheat seed when stored for 6 months with 12 per cent moisture content.

Thus, we can conclude that rice seed with 11 per cent moisture content can be stored safely upto 12 months under different CO_2 concentrations (20, 40, 60 and 80%). Rice seed with 13 per cent moisture can be stored safely only upto 8 months

Table 4. Effect of modified atmosphere storage on OD values (OD/5 seed/3 ml) for dehydrogenase activity (formazan) of rice

Treatments		Storage durations			Mean
		*D_1 (4 months)	D_2 (8 months)	D_3 (12 months)	
M_1 (MC 11%)	C_0 (ambient)	0.4814	0.4747	0.4561	0.4707
	C_1 (20%CO_2)	0.4818	0.4707	0.4415	0.4647
	C_2 (40%CO_2)	0.4815	0.4711	0.4419	0.4648
	C_3 (60%CO_2)	0.4812	0.4710	0.4404	0.4642
	C_4 (80%CO_3)	0.4821	0.4712	0.4406	0.4646
M_2 (MC 13%)	C_0 (ambient)	0.4811	0.4739	0.4557	0.4702
	C_1 (20%CO_2)	0.4695	0.4602	0.3182	0.4159
	C_2 (40%CO_2)	0.4690	0.4611	0.3144	0.4148
	C_3 (60%CO_2)	0.4700	0.4609	0.3136	0.4148
	C_4 (80%CO_2)	0.4692	0.4604	0.3141	0.4145
M_3 (MC 15%)	C_0 (ambient)	0.4809	0.4730	0.4552	0.4697
	C_1 (20%CO_2)	0.4536	0.2010	0.0703	0.2416
	C_2 (40%CO_2)	0.4572	0.2005	0.0733	0.2437
	C_3 (60%CO_2)	0.4583	0.2019	0.0727	0.2443
	C_4 (80%CO_2)	0.4577	0.2018	0.0729	0.2441
Mean	C_0 (ambient)	0.4811	0.4738	0.4557	0.4702a
	C_1 (20%CO_2)	0.4683	0.3773	0.2766	0.3741b
	C_2 (40%CO_2)	0.4692	0.3775	0.2765	0.3744b
	C_3 (60%CO_2)	0.4698	0.3779	0.2756	0.3744b
	C_4 (80%CO_2)	0.4696	0.3778	0.2759	0.3744b
Mean	M_1	0.4816	0.4717	0.4441	0.4658a
	M_2	0.4717	0.4633	0.3432	0.4261b
	M_3	0.4615	0.2556	0.1489	0.2887c
Mean		0.4716a	0.3969b	0.3121c	

Means with the same letter are not significantly different.
MC = Moisture content

	CD value at 5%		CD value at 5%
Moistures (M)	= 0.0032	CM	= 0.0072
CO_2 concentrations(C)	= 0.0042	CD	= 0.0072
Durations (D)	= 0.0032	CDM	= 0.0125
MD	= 0.0056		

*OD values for dehydrogenase activity before starting storage = 0.4861

without much effect on dehydrogenase activity.

Malondialdehyde (MDA) content: Malondialdehyde content remained unaffected under all CO_2 concentrations under MA storage at 11 per cent moisture content up to 8 months. After 12 months, malondialdehyde content was slightly more in MA storage than ambient storage. Increase in OD values with the advancement of storage duration in higher moisture levels was indicative of an increase in malondialdehyde content *vis-a-vis* seed deterioration.

This clearly indicates that CO_2 rich atmosphere (20, 40, 60 and 80% CO_2) has no differential effect on either retarding or accelerating lipid peroxidation.

Fleuret-Lessard *et al.* [20] also reported that MA atmospheres were not capable of retarding lipid peroxidation in stored wheat seed in 40 per cent and 60 per cent CO_2 for upto 4 month.

Bera *et al.* [6] reported that CO_2 concentrations (5, 10 and 20%) of MA storage could not stop or accelerate lipid peroxidation in wheat seed with 12 per cent moisture content during 6 months of storage.

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