Extending the Shelf Life of Flower Bulbs and Perennials in Consumer Packages by Modified Atmosphere Packaging

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Abstract

The quality of flower bulbs and herbaceous perennials in consumer packages declines rapidly due to sprouting and drying out. The present study was undertaken to develop Modified Atmosphere Packages (MAP) with suitable filling materials for a prolonged shelf life of different species of flower bulbs (e.g., *Lilium*, *Anemone*, *Erythronium*) and herbaceous perennials (e.g., *Hemerocallis*, *Hosta*, *Phlox*). As filling materials peat moss and Toresa (wood fiber) were tested. So-called continuous MA films were used, i.e., without laser holes, which means that they are virtually impermeable to water. The shelf life of plants and bulbs was tested in packages produced from these films after addition of filling materials with different moisture contents. The shelf life was determined in a climate chamber at 23°C with a high ventilation rate. The same products were packed in traditional packages with microperforation for comparison.

The shelf life of bulbs and perennials was extended dramatically from 3 to 4 weeks in the traditional package with microperforation to 2 to 3 months by the use of MA packaging. It was however not the low oxygen level inside the packages that caused this effect but the reduction of water loss by using MA films. In microperforation packages the products dried out completely in 3 to 4 weeks, whereas in the MA packages the products remained turgescent and vital for 2 to 3 months. Sprouting was inhibited by using dry filling materials. The term Modified Humidity Packaging therefore seems to be more appropriate for this type of packaging. To prevent too low oxygen levels inside MA packages it is recommended to use an MA film with a high permeability for oxygen. This also enables the use of one film for a wide range of products.

INTRODUCTION

Flower bulbs and bare-root perennials are sold to consumers in plastic packages with many small holes (<1 mm in diameter, so-called microperforation) or with a few larger holes (several mm's in diameter) to enable O_2 and CO_2 exchange. However, these holes are also the cause of water loss. To prevent the product from drying out too rapidly a moist filling material (usually peat moss) is added to the package, but the combination of a high humidity and sufficient air induces sprouting and rooting. As a consequence the products show too much rooting and sprouting during the first weeks at the retailer and after a few weeks the product and the filler become too dry. Therefore often the shelf life of bulbs and perennials is not longer than 3 or 4 weeks.

Modified Atmosphere Packaging nowadays is a common technique to increase the shelf life of fruits, vegetables and horticultural products by inhibiting the developmental or senescence processes and by preventing the products from drying out (Kader et al., 1989). The technique is based on packing the products in sealed packages consisting of films with a limited permeability for O_2 and CO_2. So-called continuous MA-films (without laser holes) are virtually impermeable to water. Due to the respiratory activity of the packed products the O_2 level declines and the CO_2 level increases, thus creating ('modifying') an atmosphere that inhibits the metabolism and retards the development/senescence of the products. The low permeability of the package for water delays the drying out of the products.

The objective of the present study was to develop modified atmosphere packages with suitable filling materials for a prolonged shelf life of flower bulbs and bare-root perennials. Generally moist peat moss is used as filling material for flower bulbs and bare-root perennials. In this study Toresa, a wood fibre material with characteristics similar to peat moss, is tested as an alternative for peat moss.

MATERIAL AND METHODS

Plant Material

The experiments were carried out with the following species of flower bulbs and perennials:

Flowerbulbs: *Lilium* 'Salmon Classic' [LA-hybrid], *Zantedeschia* 'Black Eyed Beauty' and 'Rehmanii', *Dahlia* 'Lenny's Dream' and 'Miramar', *Erythronium pagoda*, *Galanthus nivalis*, *Fritillaria meleagris* and *Anemone blanda*. The bulbs were obtained from commercial growers or exporters and were stored under standard conditions until packaging: lilies at -1°C, *Zantedeschia*, *Dahlia*, *Erythronium* and *Fritillaria* at 9°C and *Galanthus nivalis* and *Anemone blanda* at 17°C.

Perennials: *Hosta* 'Aureomarginata', *Phlox* 'Bright Eyes' [*Paniculata* group] and *Hemerocallis* 'Stella d'Oro'. The perennials were washed thoroughly before the start of the packaging experiments to remove all soil and sand particles (according to the standard procedure before export).

Only one species of flower bulbs and one perennial will be described in this paper: *Lilium* and *Phlox*. The trends observed in lily were representative for the other flower bulbs tested and the trends in *Phlox* were similar in all perennials.

Packaging Experiments

In preliminary experiments bulbs and perennials were sealed in MA-bags produced from films with different, relatively low permeability for oxygen. However, at a later stage during this research it became evident that preventing the plant material from drying out was more important than a low oxygen level (see below) and that a much greater range of bulb and plant species could be packed successfully by using only one film with a relatively high permeability. Therefore in the experiments described below lilies and *Phlox* were packed in a SAP Fresh film produced by Saint-André Plastique (France) with a high permeability for oxygen, yielding oxygen levels inside the packages of 5 to 19% for a large range of plant species and amounts of plant material. Plants and bulbs were packed with or without the filling materials peat moss (standard) and so-called Toresa, a wood fiber material with characteristics similar to peat moss. The average moisture content of the peat moss was 45-60% (depending on the batch) and the Toresa contained around 40% water. For some treatments the material was dried in a stove at 70°C until a moisture level of 20 or 0% was obtained. The filling materials were added to such an amount that the bulbs or plants were covered with a thin layer. One bare-root *Phlox* plant or 2 lily bulbs were packed per package. Drying out of the plants and bulbs was determined as fresh weight loss. The shelf life (weeks) was determined as the time that the plants or bulbs remained vital (confirmed by regrowth after planting) with turgescent sprouts and roots. Sprout length (cm) was recorded as a quality parameter.

RESULTS

Phlox

The plants and bulbs in MA packages had a much longer shelf life than those in the traditional packages with microperforation (Tables 1 and 2).

The weight loss of bare-root *Phlox* plants was highest (68%) after 4 weeks in the traditional package with microperforation and peat moss (Table 1). Some sprouting occurred in the first few weeks after packing, but due to the excessive water loss of the whole package after 3 to 4 weeks the plants were completely dried out (and unable to regrow). Since the MA packages are virtually impermeable to water, the weight loss of the plants in these packages was much smaller. Depending on the moisture content of the filling material water moved from the plant to the filler or the other way round. In the MA packages with moist peat moss and Toresa the plants increased in weight with 16 and 2% respectively by taking up water from the filling material. In the partly desiccated peat moss (20% moisture content) or fully desiccated Toresa the plants lost some water (26 and 25% resp.), which was taken up by the fillers. In the package without filling material the plants lost only 9% of their fresh weight in 4 weeks. Shoot length was positively correlated with the moisture content of the filling materials: the drier the filler, the less sprouting occurred. In an MA package with moist peat moss (60%) an average shoot length of 8 cm was already observed after 4 weeks. These plants also developed new roots (results not shown). With drier peat moss (20%) the sprouting was much less. Similar trends were observed with Toresa as filling material. The use of completely dehydrated (0%) peat moss resulted in *Penicillium* infestation of the plants (results not shown). The other perennials that were investigated in this study showed the same trends. In *Hemerocallis*, however, the inhibition of shoot growth by using a dry filler was much smaller than in *Phlox* (results not shown). From a practical point of view the MA packages with the dry fillers or without any filler yielded the best results: a long shelf life and an acceptable degree of sprouting.

Lily

In packages with lily bulbs similar trends were observed after 5 weeks at 23°C (Table 2): the highest weight loss in packages with microperforation and a smaller weight loss in MA packages, an increase in fresh weight by using moist fillers and a positive correlation between shoot length and moisture content. An extreme shoot extension was observed in the MA package with moist peat moss. As in the *Phlox* experiment peat moss with a moisture content of 20% was slightly more effective in inhibiting sprout growth than Toresa with 0% moisture content. In lily bulbs the combination of an MA package (with a high oxygen permeability) and a dry filler also resulted in a considerable shelf life with an acceptable degree of sprouting.

Similar results were obtained with other flower bulbs or corms.

DISCUSSION

The experiments with MA packages described above have been carried out with MA films with a very high permeability for oxygen. The reason for this is that it is practically impossible to develop MA packages for bulbs and perennials without the necessity of a large number of MA films differing in permeability. Legnani et al. (2004) showed that the sprouting of lily bulbs could be inhibited by oxygen concentrations around 1% but that at lower oxygen concentrations the chances of bulb or flower damage increased. Under practical conditions this means that damage would occur when the bulbs would be displayed at higher temperatures than those tested (and the respiratory activity would be higher). The same would happen when more bulb material would be added to the package or when respiration is higher as a consequence of the previous storage conditions. This paper shows that sprouting of bulbs and plants was inhibited by using dry filling materials (Tables 1 and 2). Dry fillers however cannot be used in microperforation packages because in that situation the products would dry out even quicker than with moist fillers. MA films enable the use of dry fillers because, in spite of an early water loss from the plant to the filler, the entire package will not dry out. It is thus the MA package that extends the shelf life by its water tightness and the dry filler that inhibits sprouting. By choosing an MA film with a high permeability for oxygen a wide range of perennials and flower bulbs can be packed in one type of film. The importance of water loss as a crucial factor in the decline of quality of perennials was described by Cameron and Maqbool (1986).

Some packages showed (air) leakage due to dust from the filler in the seal. In these packages an oxygen level of 20% was measured (as in ambient air; results not shown). Nevertheless the shelf life of these packages was not negatively affected by the leakage, indicating that although apparently the oxygen diffused freely through the leaks, the water loss was still limited: the products did not dry out more quickly than in properly sealed bags. These observations demonstrate once more that dry conditions (and not a lowered oxygen concentration) in the MA packages in this research reduce sprouting and that the shelf life is extended by reducing the water loss from the package. The term Modified Humidity Packaging therefore seems to be more appropriate for this type of packaging.

In some countries the use of peat moss is not allowed anymore or strictly regulated. The wood fibre material Toresa proved to be a suitable alternative for peat moss in consumer packages with flower bulbs and perennials.

CONCLUSIONS

The shelf life of flower bulbs and perennials in consumer packages can be extended dramatically by Modified Atmosphere Packaging combined with a dry filling material. The dry filler inhibits sprouting and rooting. The MA film extends the shelf life by its water tightness rather than by creating low oxygen levels in the packages. By choosing an MA film with a high permeability for oxygen a wide range of flower bulbs and perennials can be packed in one type of film.

The wood fibre material Toresa may serve as alternative for peat moss in consumer packages for flower bulbs and perennials.

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Tables

Table 1. Weight loss (or increase: negative figures) of the plant material, shoot length after 4 weeks at 23°C and eventual shelf life of bare-root *Phlox* plants packed in traditional packages (microperforation) or in MA packages without filler or with peat moss or Toresa with different moisture contents. Mean values of 10 packages, 1 plant per package.

Type of package	Filling material	Moisture content (%) at start	Weight loss of plants (%)	Shoot length (cm)	Shelf life (weeks)
Microperforation	Peat moss	60	68	2 (not vital)	3-4
MAP	Peat moss	60	-16	8	8-10
MAP	Peat moss	20	26	1	8-10
MAP	Toresa	40	-2	6	8-10
MAP	Toresa	0	25	2	8-10
MAP	No	-	9	4	8-10

Table 2. Weight loss (or increase: negative figures) of the bulbs, shoot length after 5 weeks and shelf life at 23°C of lily bulbs ('Salmon Classic') packed intraditional packages (microperforation) or in MA packages with peat moss or Toresa with different moisture contents. Mean values of 8 packages.

Type of package	Filling material	Moisture content (%)	Weight loss (%)	Shoot length (cm)	Shelf life (weeks)
Microperforation	Peat moss	50	19	6	3-4
MAP	Peat moss	50	-10	17	8-10
MAP	Peat moss	20	11	1	8-10
MAP	Toresa	40	-1	9	8-10
MAP	Toresa	0	9	6	8-10