Commercially available modified atmosphere packaging for asparagus

A report prepared for the
New Zealand Asparagus Council

D W Brash & B L Bycroft
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New Zealand Institute for Crop & Food Research Limited
Private Bag 4005, Levin, New Zealand

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D W Brash & B L Bycroft

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1 EXECUTIVE SUMMARY

We tested four commercial or pre-commercial modified atmosphere packaging (MAP) film packs for their benefits, particularly extra shelf-life, and for their potential drawbacks, such as an inability to cope with higher than expected temperatures. Three packs (Films A, B and C) are for use on coolstored asparagus (0-4°C) and one (Film D) is for use under ambient temperatures (close to 15°C), possibly airfreight.

Asparagus was packed in the MAP films and stored for either 14 days at 4°C or 4 days at 15°C. Following storage, packs were opened and the asparagus was held in air at 20°C for assessment of shelf-life (based on visual quality). Some packs were exposed to temperatures 5°C higher and then 10°C higher than their optimum temperature.

At both 4°C and 15°C, the MAP packs extended asparagus shelf-life by nearly a day compared to air-storage. There was no difference in the shelf-life benefit of the three films tested at 4°C.

Films A and B maintained high oxygen and moderate carbon dioxide levels. Some Film C packs had low oxygen and film D packs had low oxygen (4-8%) and high carbon dioxide (10-14%). These atmospheres are not likely to cause off-flavours.

Raising storage temperatures may lower oxygen and raise carbon dioxide to levels that cause off-flavours. Although a 5°C rise did not lower oxygen to very low levels for any of the film packs we would still recommend following the storage guidelines for each film.

MAP is not a substitute for proper temperature management. The MAP films tested improved quality through extended shelf-life, but must be combined with good temperature control. Further testing, including sensory evaluation, is recommended.

2 RECOMMENDATIONS

The MAP film packs tested on asparagus show promise. We recommend interested growers test them on a restricted scale. Successful introduction of MAP films for asparagus will depend on the cost of the films, the ability of growers and exporters to keep to the recommended storage temperatures and on the willingness of customers to pay a premium over conventionally packed asparagus.

3 INTRODUCTION

Asparagus responds to controlled atmosphere (CA) storage. Increases in shelf-life have been obtained after storage at 1°C (King et al. 1986) and at 20°C (Lill and Corrigan, 1996). Larger responses (as a percentage) are obtained at the higher temperature with a near doubling of residual shelf-life in response to CA at 20°C (4.8 days shelf-life for CA-stored asparagus compared to 2.5 days for air-stored asparagus after both were stored for 4 days at 20°C).

CA storage is not a commercial option during distribution of asparagus because a large volume of asparagus is required to fill a CA container. MAP is more practical and provides a beneficial atmosphere by allowing oxygen levels to decline and carbon dioxide levels to build up inside a sealed plastic film pack. The composition of the atmosphere will depend on the permeability characteristics of the package, the temperature and the weight and type of produce. Because asparagus has a very high respiration rate at 20°C (Brash et al. 1995) most plastic films have inadequate permeability for MAP of asparagus at ambient temperatures. Films of very high gas exchange characteristics are required for commercial use. Microperforated films can provide such gas exchange characteristics.

A packaging system that helps extend the shelf-life of asparagus could have advantages for the asparagus industry. Any system should be considered as a backstop measure rather than as an alternative to refrigeration. Higher than optimum storage temperatures occur frequently during air freight and domestic distribution of asparagus, so packaging systems need to be able to withstand at least short periods at higher than optimum temperatures.

We evaluated four film packs designed for asparagus in this study. The packs are at a pre-commercial stage. One pack was designed for use at up to 15°C and so is more suited to airfreight. The remaining packs were designed for use at up to 4°C and are suited to long term refrigerated storage, possibly seafreight.

We have tested the film packs in two ways. Firstly, we assessed their benefits at recommended storage temperatures and, secondly, we examined the atmosphere overmodification of each pack in temperatures up to 10°C higher than their optimum range.

4 METHODS

4.1 Films

Details of the film packs are outlined below. The films have been given a simple code label because one of the companies has asked for confidentiality at this stage (The Executive Officer, N.Z. Asparagus Council has been advised of the films used and their suppliers. He is able to provide more information on the films and their suppliers for interested growers and exporters).

Film code	Temperature used (°C)	Pack size (kg)
A	4	0.45
B	4	1.36
C	4	5
D	15	5

Films A and B are designed for retail packs while films C and D are designed to cover export boxes. The bags were sealed after filling. Films A and B required a heat sealer and Films C and D required a cable tie over a twisted and folded bag end for sealing.

4.2 Experiment 1: Benefits following 4°C storage

We used export quality asparagus for the experiment. It was obtained the previous day from a local grower and held overnight at 0°C.

We set up four replications of each of the following treatments:

1. Air control (0.5 kg asparagus, held in a perforated plastic bag)
2. Film A
3. Film B
4. Film C

The treatments were stored for 14 days at 4°C and then a 0.45-0.50 kg sub-sample was held in air (using a perforated bag to minimise moisture loss) at 20°C for daily visual quality assessment (using the 1-9 scale of Lill 1980) and estimation of shelf-life (days to reach a visual quality score of 6, unacceptable for sale).

Gas atmospheres (oxygen and carbon dioxide levels) in each film pack were measured after 2, 24, 48 and 96 hours and 6, 10 and 14 days storage.

4.3 Experiment 2: Benefits following 15°C storage

We used export quality asparagus obtained at the same time and from the same source as in Experiment 1. We set up four replicates of each of the following treatments:

1. Air control (0.5 kg asparagus, held in a perforated bag).
2. Film D.

The treatments were stored for four days at 15°C and then a 0.45-0.50 kg sub-sample was held in air (using a perforated bag to minimise moisture loss) at 20°C for daily visual quality assessment and estimation of shelf-life as in Experiment 1.

Gas atmospheres in each film pack were measured after 4, 24, 48 and 96 hours storage.

4.4 Experiment 3: Raising storage temperature from 4°C to 15°C

We used export quality asparagus obtained at the same time and from the same source as in Experiment 1. We set up four replicates of each of the following treatments:

1. Film A
2. Film B
3. Film C

All treatments were held for 6 days at 4°C then two days at 10°C and then 2 days at 15°C. Gas atmospheres in each film pack were measured after 4, 24, 48, 96 and 144 hours (at 4°C) and 4, 8, 24 and 48 hours after each rise in storage temperature.

4.5 Experiment 4: Raising storage temperature from 15°C to 25°C

We used export quality asparagus obtained at the same time and from the same source as in Experiment 1. We set up four replicates of the following treatment:

1. Film D

This treatment was held for two days at 15°C, one day at 20°C followed by one day at 25°C.

Gas atmospheres in each film pack were measured after 4, 24 and 48 hours and then 4, 6, 12 and 24 hours after each rise in storage temperature.

5 RESULTS AND DISCUSSION

5.1 Experiment 1: Benefits following 4°C storage

MAP extended shelf-life by nearly a day compared to air storage (Figure 1). There were no differences among the three films tested.

Figures 2, 3 and 4 show the oxygen and carbon dioxide levels for films A, B and C. Film C modified the atmosphere more than films A and B, i.e. oxygen levels were lower and carbon dioxide levels higher. It is unlikely that the atmospheres generated would cause development of off-flavours. Kader (1992) recommends asparagus be stored in atmospheres over 5% oxygen and under 10% carbon dioxide. Lill and Corrigan (1996) found sensory quality unaffected by atmospheres in the range 5-10% oxygen and 5-15% carbon dioxide.

The atmospheres generated by Film C appear to be more variable than those generated by Films A and B. Experiment 3 results showed a similar pattern (Figures 7, 8 and 9).

5.2 Experiment 2: Benefits following 15°C storage

MAP extended shelf-life by nearly a day compared to air storage (Figure 5).

Figure 6 shows the oxygen and carbon dioxide levels generated by film D. Levels of oxygen may have fallen below 4% for a short period in the first 24 hours of storage. It is unlikely that the atmospheres generated caused off-flavours but this should be tested in future work using sensory analysis. A slight increase in the gas exchange of this film would help to ensure that oxygen and carbon dioxide levels are not in the marginal range, i.e. the packs would have a margin to cope with produce and film variability.

5.3 Experiment 3: Raising storage temperature from 4°C to 15°C

Figures 7, 8 and 9 show oxygen and carbon dioxide levels for films A, B and C. Films A and B showed the typical pattern of decreasing oxygen and increasing carbon dioxide as temperatures rose from 4°C to 10°C and from 10°C to 15°C. Results for film C were more variable, with very low oxygen levels in some film packs. oxygen levels tended to rise between 4°C and 10°C which was unexpected.

We noted some water on the top of some packs at 4°C and think this may have slowed movement of oxygen into the packs at this temperature (by blocking microperforations). Oxygen dropped to very low levels at 15°C. Carbon dioxide levels were highest when oxygen was lowest. One pack had a tear in the film and was replaced after 2 days.

Because of concern over generating damaging levels of oxygen and carbon dioxide at higher temperatures, storage at 4°C is recommended with only short periods at higher temperatures. Films A and B did not generate damaging atmospheres at 10°C. Film C needs to be re-tested to understand why atmospheres were so variable and why oxygen levels were so low and carbon dioxide levels so high in some packs at 4°C.

We raised temperatures after six days in storage. The response to a rise in storage temperature would have been greater closer to harvest when respiration rates are higher. There is also significant danger of modifying the atmosphere to anaerobic levels if the asparagus is not cooled adequately prior to packing.

5.4 Experiment 4: Raising storage temperatures from 15°C to 25°C

Figure 10 shows oxygen and carbon dioxide levels for film D at 15, 20 and 25°C. Unlike the results in Experiment 3, raising the storage temperature had little effect on atmospheres for film D. Perhaps the response can be explained by the rapid decline in carbohydrate reserves and respiration rates at high temperatures. After two days at 15°C reserves may be reduced sufficiently that respiration does not increase rapidly when the temperature is raised. The low oxygen and high carbon dioxide levels measured in packs using Film D may also dampen the respiration response.

6 CONCLUSIONS

1. MAP extended shelf-life.

2. Film packs A and B generated beneficial atmospheres. Film C generated a beneficial atmosphere in some packs and should be re-tested with no free water over the packs. Film D generated a beneficial atmosphere but needs higher permeability to bring atmospheres into a safer range.

3. Although the film packs can tolerate periods at higher than recommended temperatures, storage at the recommended temperature must be emphasised for the concept to succeed. The asparagus should also be adequately cooled prior to packing.

7 REFERENCES

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8 ACKNOWLEDGEMENTS

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Figure 1: Asparagus shelf-life after 14 days storage at 4°C. LSD (p<0.05) is shown, F. Test significant (p=0.047).

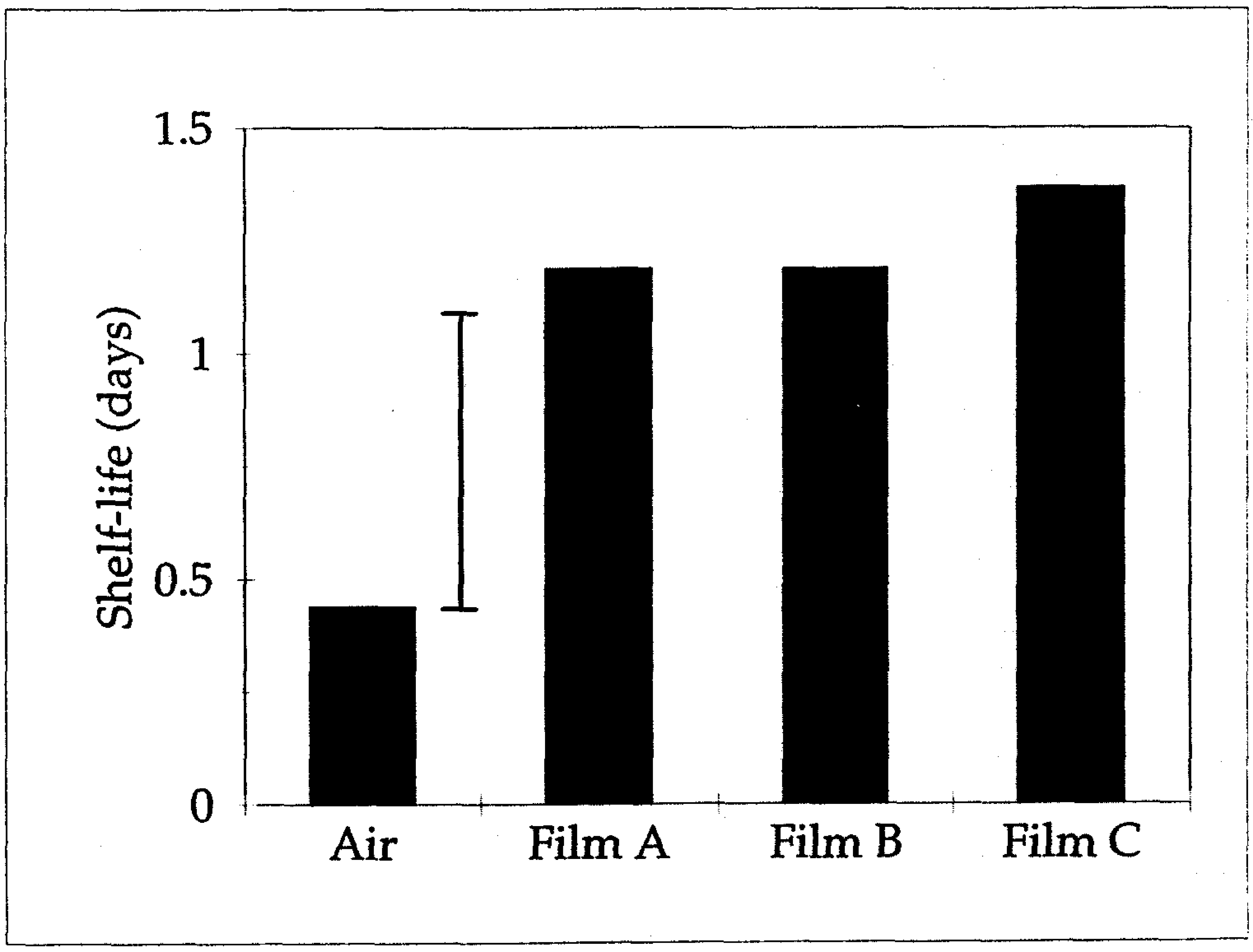

Figure 2: Oxygen and carbon dioxide in storage at 4°C for film A

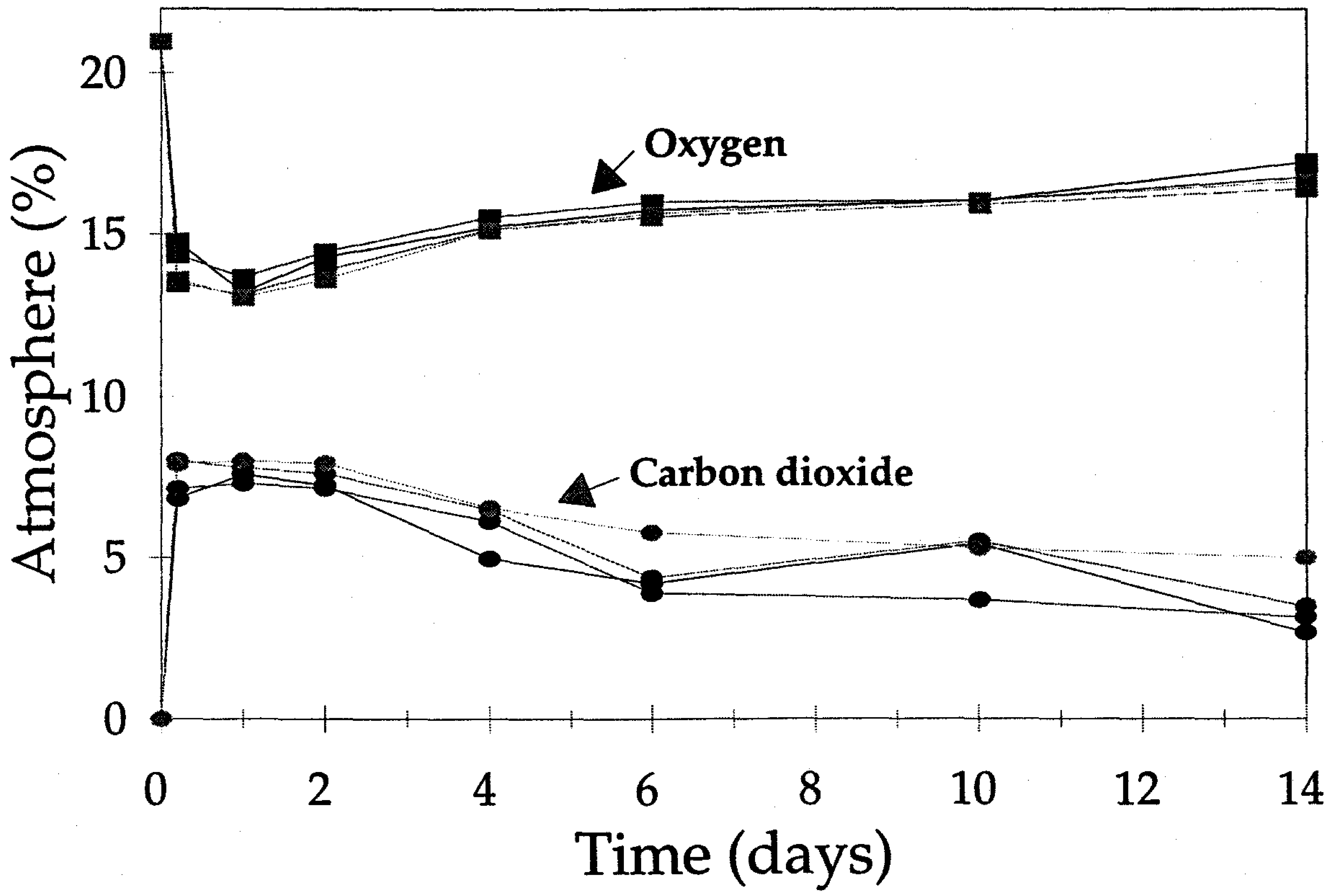

Figure 3: Oxygen and carbon dioxide in storage at 4°C for film B.

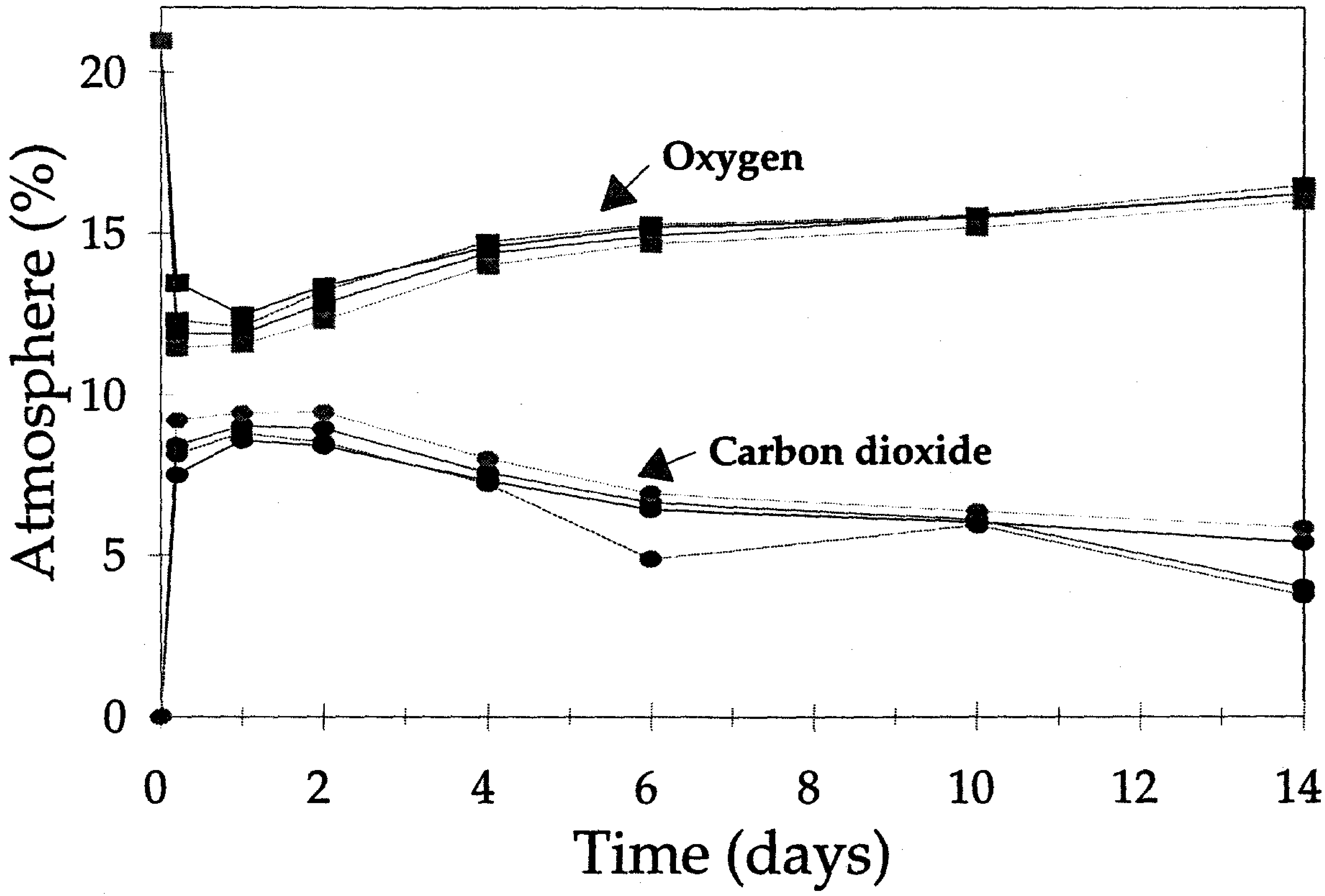

Figure 4: Oxygen and carbon dioxide in storage at 4°C for film C.

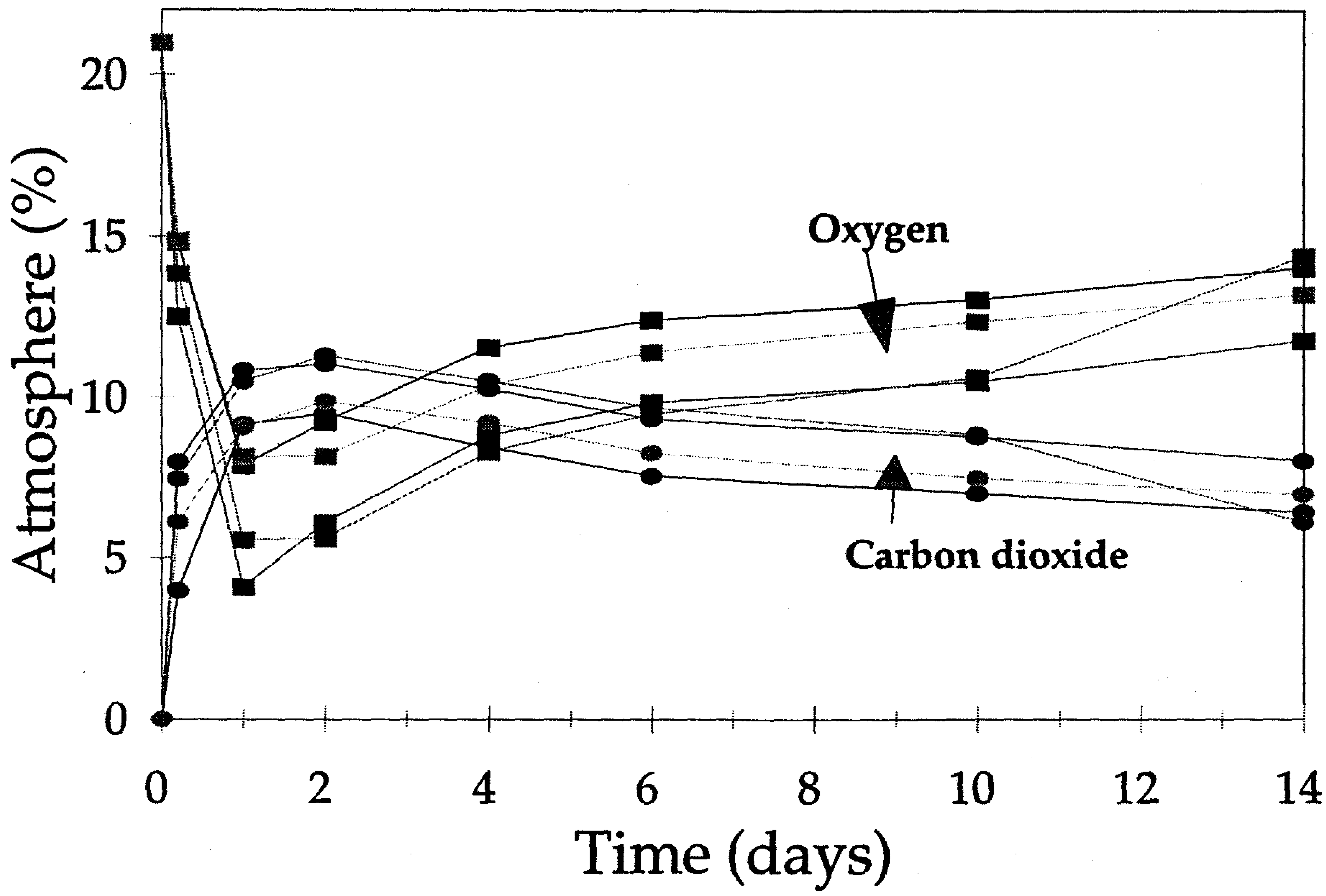

Figure 5: Asparagus shelf-life after 4 days storage at 15°C. LSD (p<0.05) is shown, F-test was significant (p<0.001).

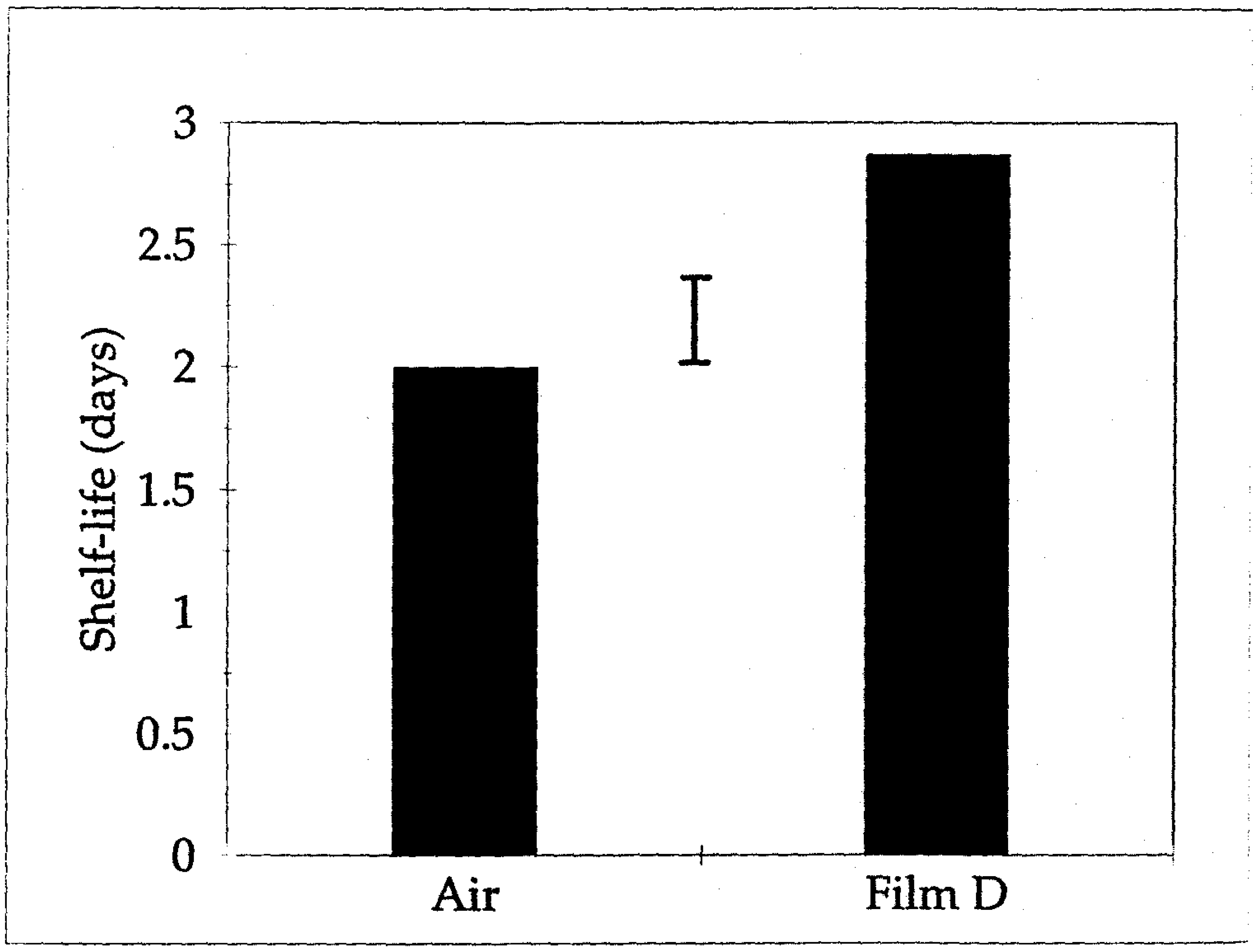

Figure 6: Oxygen and carbon dioxide in storage at 15°C for film D.

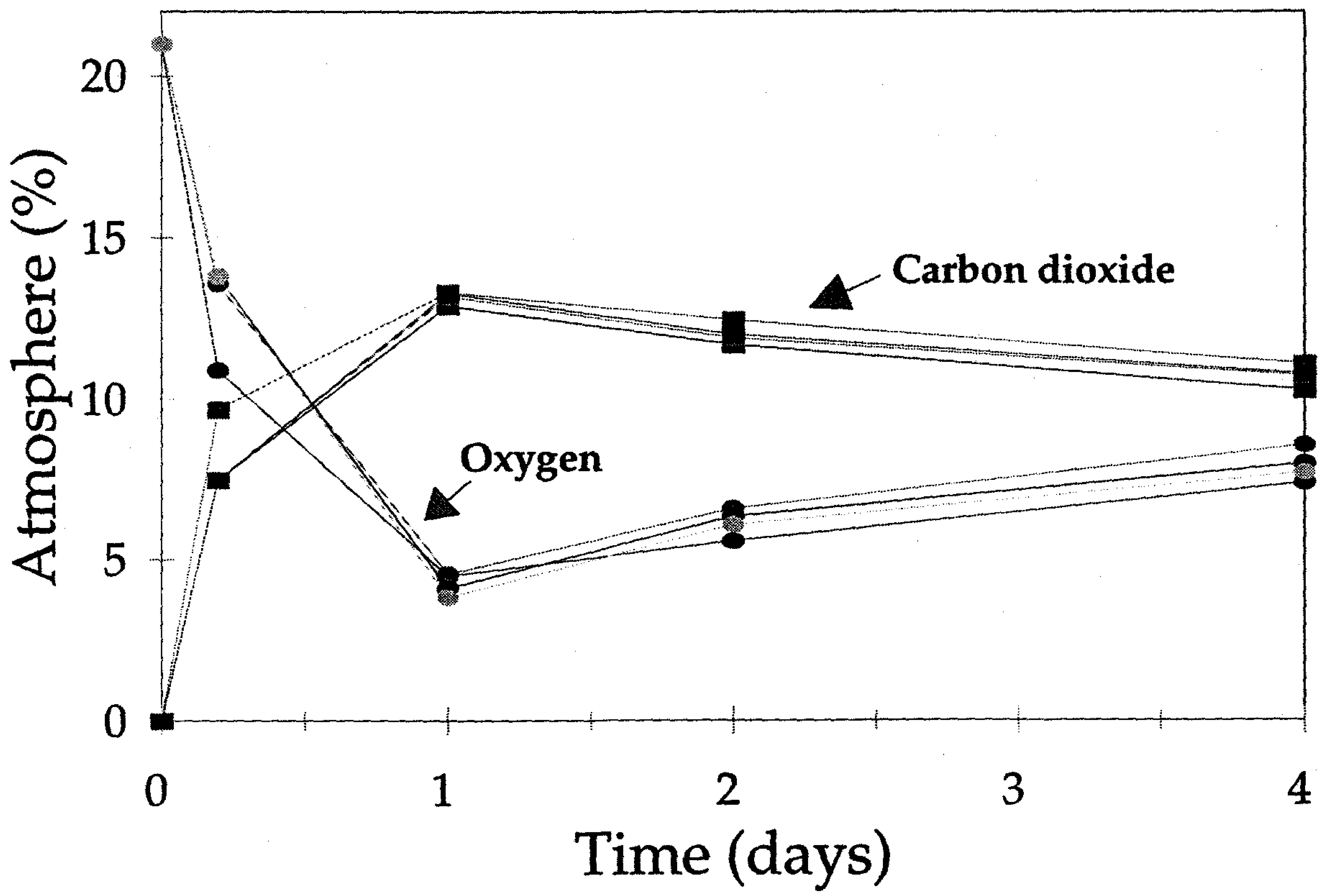

Figure 7: Oxygen and carbon dioxide in storage at 4, 10 and 15°C for film A.

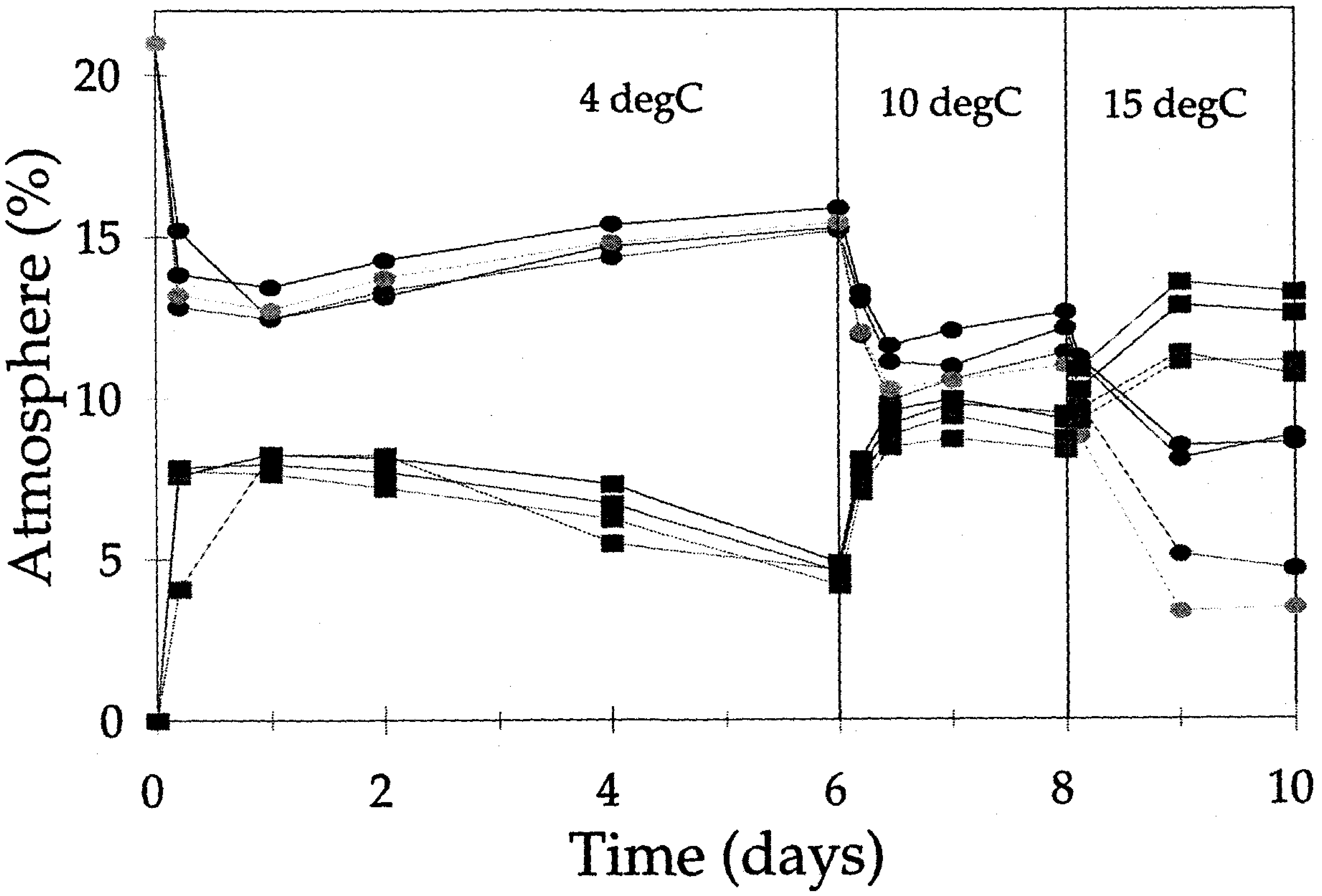

Figure 8: Oxygen and carbon dioxide in storage at 4, 10 and 15°C for film B.

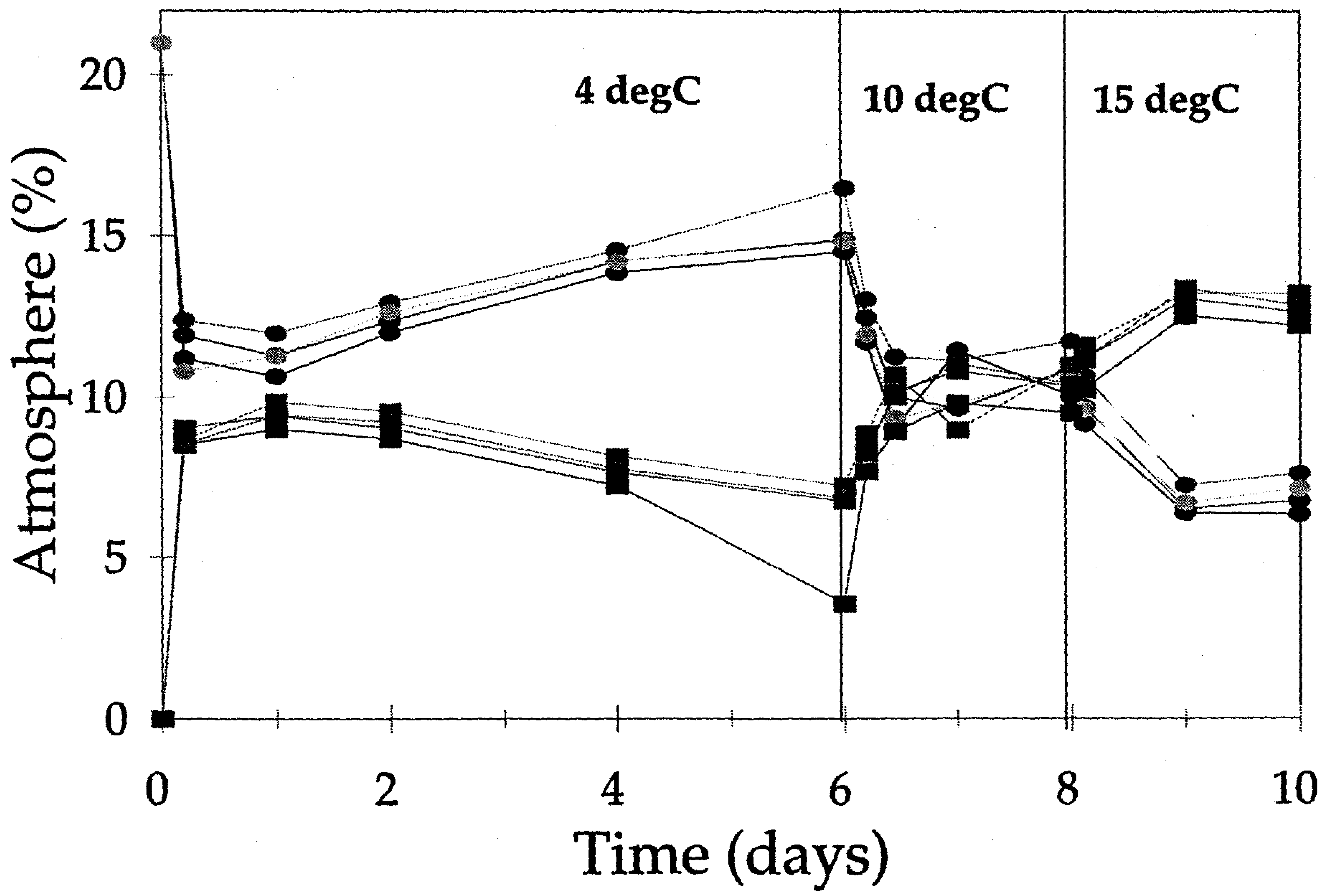

Figure 9: Oxygen and carbon dioxide in storage at 4, 10 and 15°C for film C.

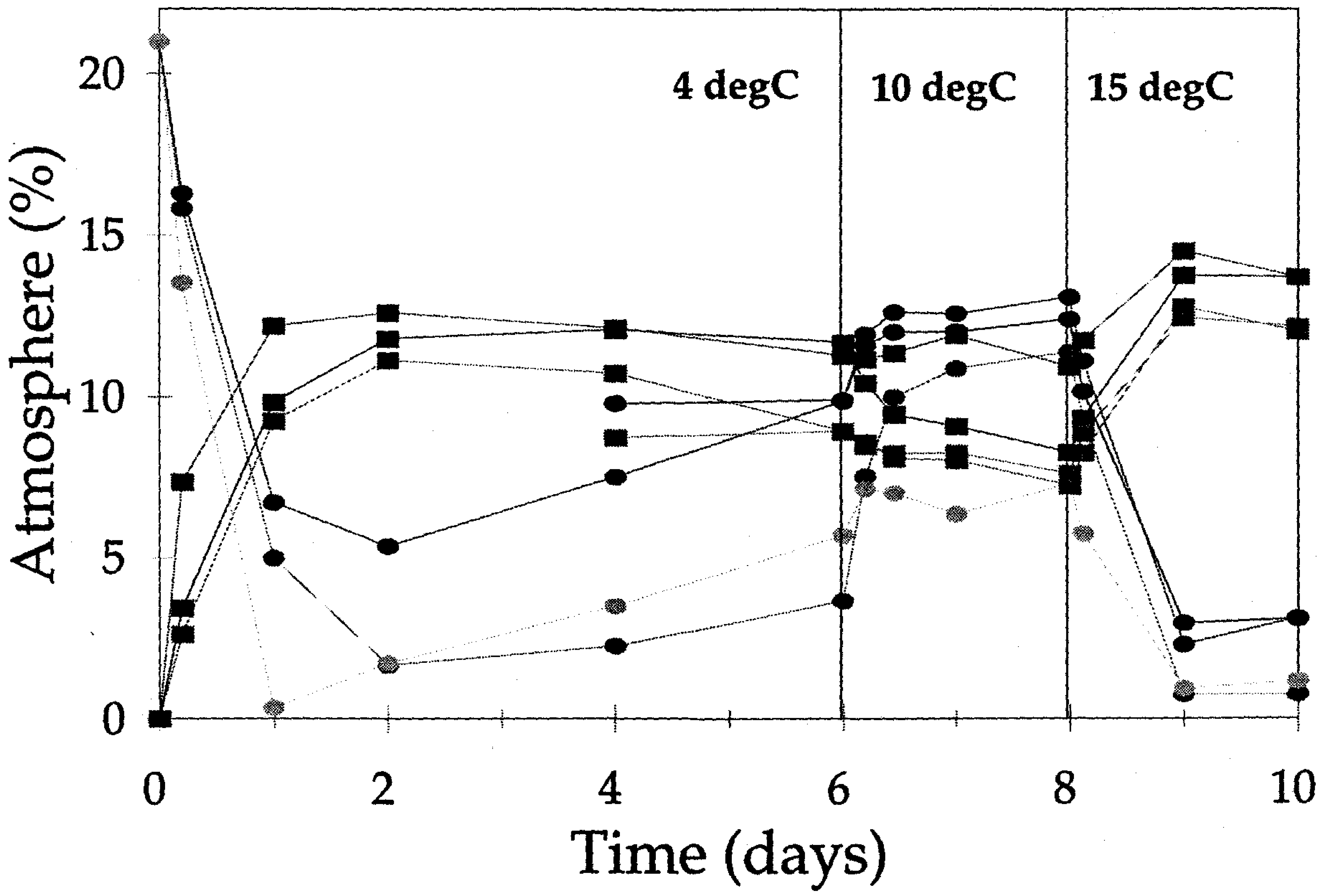

Figure 10: Oxygen and carbon dioxide in storage at 15, 20 and 25°C for film D.