THE EFFECT OF FLUSH ON MUSHROOM QUALITY

REPORT FOR HORTICULTURAL DEVELOPMENT COUNCIL

THE EFFECT OF FLUSH ON MUSHROOM QUALITY

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SUMMARY AND CONCLUSIONS

The effects of flush on mushroom quality, the susceptibility to bruising and their interaction with storage temperature have not previously been studied in detail. The objective of the present work was to determine whether there were differences (**1**) in quality between the first three flushes of mushrooms, (**2**) their susceptibility to bruising. Quality was measured as mushroom colour, cap development and fresh weight loss at the time of harvest and during storage.

Mushrooms (strain Hauser A9.3) for the experiment were grown in trays on a commercial farm. Some mushrooms were given a bruising treatment, applied about 2 hours after harvest at HRI Littlehampton using a polystyrene 'shaking box'. Mushrooms were stored at either 5°C (73% relative humidity) or 18°C (90% relative humidity).

Mushroom colour was measured using a Hunter Colormeter. This measured over-all discolouration, 'redness' and 'yellowness' of the mushrooms. Mushroom weight loss and cap development (opening) were also assessed at the same intervals as mushroom colour measurements.

The main conclusions of the work were:

1) No flush differences were observed with dry matter content.

2) At 5°C:

   (a) mushroom colour of first and second flushes were consistently better than of the third flush,

   i.e. (1,2) better than 3

   (b) post-harvest development was slow and no flush differences were observed.

   (c) weight was lost from third flush mushrooms at a faster rate than from second flush mushrooms, which lost more weight than first flush mushrooms,

   i.e. 1 better than 2 better than 3

   (d) the bruising treatment caused mushroom discolouration (browning) equivalent to 7 days storage at 5°C. After bruising, the rates of discolouration of bruised and unbruised mushrooms were similar. No flush differences (discolouration or yellowing) as a result of bruising treatments were observed followed by storage at 5°C.

3) At 18°C:

   (a) mushroom colour of the second flush was better than from the third flush,

which overall was better than the first flush, i.e. 2 better than 3 better than 1

(b) the rate of cap development decreased with flush number. The third flush having the lowest rate therefore had the best quality in this aspect, i.e. 3 better than 2 better than 1

(c) weight was lost from third flush mushrooms at a faster rate than from first or second flush mushrooms, i.e. (1, 2) better than 3

(d) the bruising treatment caused mushroom discolouration (browning) equivalent to 2 days storage at 18°C. No differences were observed in the rate of browning between bruised and unbruised mushrooms. The mushroom tops of first flush mushrooms showed greater susceptibility to become yellow as a result of bruising than from the second or third flush. However, no other flush differences (discolouration or yellowing) as a result of bruising treatments were observed at 18°C.

The results from this experiment show that mushroom quality factors (i.e. mushroom colour, cap development and weight loss) are influenced differently by flush number.

To integrate and combine these results, it is necessary to assess the relative importance of the quality parameters measured. The results from this project emphasise the need to cool mushrooms immediately after harvest and to avoid handling damage to maintain high quality to the customer.

RECOMMENDATIONS FOR FUTURE WORK

1) The results of this work were obtained from three crops of mushrooms grown under similar conditions, which may not be representative of all other crops. Results differing from those found in this report may be obtained with mushrooms grown under different conditions.

2) Mushrooms for the present work were picked on the main picking day of each flush. Mushrooms picked on earlier or later stages of each flush may have different quality characteristics and could be compared.

3) The work presented in this report shows differences in quality parameters as affected by flush number, bruising treatment and storage temperature. Differences in post-harvest quality associated with pre-harvest growing factors, e.g. humidity, temperature and watering, are also likely to occur and should be investigated.

INTRODUCTION

Mushroom quality is a major determinant of sales and price. A consumer survey in the UK has identified good quality characteristics of mushrooms as (in order) freshness, whiteness, cleanness, uniformity and "closedness" (Berendse, 1984). The mushroom industry is aiming to improve the high quality of its produce by determining which factors are beneficial and deleterious to quality. Flush number is one factor thought to have an influence on quality, although most of the evidence is anecdotal. Bartley et al (1991), using off-white hybrids grown in the USA, found that first flush mushrooms were whiter at harvest and remained whiter in storage than second flush mushrooms, which in turn discoloured more slowly than third flush mushrooms. The effects of flush on mushroom quality, the susceptibility to bruising and their interaction with storage temperature have not been studied in detail.

The objective of the present work was to determine whether there was a difference between the first three flushes of mushrooms in their susceptibility to bruising or in storage life, specifically changes in mushroom colour, cap development and fresh weight loss.

MATERIALS AND METHODS

Mushroom samples

The mushrooms (Agaricus bisporus, strain Hauser A9.3) were grown in trays using standard commercial practices at Chesswood's Produce Ltd, Sussex. Button mushrooms with a cap diameter of 30 - 35 mm were harvested from the first three flushes of three separate crops. Following transport to HRI Littlehampton, mushrooms were selected for freedom from blemishes and casing material.

Bruising treatment

The bruising treatments were applied to samples of 10 mushrooms by placing them in a polystyrene 'shaking' box (280 x 225 x 125 mm deep) which oscillated horizontally through a distance of 40 mm at a frequency of 2 Hz. Bruising of mushrooms was caused largely by them rolling along the base of the box, but also by collisions with the sides of the box or with other mushrooms. Samples of mushrooms were randomly allotted to three bruising treatments, which varied according to the time in the shaking box: 0 (unbruised), 5 seconds, and 10 seconds. Bruising treatments were applied about 2 hours after harvest.

Storage treatment

Following the application of the bruising treatments, the samples of 10 mushrooms were placed into plastic punnets (140 x 140 x 60 mm deep). The mushrooms were then stored at either 5°C (73% relative humidity) or 18°C (90% relative humidity).

Dry matter content

The dry matter content of each batch (flush and crop) of mushrooms was assessed by weighing the fresh weight of two samples of 20 mushrooms, then oven drying the samples for one week at 75°C and weighing the dry weight.

Mushroom colour measurement

Mushroom colour was measured using a Hunter Colormeter (Hunter Assoc. Lab. Inc., Virginia, U.S.A.) with a 6 mm port. The Hunter Colormeter produces three parameters 'L', 'a' and 'b' to describe the reflected light. 'L' is the overall reflectance, independent of colour. The parameters 'a' and 'b' are known as opponent colour scales and they attempt to analyse colour in a similar manner to the human vision system. A negative value of 'a' refers to green colour and positive value to red colour. Negative and positive values of 'b' refer to blue and yellow colours respectively.

Each mushroom was measured once on the top of the cap and at four different points on the side. For the mushrooms stored continuously at 18°C, reflectance measurements were made on days 0, 1, 2, 3 and 4 (3, 27, 51, 75 and 99 hr after harvest). For the mushrooms stored continuously at 5°C, reflectance measurements were made on days 0, 2, 4 and 7 (3, 51, 99 and 171 hr after harvest). The day 0 measurements were made 1 hr after bruising, i.e. 3 hr after harvest.

A different sample of 10 mushrooms was used for each set of readings to avoid recording the damage that might be caused by contact with the reflectometer head.

Mushroom development

The stage of development of the mushrooms was assessed using an arbitrary 1 - 7 scale of development stage (Hammond and Nichols, 1975; 1976). The stages in cap development corresponding to each point on the scale are shown in Figs. 24 - 26. Cap development was assessed on the same mushrooms and at the same intervals used for assessing mushroom colour.

Mushroom weight loss

Fresh weight loss was calculated by measuring the initial weights of the punnets of 10 mushrooms, and their weights at the times of the subsequent quality assessments.

Experimental design

Three replicate experiments (crops) were conducted in October and November 1991.

The experiment had a factorial design with the following number of treatments:

2 bruising x 3 flushes x 4 or 5 storage durations (at 5°C or 18°C) x 3 replicate crops.

The mean of the 10 colour and cap development measurements from one punnet served as a single plot value.

The data from each of the storage temperatures (5°C and 18°C) were analysed separately in two analyses of variance due to the large difference in values between the two sets of data. Since the relative effects of the 5 and 10 second bruising treatments on the different flush and storage temperature treatments were similar, only the unbruised and 10 second bruising treatments were included in the main analysis.

For statistical reasons, the reflectance 'L' data was mathematically transformed using the function developed by Burton et al (1987):

$$\text{degree of browning} = \log_n (100 - L)$$

A good quality freshly picked mushroom would have a reflectance (L value) of 88 - 90, and therefore a degree of browning of 2.3 - 2.5.

RESULTS

Dry matter content

There was no significant difference between the dry matter contents of mushrooms from flushes 1, 2 or 3 (Fig. 1).

Mushroom colour

As a consequence of the factorial design of the experiment (5°C and 18°C storage, bruised and unbruised) and the complexity of colour measurement (L, 'a' and 'b' measurements on cap tops and sides) a large quantity of data was obtained. To enable rapid comprehension, summary graphs are presented to show the overall trends in mushroom colour during storage, irrespective of flush number. Each summary graph is followed by graphs presenting the data in more detail, separating out the flushes into bruised or unbruised, cap tops or sides. When examining the graphs of mushroom colour, one has to collate and integrate the trends into overall treatment effect differences.

Degree of browning - storage at 5°C

Summary Fig. 2 shows the effects of storage at 5°C on the degree of browning of mushrooms. The degree of browning increased during storage in a linear manner. The 10 seconds bruising treatment on day 0 discoloured the mushrooms to about the same extent as 7 days' storage at 5°C without bruising. During storage the rate of browning of bruised mushrooms was the same as unbruised mushrooms.

Figs. 3 and 4 show effects of 5°C storage on browning of mushroom tops. Statistical analysis showed that flush 3 mushroom tops were browner than those of flushes 1 and 2 (5% level). The rate of browning of flush 3 mushroom tops was also greater than for flushes 1 and 2.

Figs. 5 and 6 show the effects of 5°C storage on browning of mushroom sides. No significant differences were found between flushes in the average browning value of the overall storage period, but the rate of browning of flush 3 was greater than for flushes 1 and 2.

Degree of browning - storage at 18°C

Summary Fig. 7 shows the browning of bruised and unbruised mushrooms (cap top and sides) during storage at 18°C. The rate of browning was greater at 18°C than at 5°C. The bruising treatment increased the degree of browning at day 0 to approximately that

of unbruised mushrooms at day 2. The lines are parallel showing that the mushrooms browned at the same rate irrespective of any bruising treatment. A small but consistent fall in the degree of browning between days 0 and 1 was observed. This increase in cap reflectance may have been due to loss of surface moisture after harvest.

Figs. 8 and 9 show the effects of 18°C storage on the browning of mushroom tops. When averaged over the storage period, mushrooms from flush 2 were significantly less brown (i.e. whiter) than from flushes 1 and 3.

Figs. 10 and 11 show the effects of 18°C storage on the browning of mushroom sides. The mushroom sides from flush 2 were significantly least brown (i.e. whitest) when averaged over the storage period. Flush 1 mushrooms were significantly more brown than the other flushes.

Over-all effect of flush number on post-harvest browning

When stored at 5°C, mushrooms from flush 3 were more brown than those from flushes 1 or 2 which were similar. At 18°C storage, the same situation existed for the mushroom cap tops, but for the sides, flush 2 was whitest followed by flush 3 and then flush 1. Bruising did not affect the relative flush differences at 5°C or 18°C.

The effects of the bruising and storage temperature treatments are illustrated in Photo.1.

'a' value - redness of stored mushrooms

The 'a' values were very low (0 - 1.5) and positive therefore referring to redness. No significant or consistent differences were found between flushes.

Fig. 12 shows average 'a' values of mushrooms stored at 18°C.

'b' value (yellowness) - storage at 5°C

The 'b' value was positive for all treatments, and therefore refers to the yellowness of the mushroom.

Summary Fig. 13 shows the effect of 5°C storage on the yellowness of mushrooms. The 'b' value increased, i.e. mushrooms became more yellow during the storage period. The rate of increase of yellowness was similar for all treatments. Bruising caused the 'b' value to rise at day 0 to that of unbruised mushrooms after 1 - 1.5 days.

Figs. 14 and 15 show the changes in the yellowness of mushroom tops during storage at 5°C. Overall flush 3 had a significantly higher 'b' value (i.e. yellower) than flushes 1 and 2 which were similar.

Figs. 16 and 17 show the yellowness of mushroom sides during storage at 5°C. The sides of flush 3 mushrooms were significantly more yellow than those from flushes 1 and 2 which were similar.

'b' value (yellowness) - storage at 18°C

Summary Fig. 18 shows the effect of 18°C storage on the 'b' value of mushroom colour. The rate of yellowing was greater at 18°C than at 5°C. The bruising treatment increased yellowness at day 0 to that of unbruised mushrooms after 1 - 1.5 days storage. As storage time increased, there was less difference between the yellowness of the tops and sides.

Figs. 19 and 20 show the effects of 18°C storage on the yellowness of mushroom tops. When averaged over the storage period, the mushrooms from flush 2 were significantly less yellow than those from flushes 1 and 3 which were similar.

There was a significant interaction between flush number and bruising treatments (Fig. 21). Mushrooms from flush 1 yellowed to a greater extent as a result of bruising than mushrooms from flushes 2 and 3 which were similar.

Figs. 22 and 23 show the effects of 18°C storage on the yellowness of mushroom sides. The mushrooms from flush 2 were significantly less yellow than those from flushes 1 and 3 which were similar.

Over-all effect of flush number on post-harvest yellowing

When stored at 5°C, mushrooms from the first and second flushes were less yellow than those from the third and this trend was not affected by bruising. However, when stored at 18°C the mushrooms from flush 2 were less yellow than from flushes 1 and 3. Mushrooms from the first flush were more susceptible to yellowing as a result of bruising than mushrooms from the second or third flushes if subsequently stored at 18°C.

Mushroom development

Mushroom cap development was more rapid at 18°C than at 5°C (Figs. 24 and 25). At 5°C, there was no significant difference between flushes 1, 2 and 3 in the rate of development of the caps (Fig. 24). At 18°C, the rate of cap development was greatest in first flush mushrooms and slowest in third flush mushrooms (Fig. 25).

Bruised mushrooms developed significantly more rapidly than unbruised mushrooms, although the effect was small compared with the effects of temperature and flush (Fig. 26).

Mushroom weight loss

The rate of mushroom weight loss was significantly greater during storage at 18°C than at 5°C (Fig. 27). The weight loss of bruised mushrooms was slightly less than that of unbruised mushrooms.

At both 5°C and 18°C, mushroom weight loss from third flush mushrooms was greater than that from first or second flush mushrooms (Figs. 28 and 29). Weight loss from second flush mushrooms was slightly greater than from first flush mushrooms in storage at 5°C, but there was no significant difference at 18°C.

DISCUSSION

In agreement with the results of Kalberer (1985), no significant difference in dry matter content between the first three flushes of mushrooms was found in the present work. These results suggest that dry matter content may not necessarily influence mushroom quality. However, Laborde and Delpech (1991) found that the dry matter content of mushrooms during the first 21 day picking period was greater than that during the second 21 day picking period.

The increased mushroom weight loss and increased rate of cap development during storage at higher temperature are in agreement with previous studies (Nichols and Hammond, 1974; Murr and Morris, 1975). Differences between flushes in the rate of cap development only became apparent at the higher storage temperature of 18°C. The declining rate in cap development with later flushes may be related to the nutritional status of the mushroom. Hammond and Nichols (1975) found that the soluble carbohydrate mannitol was one of the main respiratory substrates during storage.

Parrish et al (1976) found that the mannitol content of mushrooms was greatest in the first or second flush depending on the strain, and least in the third flush. The protein levels in sporophore tissues also decline with flush number, i.e. highest in the first flush (Burton, 1988 a). When the mushroom is harvested, the protein is degraded to provide carbon and nitrogen sources for the developing sporophore.

The reduced weight loss of first flush mushrooms is an anomalous result, since their increased rate of cap development should enhance water loss.

The greater weight loss during storage of third flush mushrooms indicates that they have a more permeable surface than first or second flush mushrooms. This may be due to a difference in the hyphal network which forms the pileus and stipe, and inter-hyphal cavities which permit free interchange of water vapour from inside the mushroom to the outside air (Nichols, 1985). The reduction in weight loss caused by the bruising treatment may be due to a flattening of the surface hyphal network resulting in a lower surface area of cap surface hyphae and a restriction of water vapour exchange between internal hyphal and surrounding air.

The short and relatively mild bruising treatment caused discolouration (browning) on the cap approximately equivalent to 7 days storage at 5°C or 2 days storage at 18°C of an unbruised mushroom. The bruising treatment caused an increase in yellowness approximately equivalent to 1 - 1.5 days storage at 5° or 18°C. However, the rate of

browning or yellowing of bruised and unbruised mushrooms was similar, which means that after bruising, a more rapid deterioration does not subsequently follow.

When stored at 5°C, mushrooms from the third flush were yellower and over-all more discoloured (degree of browning) than first or second flush mushrooms which were indistinguishable in colour. Deterioration at this temperature was slow, and this result refers to market quality observed in cooled mushroom packhouses and distribution before exposure to ambient temperatures. Bruising did not cause any greater discolouration or yellowing of one flush than another at 5°C.

At 18°C, the tops of the mushrooms from the second flush were less yellow and less over-all discoloured than those from the first or third flushes which were similar. The tops of the first flush mushrooms were more susceptible to yellowing as a result of the bruising treatment than those from the second or third flushes.

The sides of the mushrooms stored at 18°C from flush 2 were the least yellow and the least discoloured or brown, flushes 1 and 3 were similarly yellow, but flush 1 was more discoloured over-all than flush 3. Bruising did not cause any greater over-all discolouration of one flush than another at 18°C.

The colour of mushrooms from the first and second flushes at harvest and during low temperature storage is considerably better than that of third flush mushrooms. However at 18°C storage, mushroom discolouration from all flushes was increased, but flush 1 discolouration was increased to a rate similar to or greater than that of flush 3. The over-all flush order of quality in terms of colour at 5°C is (1,2) 3, and at 18°C 2, 3, 1 (flush numbers in brackets indicate no difference). Bartley et al (1991) found that the whiteness of mushrooms growing on the beds and the rate of discolouration during post-harvest storage declined with flush number, i.e. 1 2 3.

Discolouration of mushrooms is caused by the oxidation of phenols catalysed by the enzyme tyrosinase. This process can be initiated by either physiological events associated with senescence, by pathological infection, principally by Pseudomonas tolaasii (bacterial blotch), or by physical damage. Post-harvest discolouration of mushrooms is due to one or more of these processes.

The consistently lower quality of third flush mushrooms, compared with second flush mushrooms (see Photo. 2) is possibly the result of higher bacterial populations on the caps leading to greater incidence of blotch. Olivier (1984) and Hayes and Nair (1984) reported that the population of Pseudomonas bacteria increases in the casing soil during cropping.

Tyrosinase activity in first flush mushrooms is greater than in second or third flush mushrooms, but consistent flush trends have not been found for the phenol contents. (Burton, 1988 b). This may offer some explanation for the greater increase in discolouration of first flush mushrooms as a result of raising storage temperature from 5°C to 18°C. Photo 2 shows the greater general discolouration of first flush mushrooms, at 18°C, compared with second flush, and the blotch discolouration of the third flush. The results found in this report suggest that the flush effects on quality are influenced by both physiological and pathological processes. The physiological processes causing less discolouration with the flush number and the pathological processes causing more discolouration with flush number.

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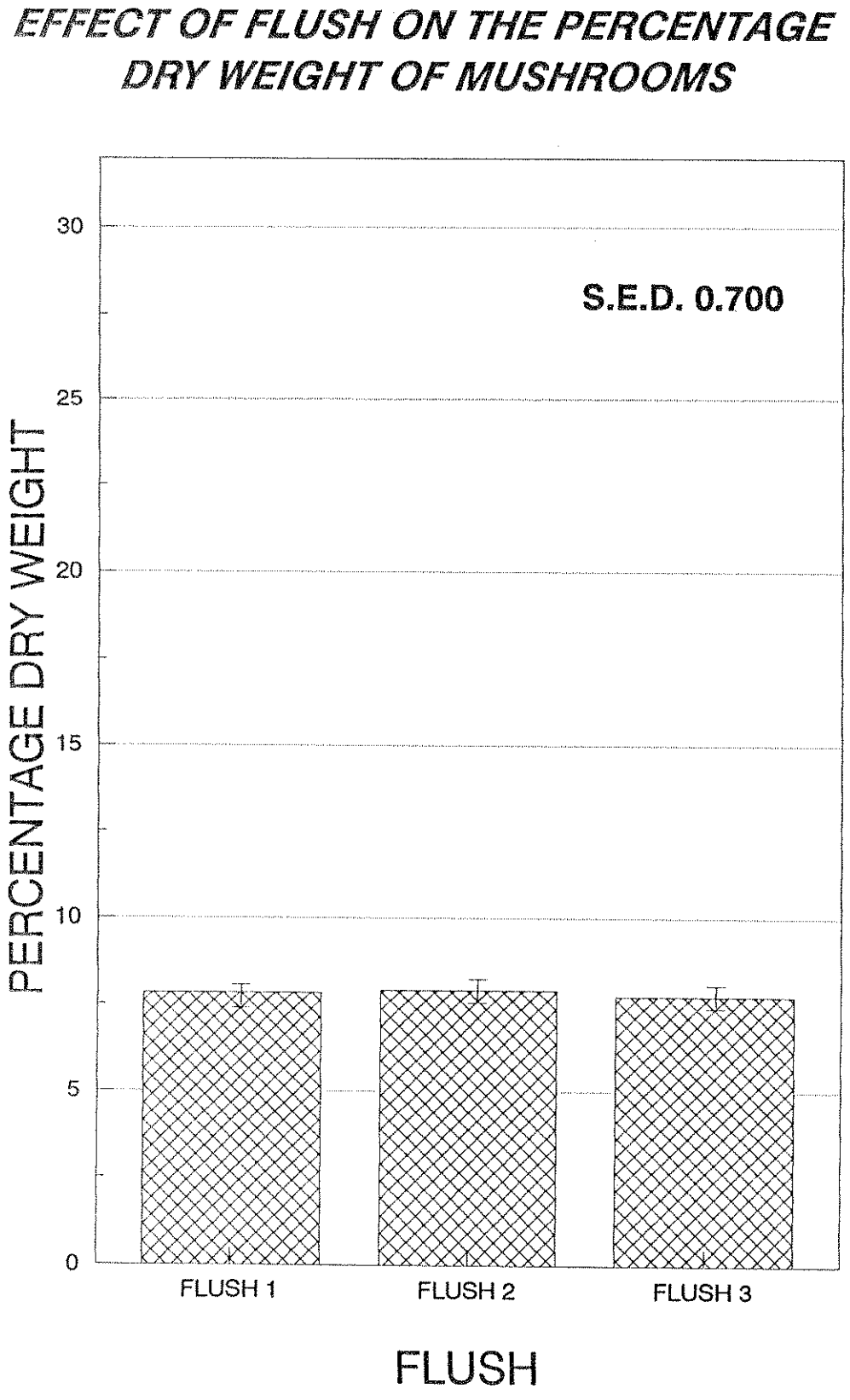
DRY MATTER CONTENT

Fig. 1


EFFECT OF FLUSH ON THE PERCENTAGE DRY WEIGHT OF MUSHROOMS
S.E.D. 0.700
PERCENTAGE DRY WEIGHT
30
25
20
15
10
5
0
FLUSH 1
FLUSH 2
FLUSH 3
FLUSH

MUSHROOM COLOUR

Fig. 2

A SUMMARY OF THE EFFECT OF STORAGE (5C) ON THE BROWNING OF BRUISED AND UNBRUISED MUSHROOMS (top and side readings)

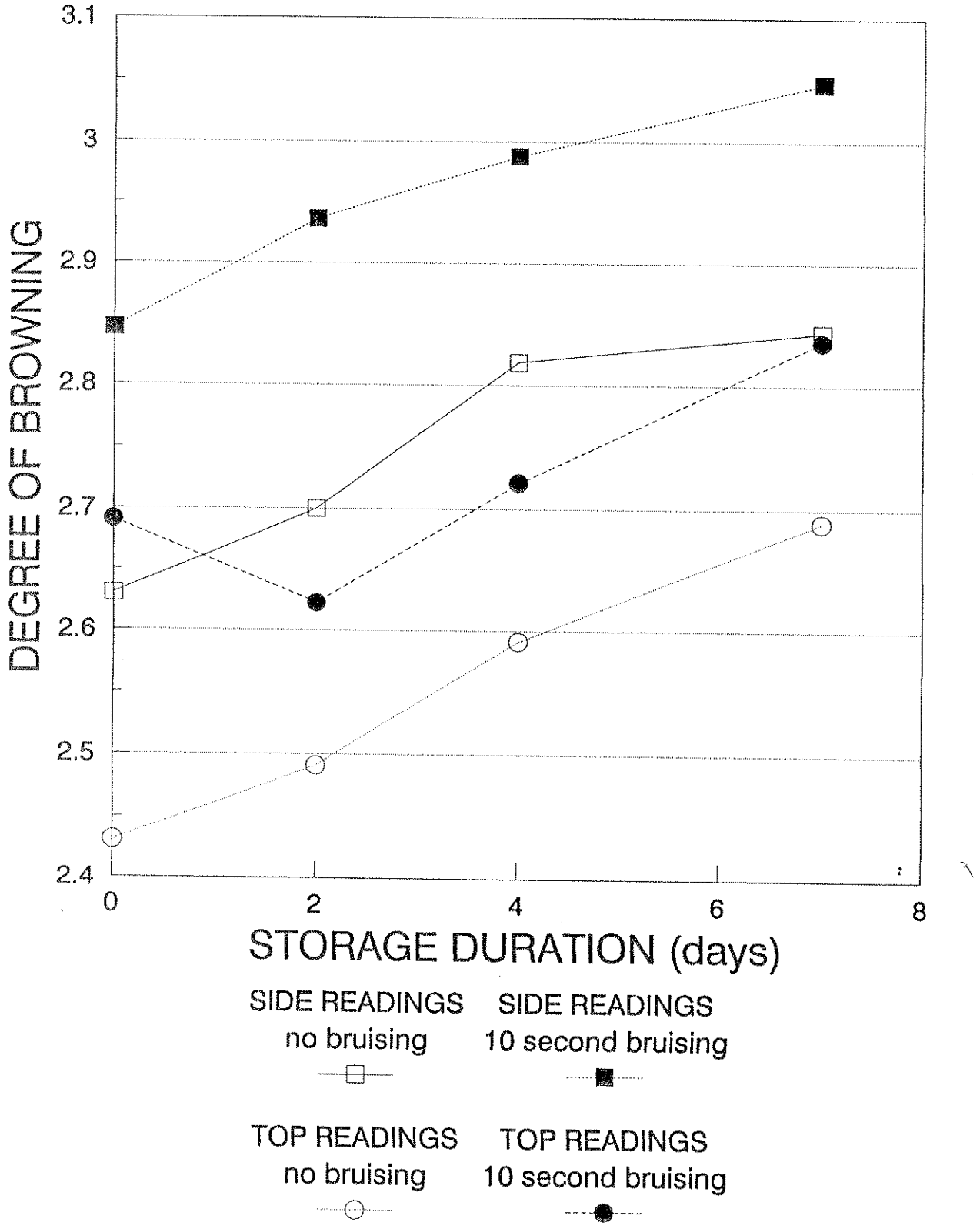


Fig. 3

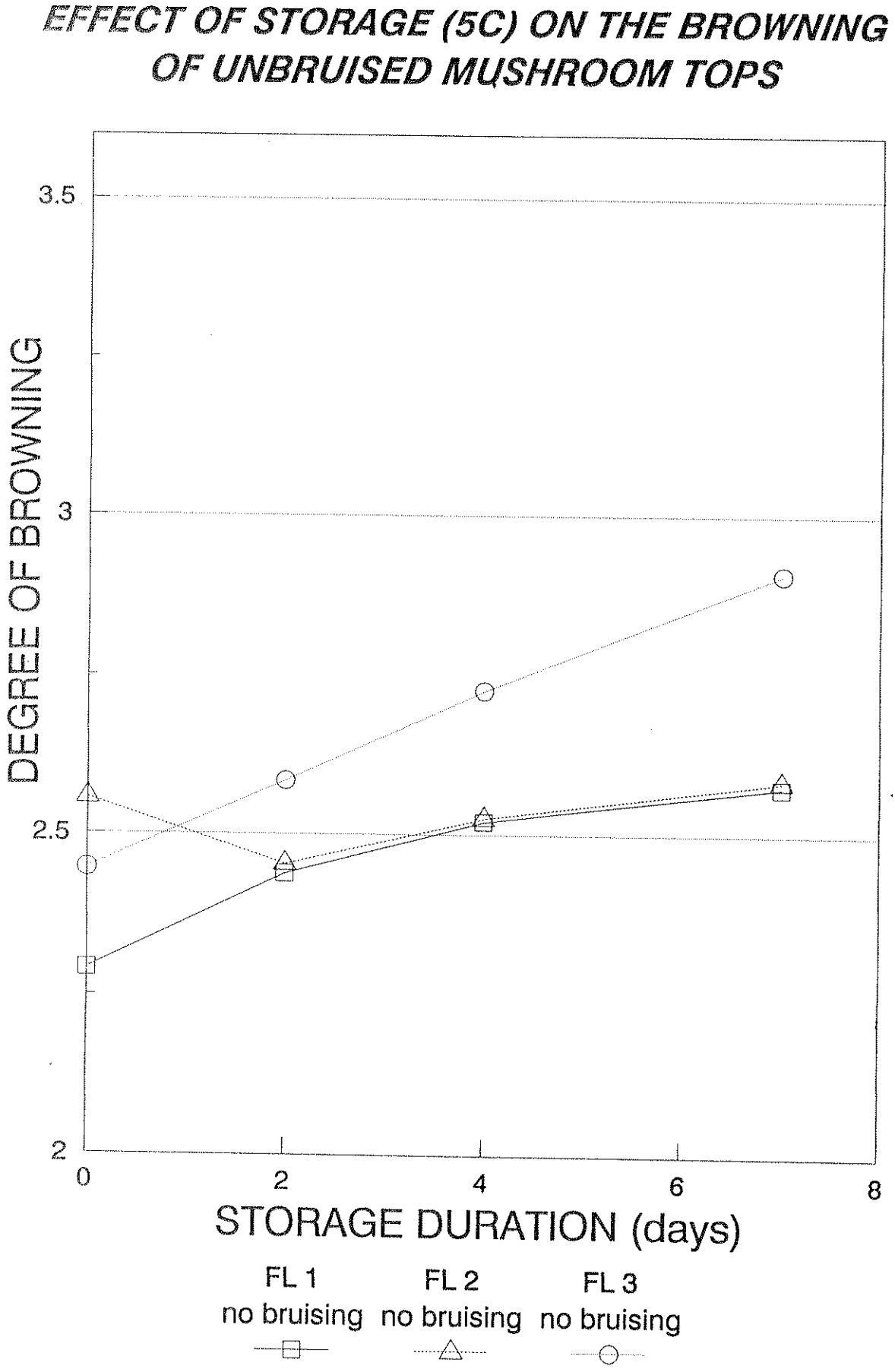

EFFECT OF STORAGE (5C) ON THE BROWNING OF UNBRUISED MUSHROOM TOPS
DEGREE OF BROWNING
3.5
3
2.5
2
0
2
4
6
8
STORAGE DURATION (days)
FL 1
no bruising
FL 2
no bruising
FL 3
no bruising

Fig. 4

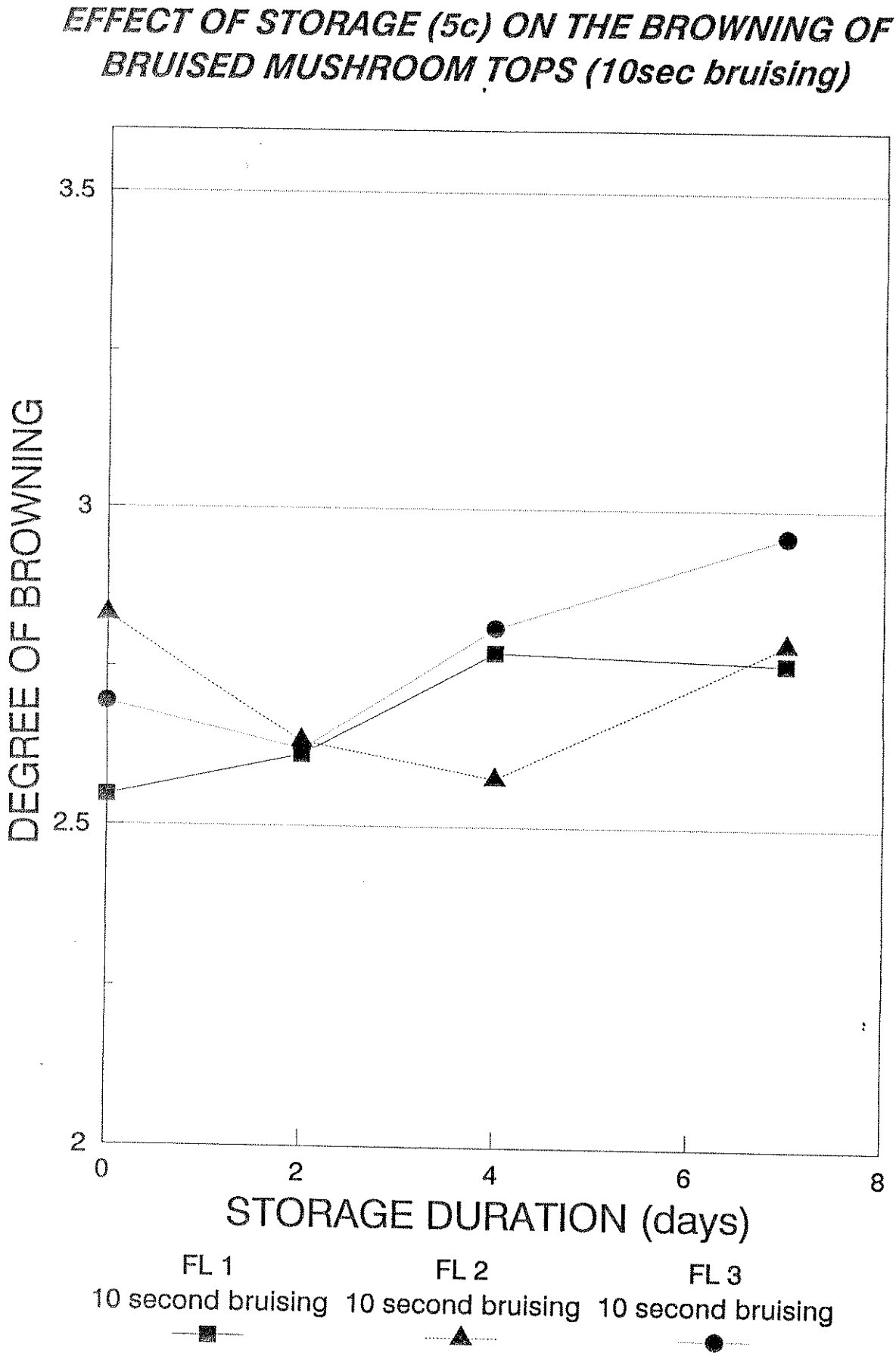

EFFECT OF STORAGE (5c) ON THE BROWNING OF BRUISED MUSHROOM TOPS (10sec bruising)
DEGREE OF BROWNING
3.5
3
2.5
2
0
2
4
6
8
STORAGE DURATION (days)
FL 1
10 second bruising
FL 2
10 second bruising
FL 3
10 second bruising

Fig. 5

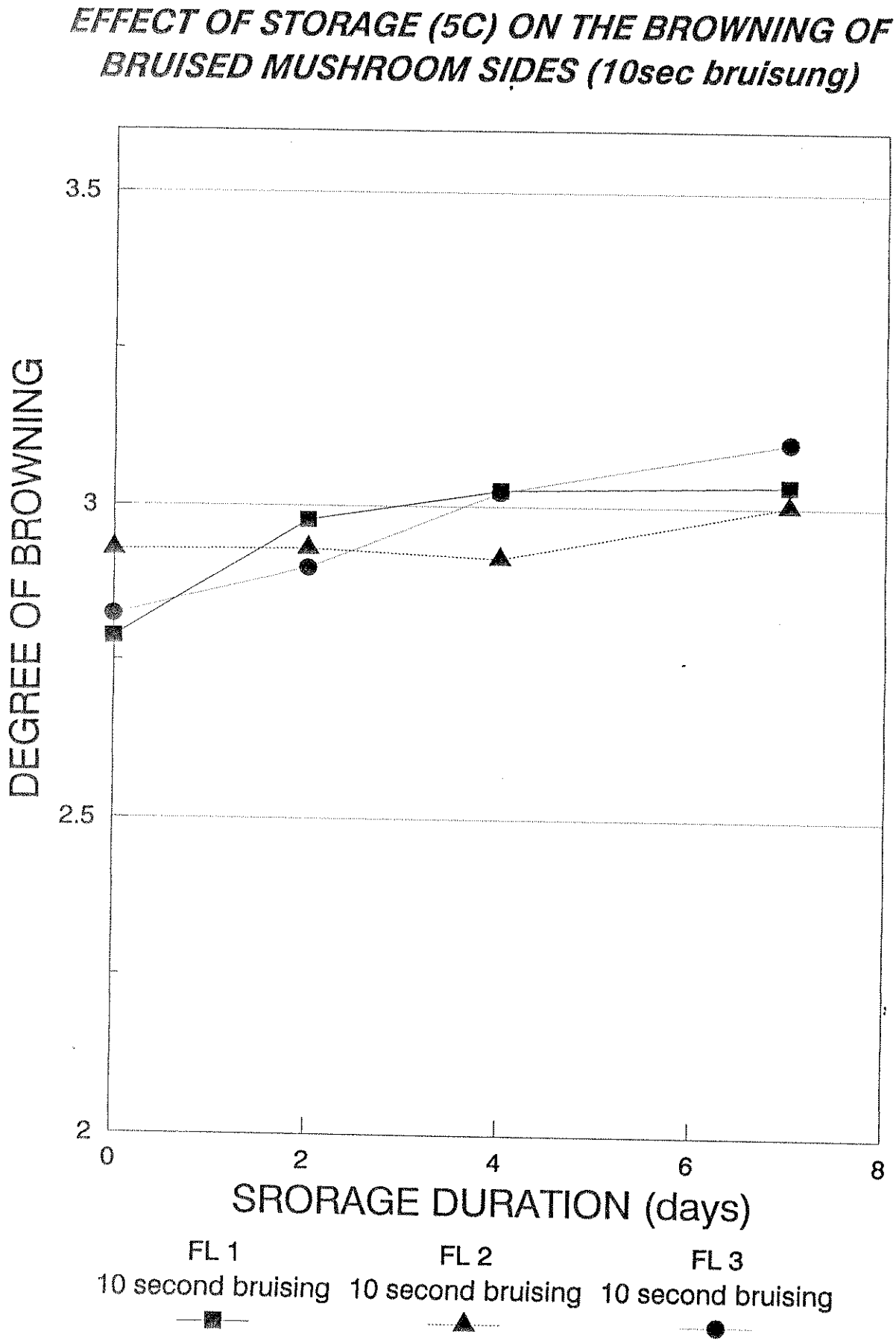

EFFECT OF STORAGE (5C) ON THE BROWNING OF BRUISED MUSHROOM SIDES (10sec bruisung)
DEGREE OF BROWNING
3.5
3
2.5
2
0
2
4
6
8
SRORAGE DURATION (days)
FL 1
10 second bruising
FL 2
10 second bruising
FL 3
10 second bruising

Fig. 6

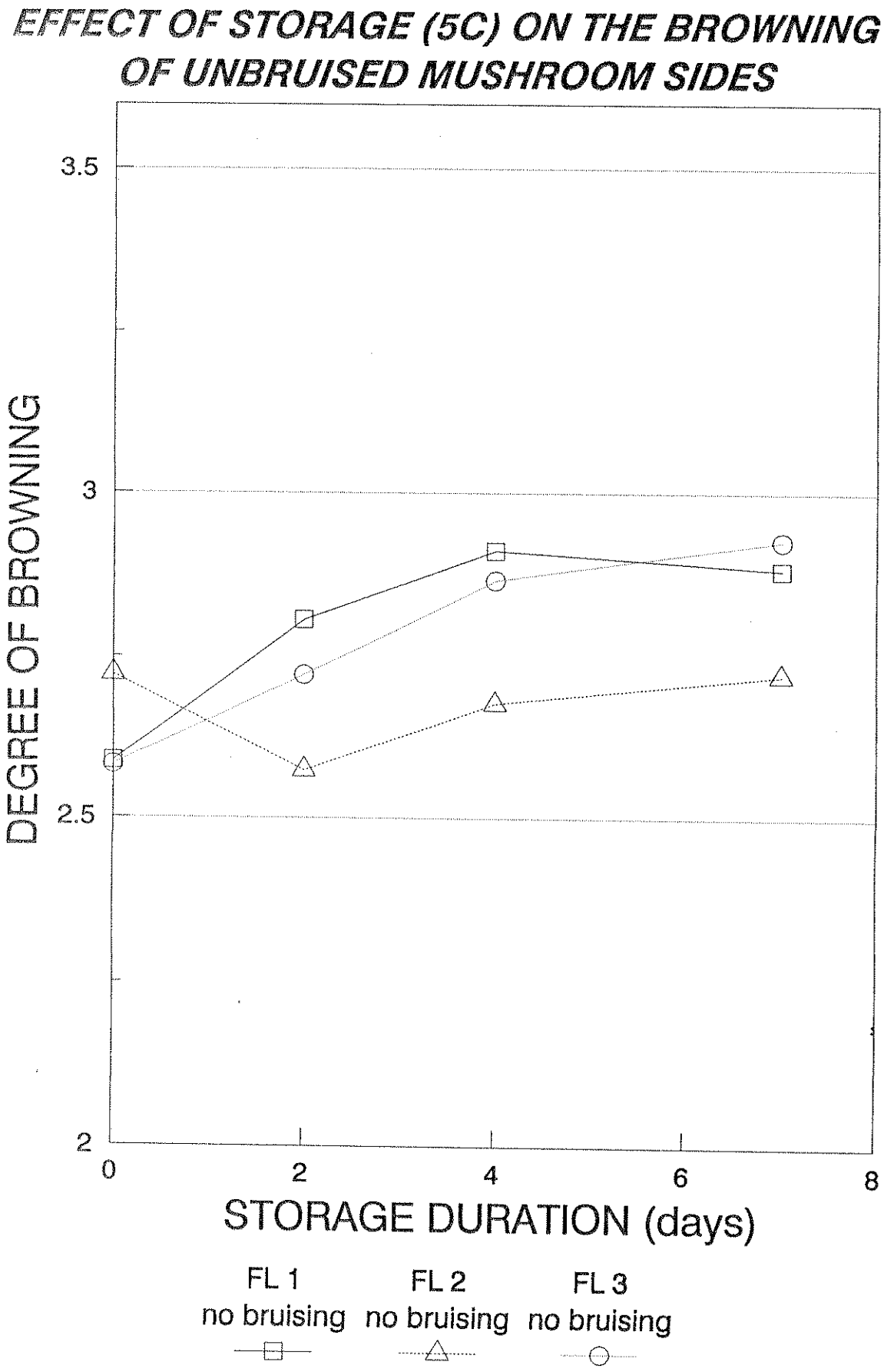

EFFECT OF STORAGE (5C) ON THE BROWNING OF UNBRUISED MUSHROOM SIDES
DEGREE OF BROWNING
3.5
3
2.5
2
0
2
4
6
8
STORAGE DURATION (days)
FL 1 no bruising
FL 2 no bruising
FL 3 no bruising

Fig. 7

A SUMMARY OF THE EFFECT OF STORAGE (18C) ON THE BROWNING OF BRUISED AND UNBRUISED MUSHROOMS (top and side readings)

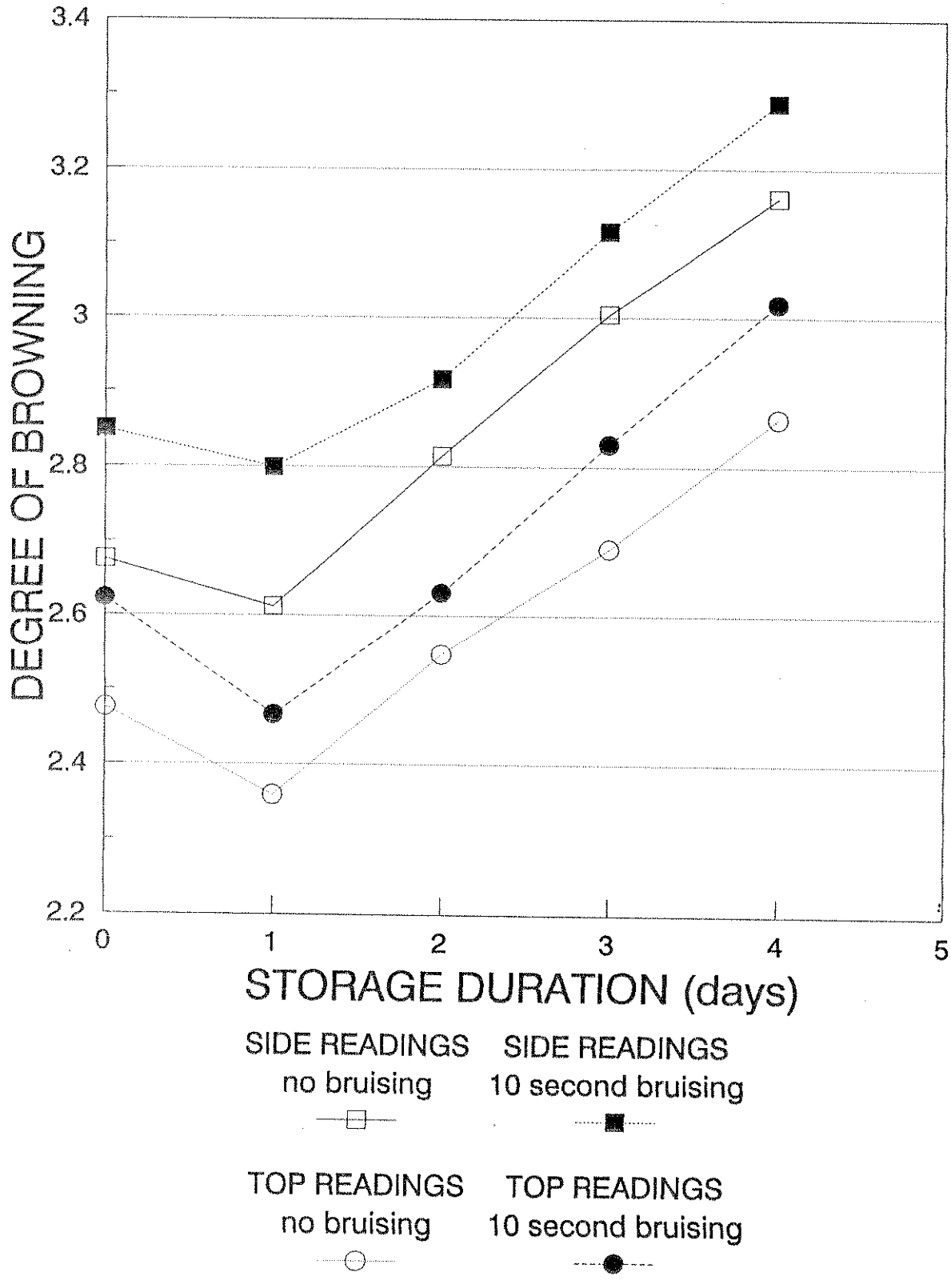


Fig. 8

EFFECT OF STORAGE (18C) ON THE BROWNING OF UNBRUISED MUSHROOM TOPS

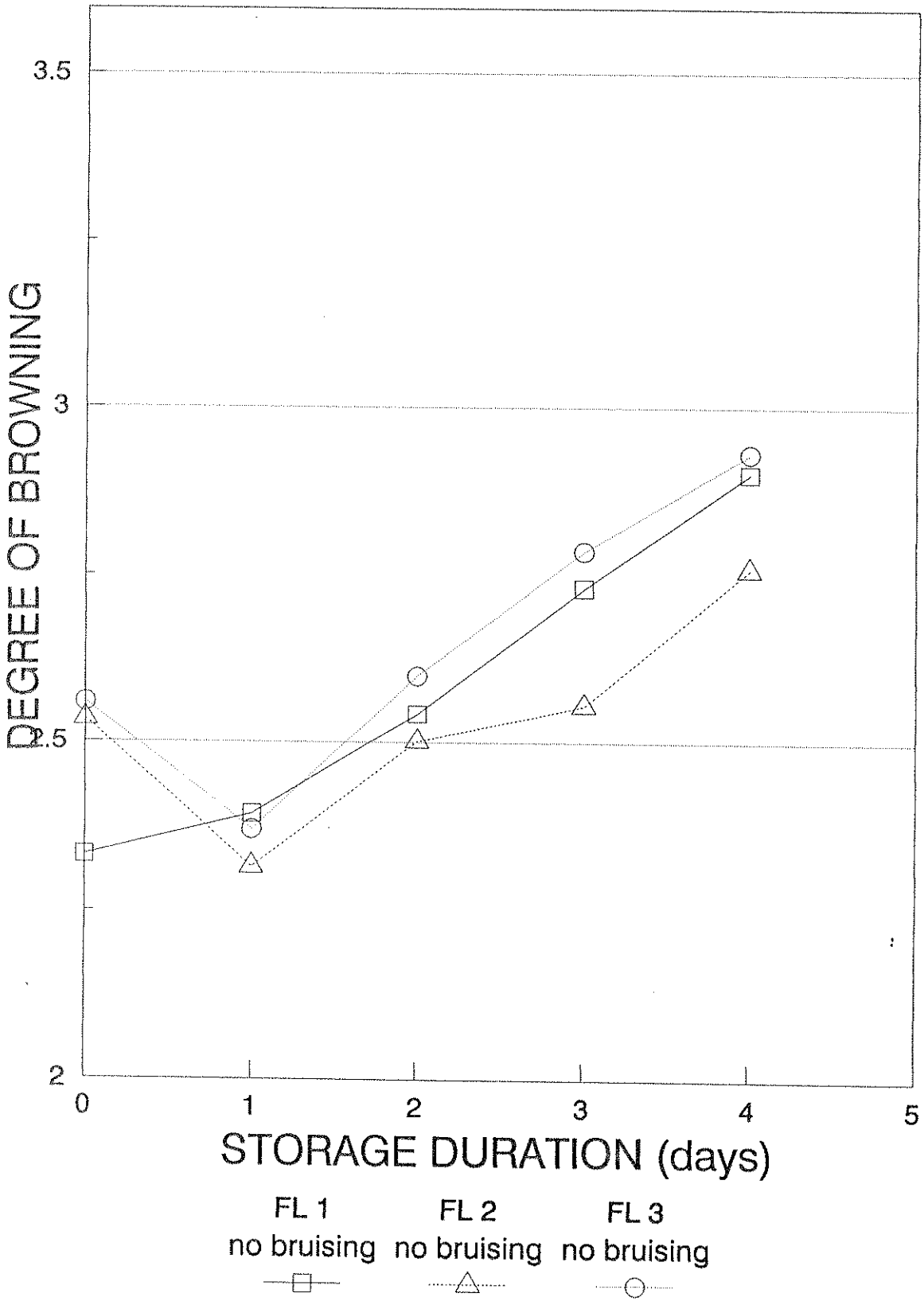


Fig. 9

EFFECT OF STORAGE (18c) ON THE BROWNING OF BRUISED MUSHROOM TOPS (10sec bruising)

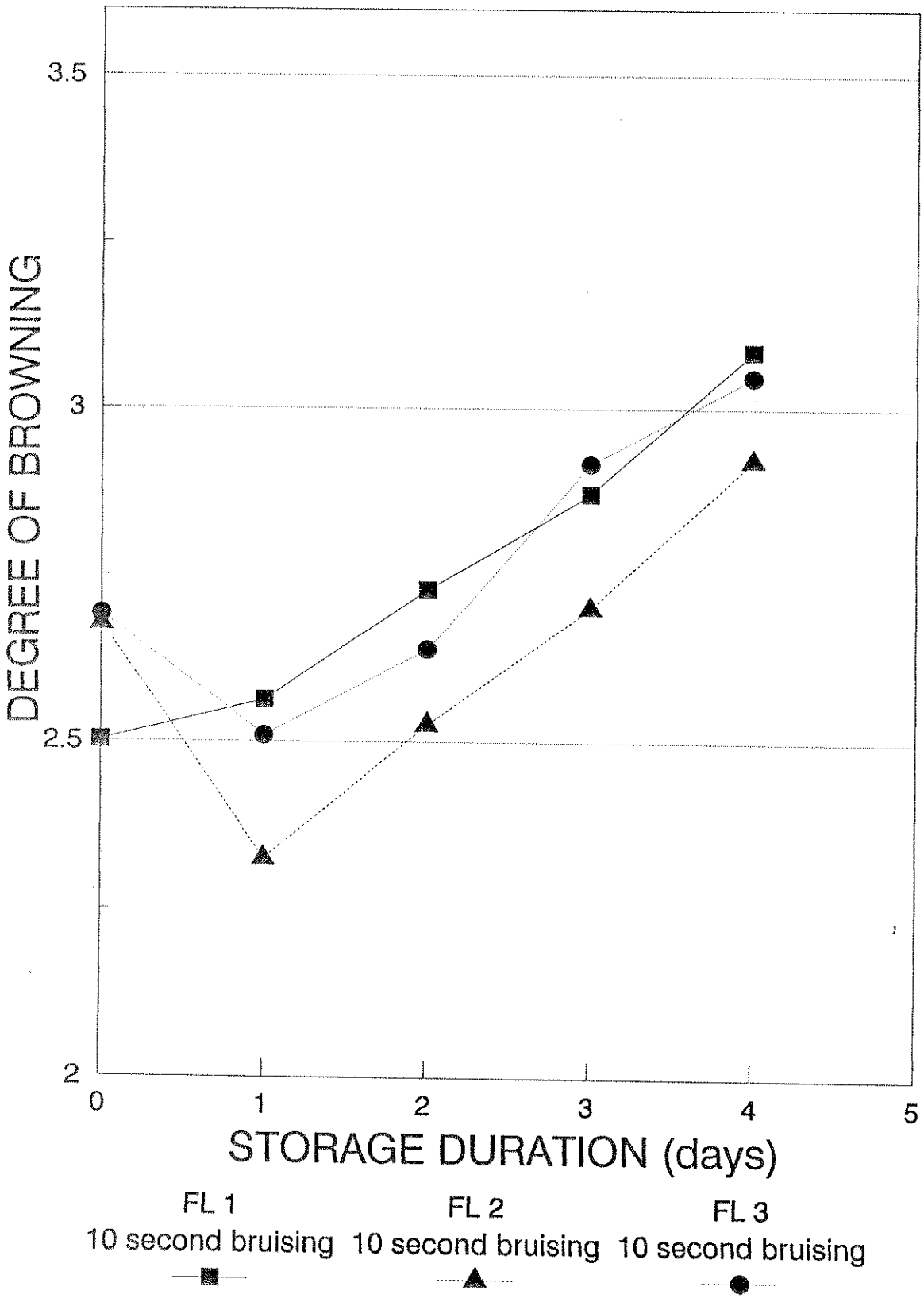


Fig. 10

EFFECT OF STORAGE (18C) ON THE BROWNING OF UNBRUISED MUSHROOM SIDES

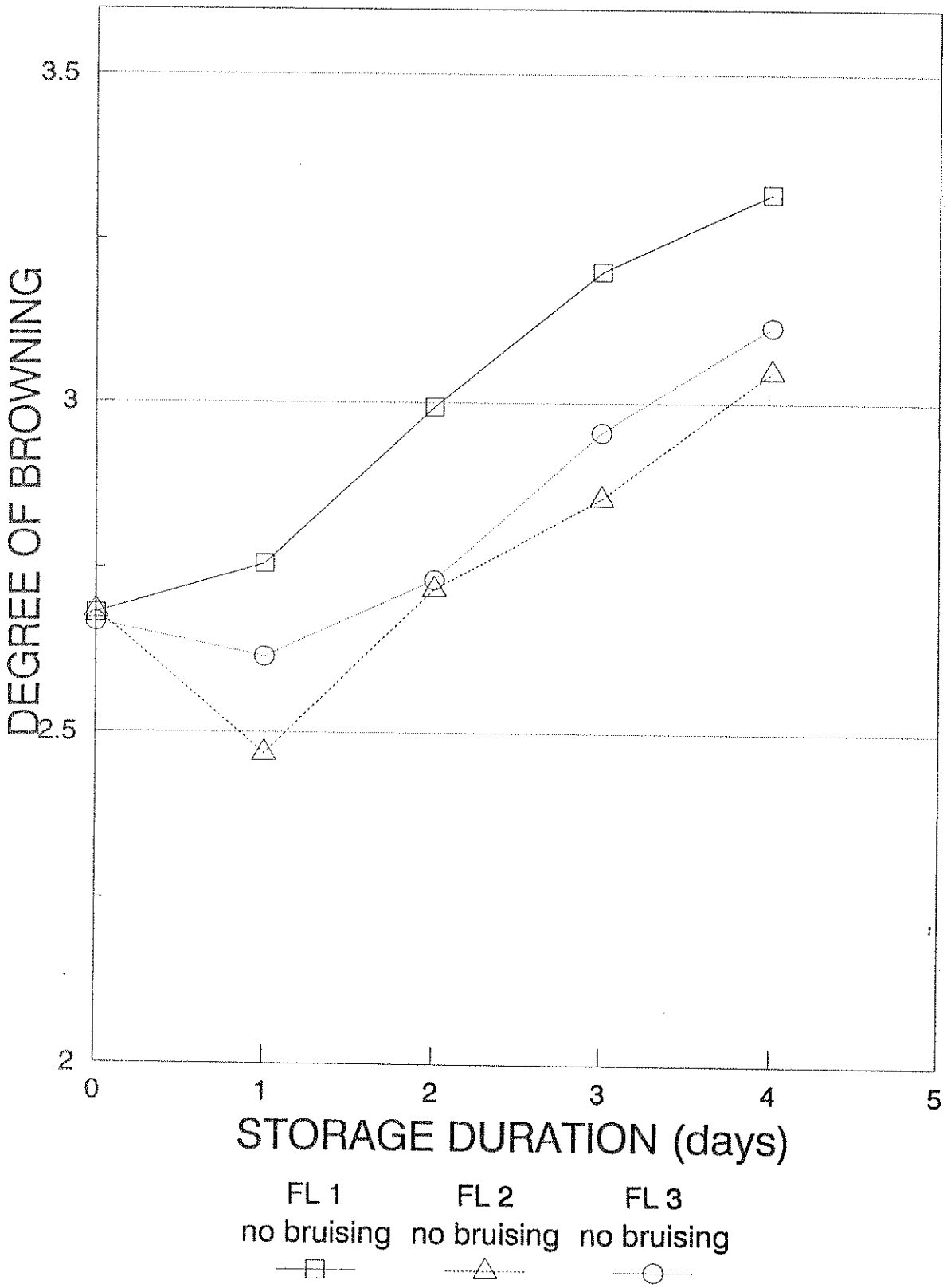


Fig. 11

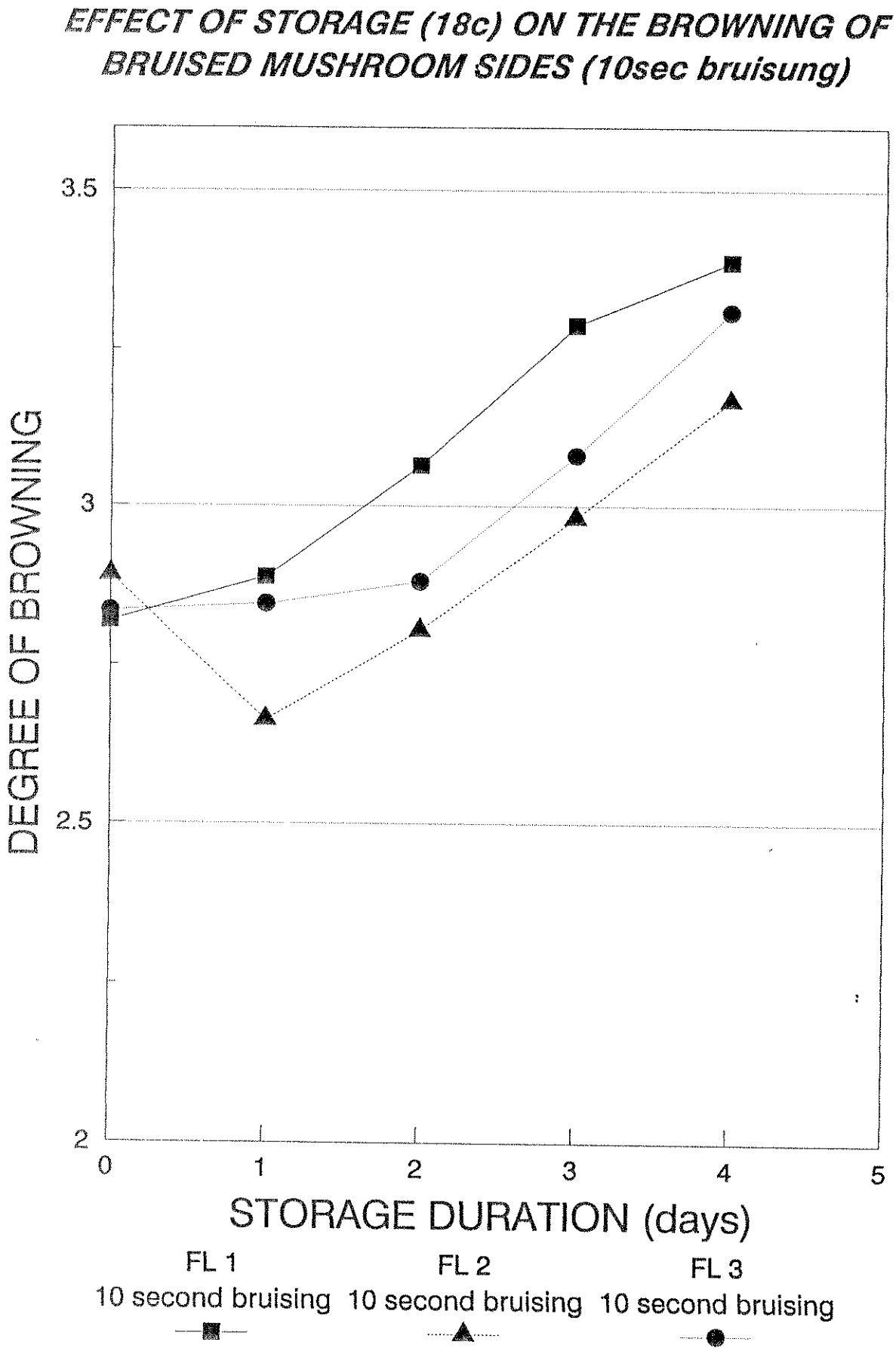

EFFECT OF STORAGE (18c) ON THE BROWNING OF BRUISED MUSHROOM SIDES (10sec bruisung)
DEGREE OF BROWNING
3.5
3
2.5
2
0
1
2
3
4
5
STORAGE DURATION (days)
FL 1
10 second bruising
FL 2
10 second bruising
FL 3
10 second bruising

Fig. 12

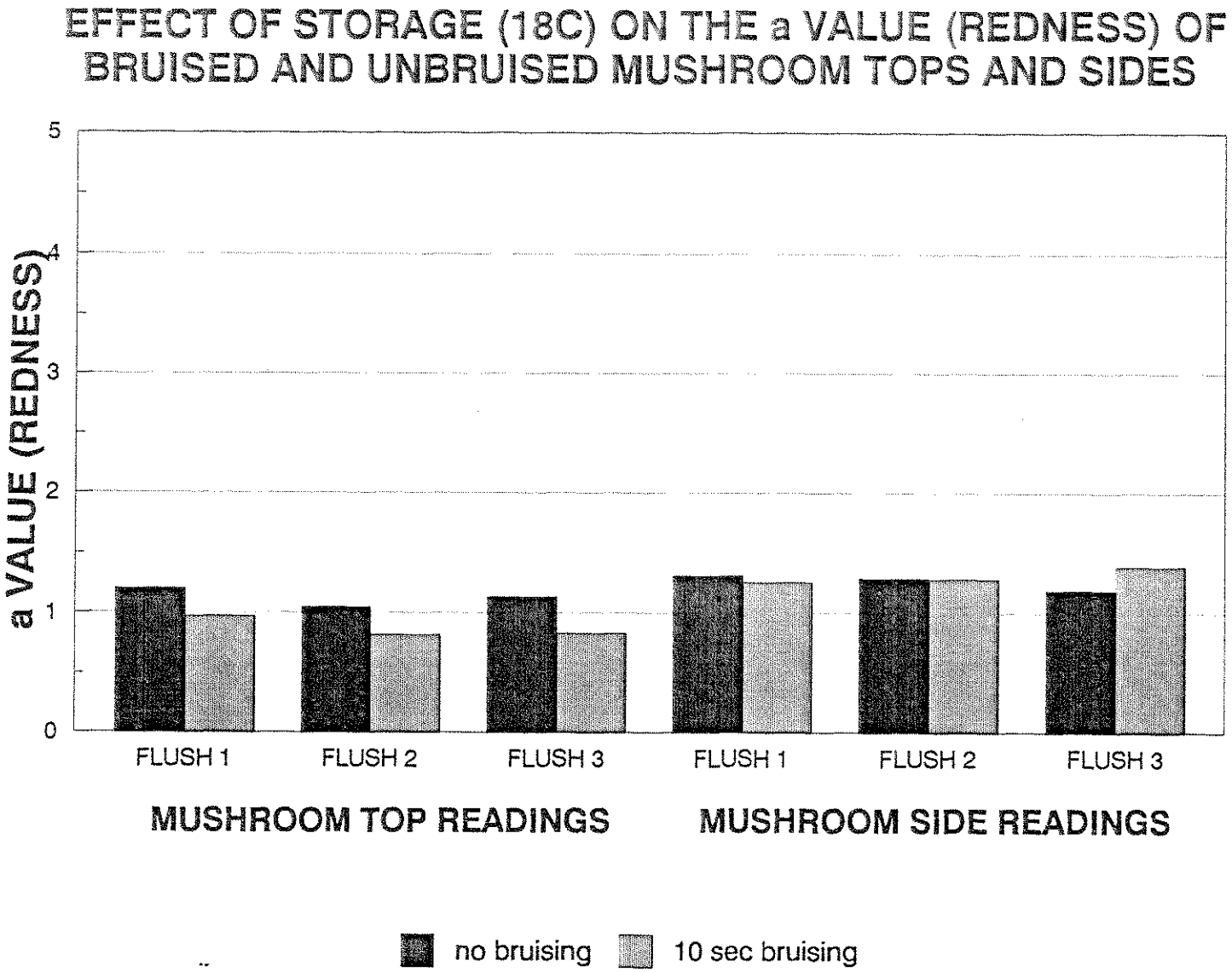

EFFECT OF STORAGE (18C) ON THE a VALUE (REDNESS) OF BRUISED AND UNBRUISED MUSHROOM TOPS AND SIDES
a VALUE (REDNESS)
5
4
3
2
1
0
FLUSH 1
FLUSH 2
FLUSH 3
FLUSH 1
FLUSH 2
FLUSH 3
MUSHROOM TOP READINGS
MUSHROOM SIDE READINGS
no bruising
10 sec bruising

Fig. 13

A SUMMARY OF THE EFFECT OF STORAGE (5C) ON THE b VALUE (YELLOWING) OF BRUISED AND UNBRUISED MUSHROOMS (top and side readings)

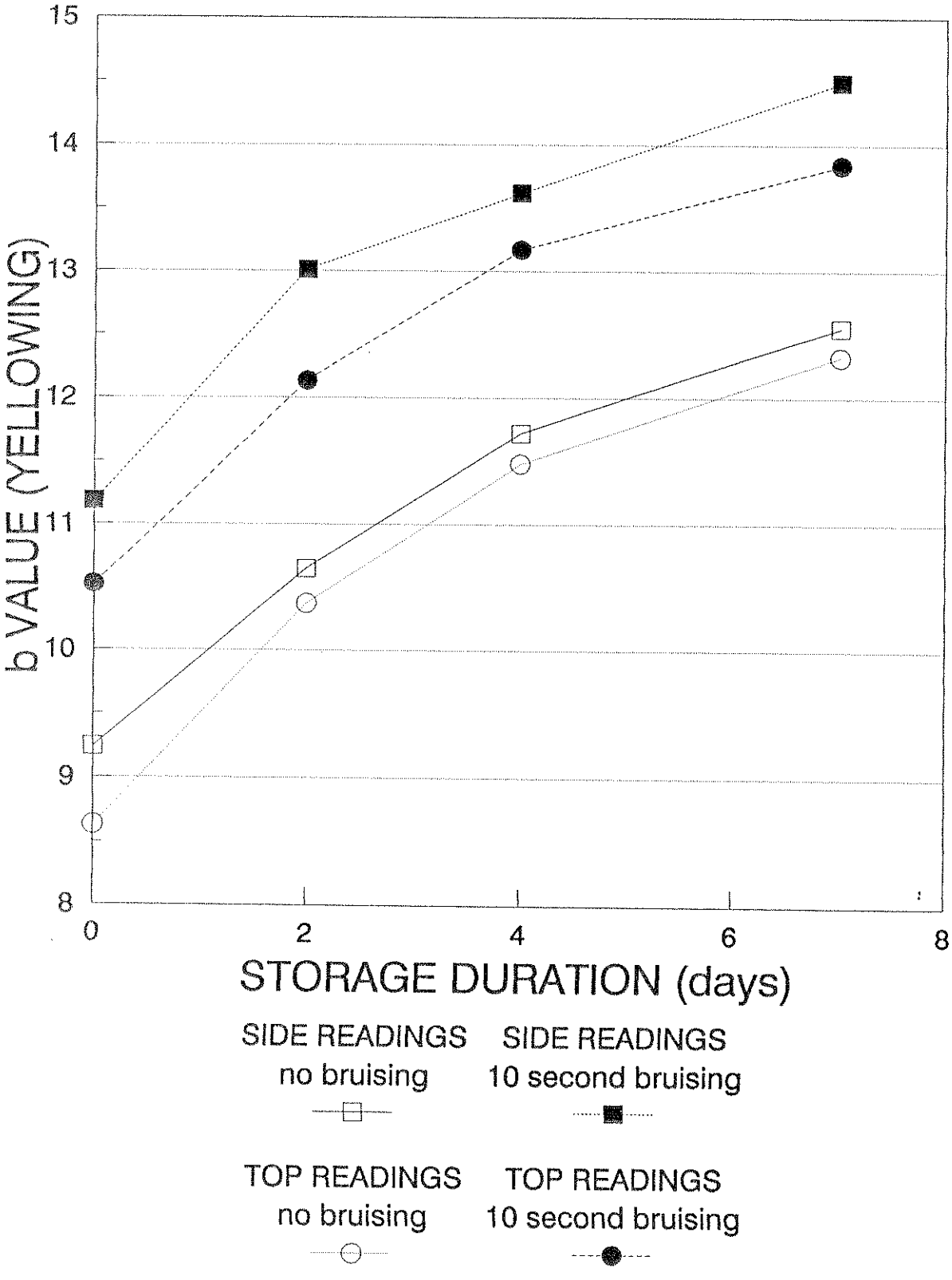


Fig. 14

EFFECT OF STORAGE (5C) ON THE b VALUE (YELLOWING) OF UNBRUISED MUSHROOM TOPS

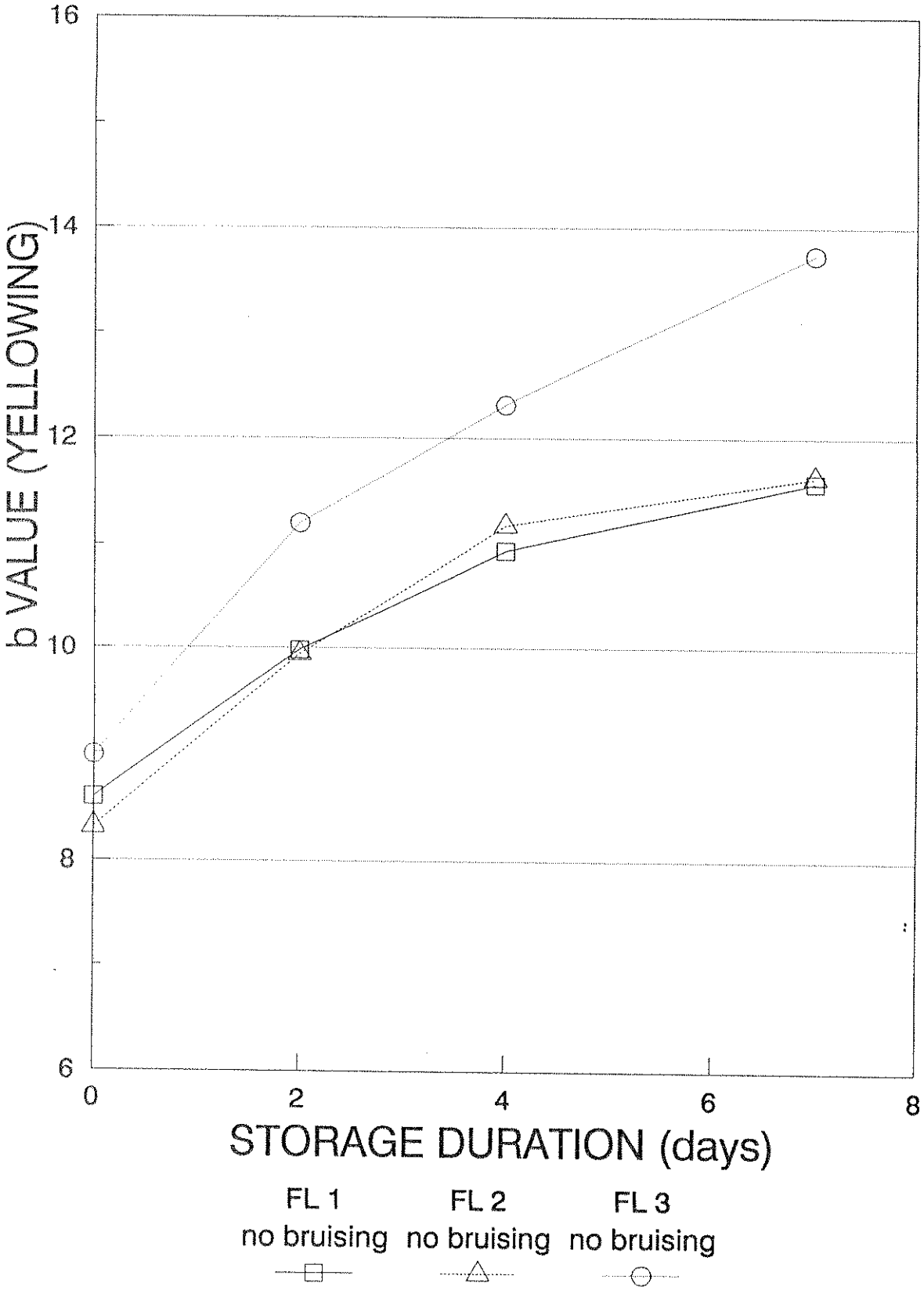


Fig. 15

EFFECT OF STORAGE (5C) ON THE b VALUE (YELLOWING) OF BRUISED MUSHROOM TOPS (10sec bruisung)

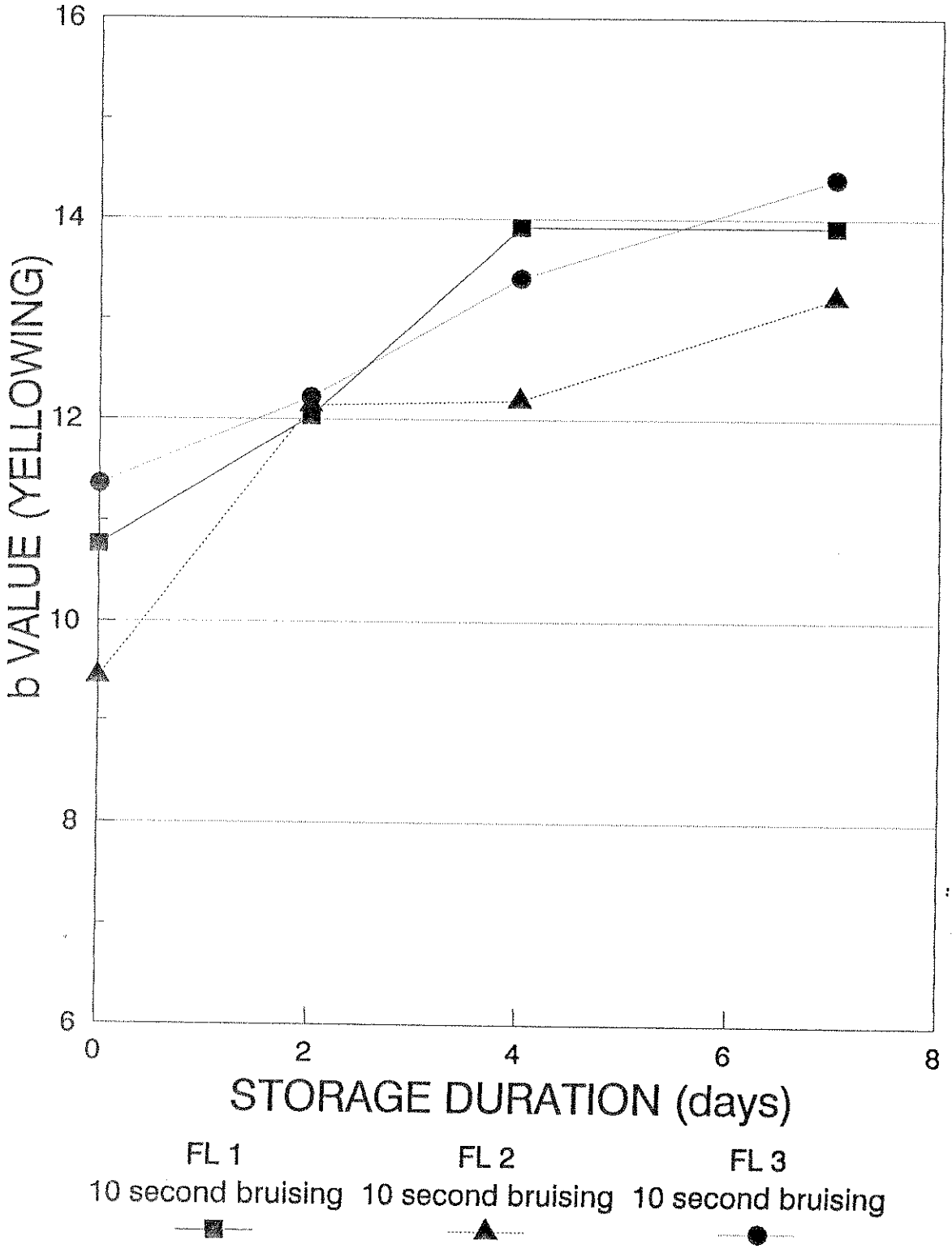


Fig. 16

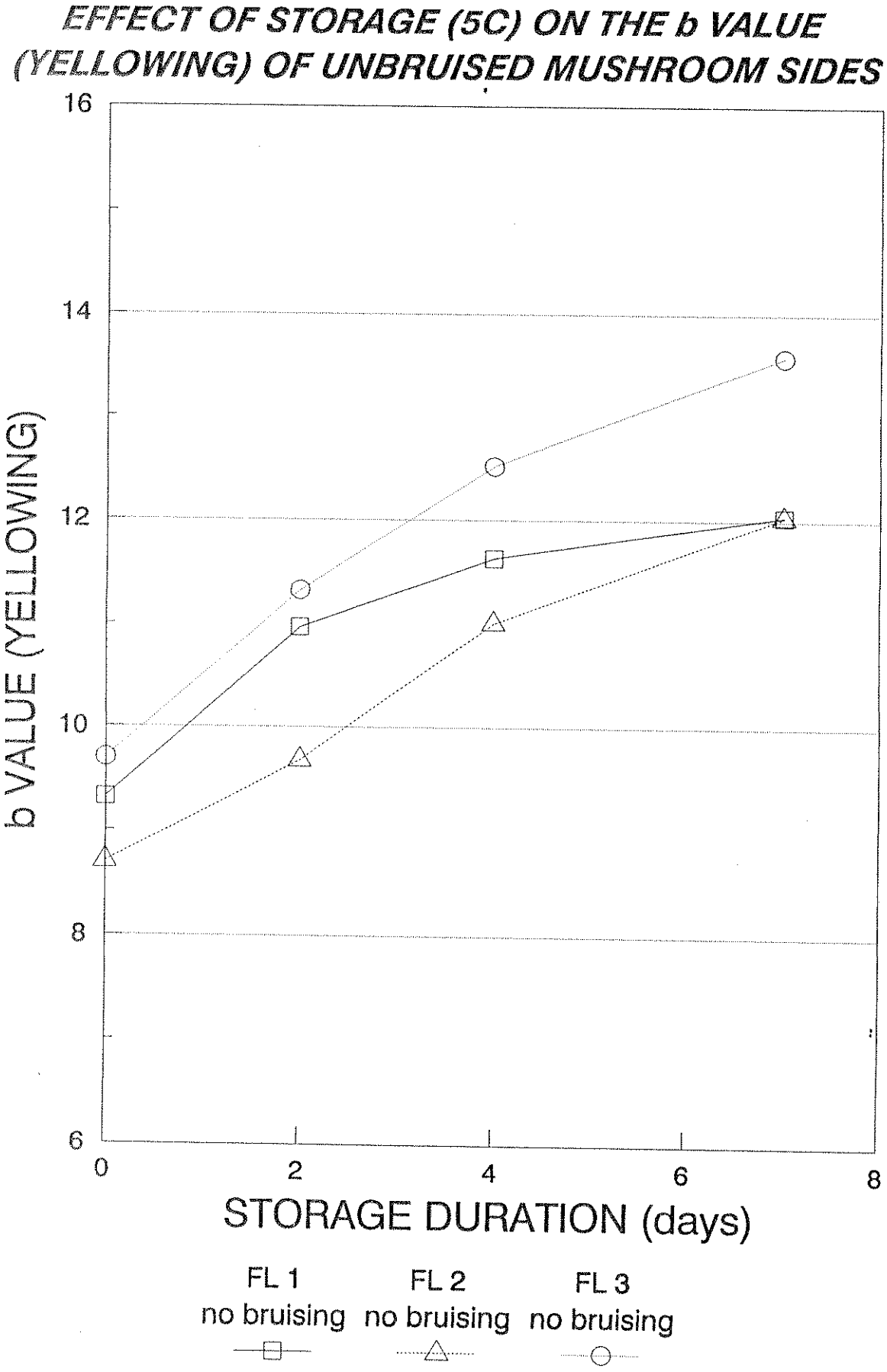

EFFECT OF STORAGE (5C) ON THE b VALUE
(YELLOWING) OF UNBRUISED MUSHROOM SIDES
b VALUE (YELLOWING)
16
14
12
10
8
6
0
2
4
6
8
STORAGE DURATION (days)
FL 1
no bruising
FL 2
no bruising
FL 3
no bruising

Fig. 17

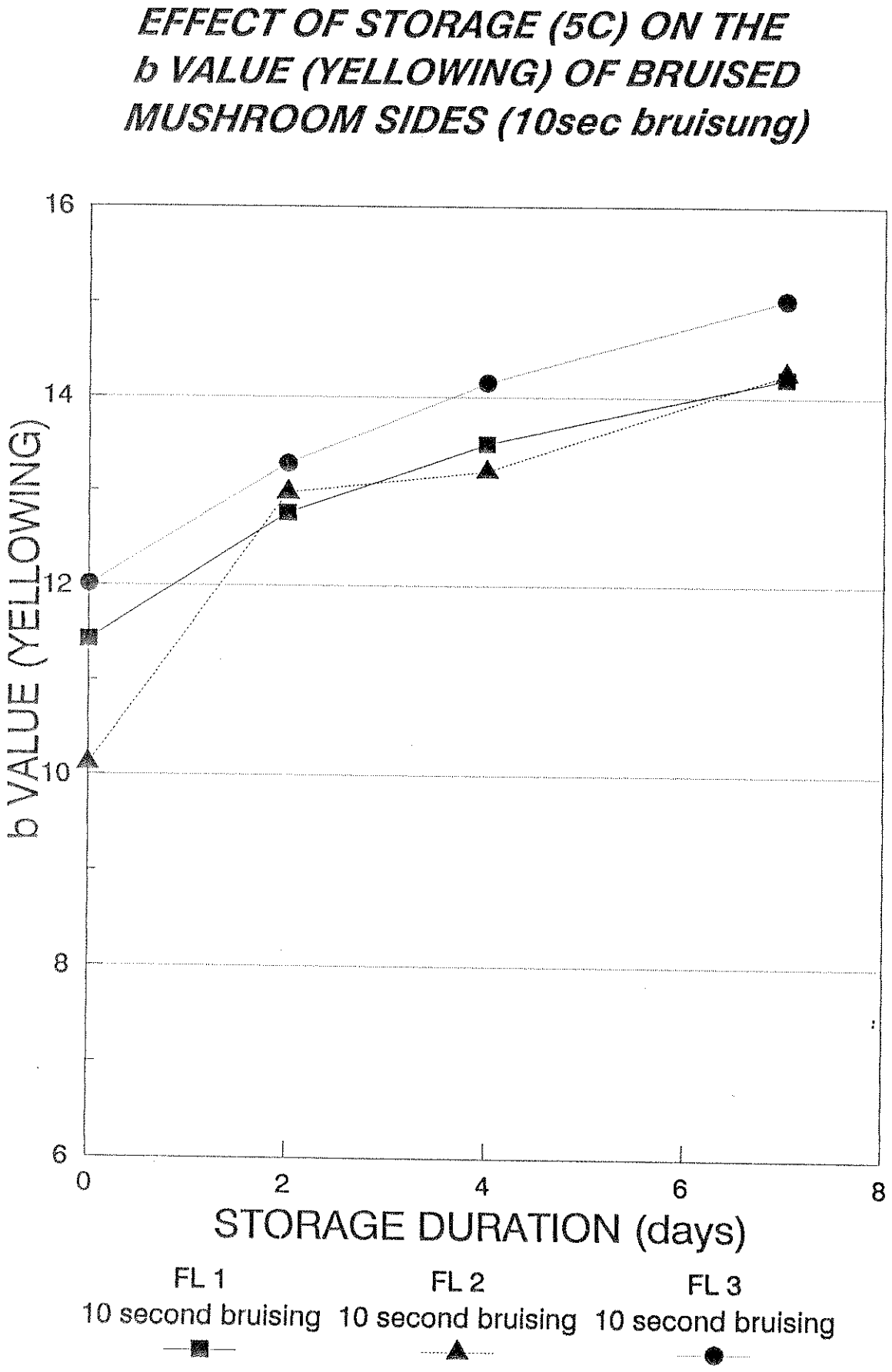

EFFECT OF STORAGE (5C) ON THE
b VALUE (YELLOWING) OF BRUISED
MUSHROOM SIDES (10sec bruisung)
16
14
12
10
8
6
b VALUE (YELLOWING)
0
2
4
6
8
STORAGE DURATION (days)
FL 1
10 second bruising
FL 2
10 second bruising
FL 3
10 second bruising

Fig. 18

A SUMMARY OF THE EFFECT OF STORAGE (18C) ON THE b VALUE (YELLOWING) OF BRUISED AND UNBRUISED MUSHROOMS (top and side readings)

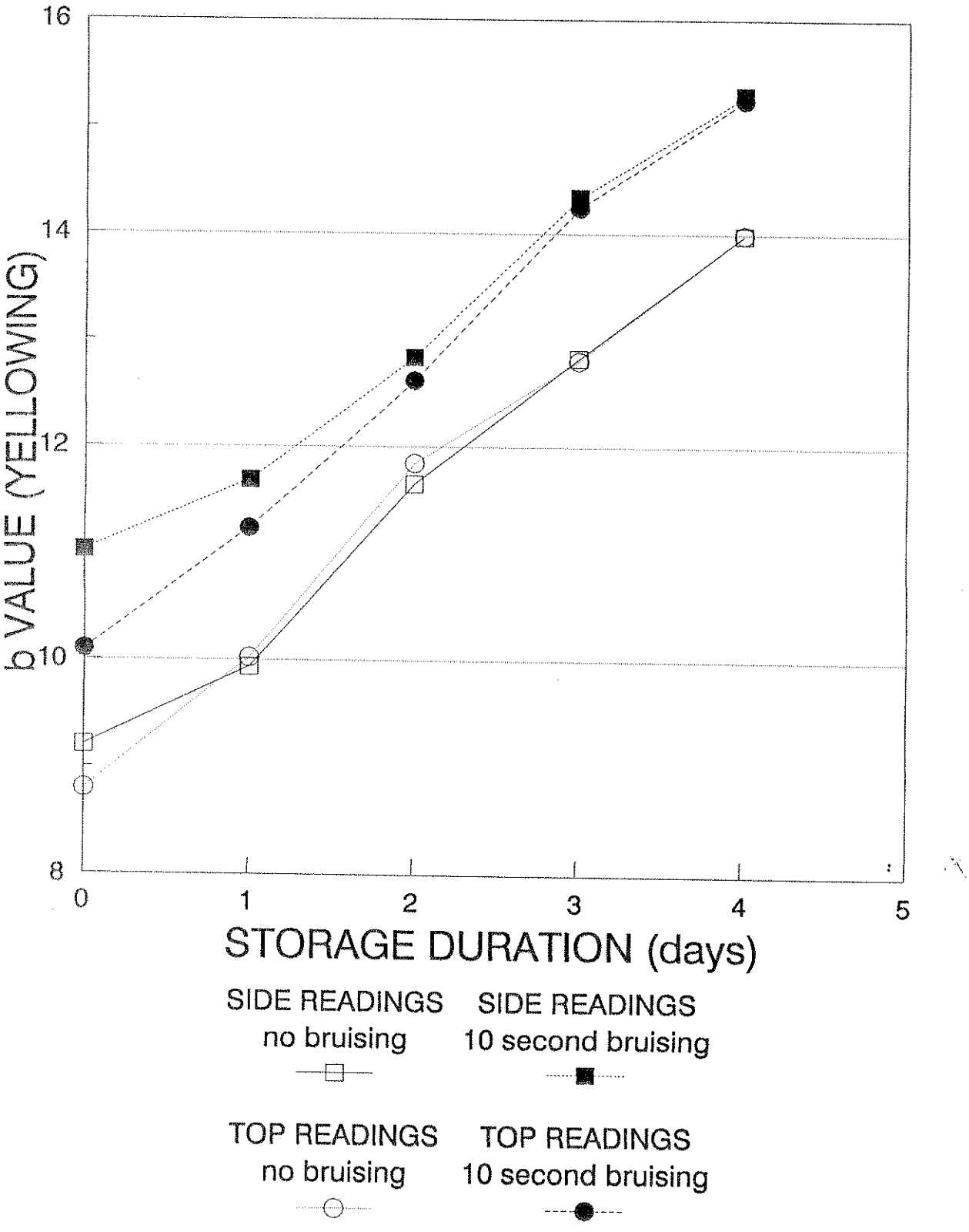


Fig. 19

EFFECT OF STORAGE (18C) ON THE b VALUE (YELLOWING) OF UNBRUISED MUSHROOM TOPS

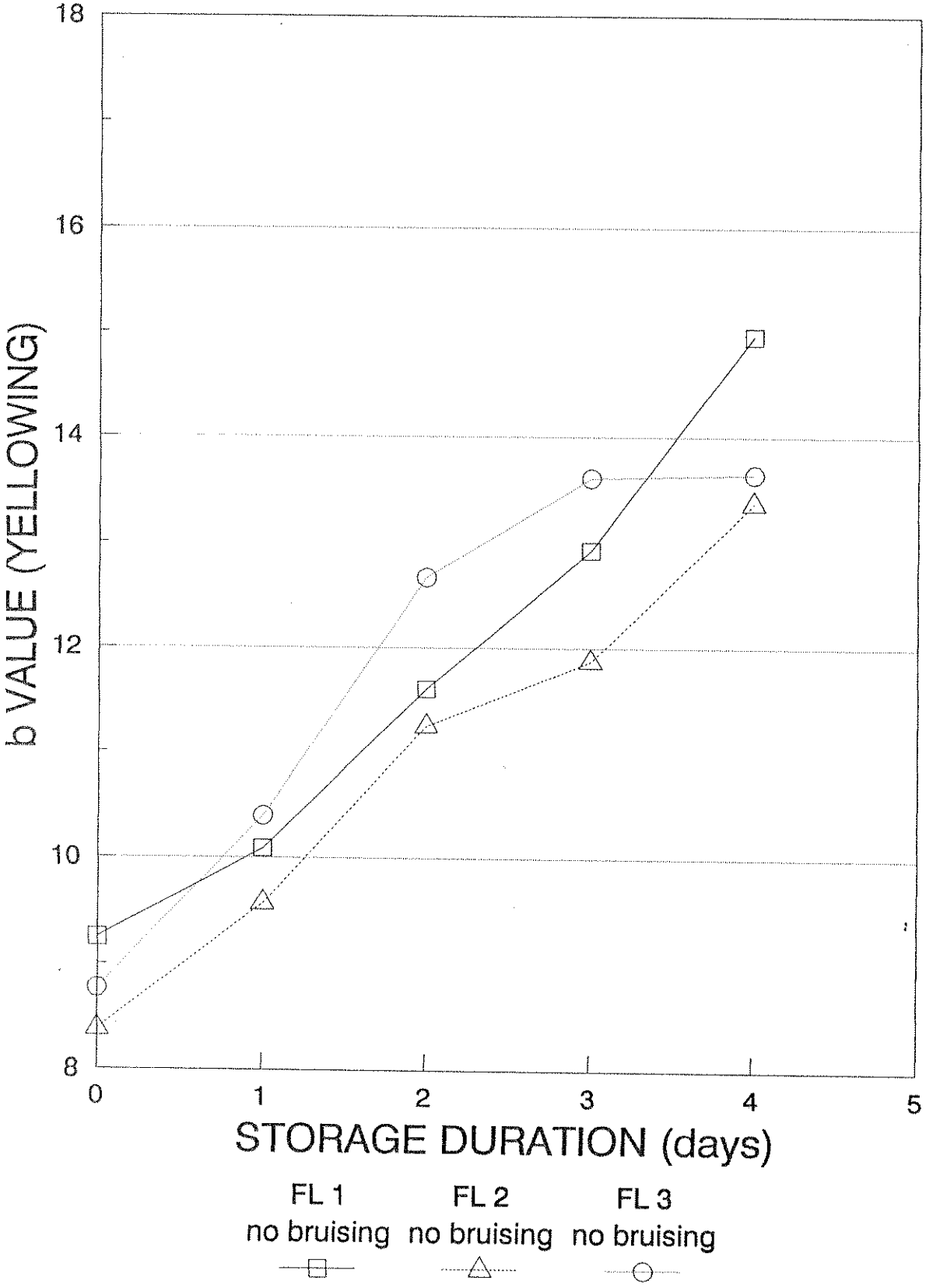


Fig. 20

EFFECT OF STORAGE (18C) ON THE b VALUE (YELLOWING) OF BRUISED MUSHROOM TOPS (10sec bruisung)

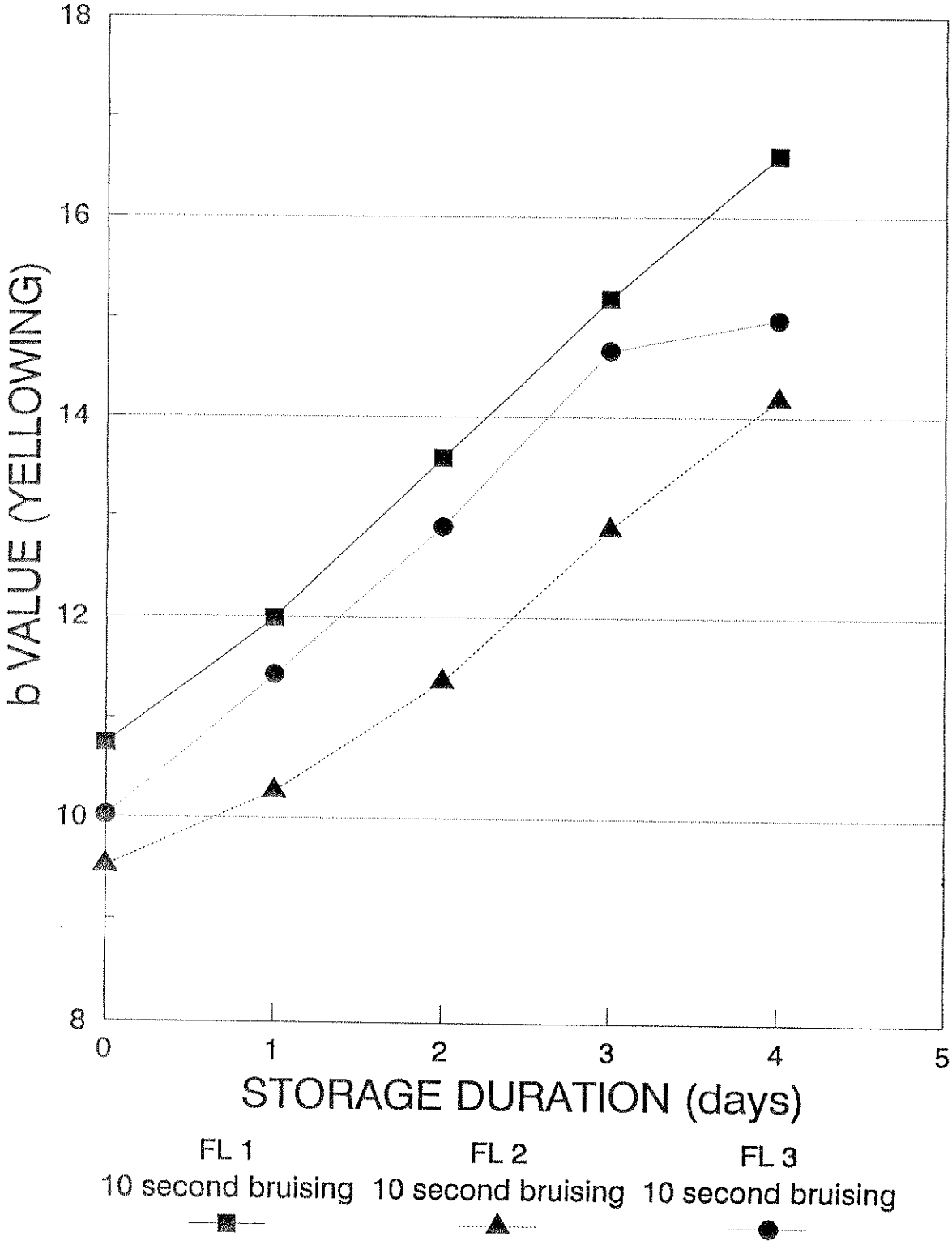


Fig. 21

EFFECT OF BRUISING ON THE b VALUE (YELLOWING) OF MUSHROOM TOPS STORED AT 18C

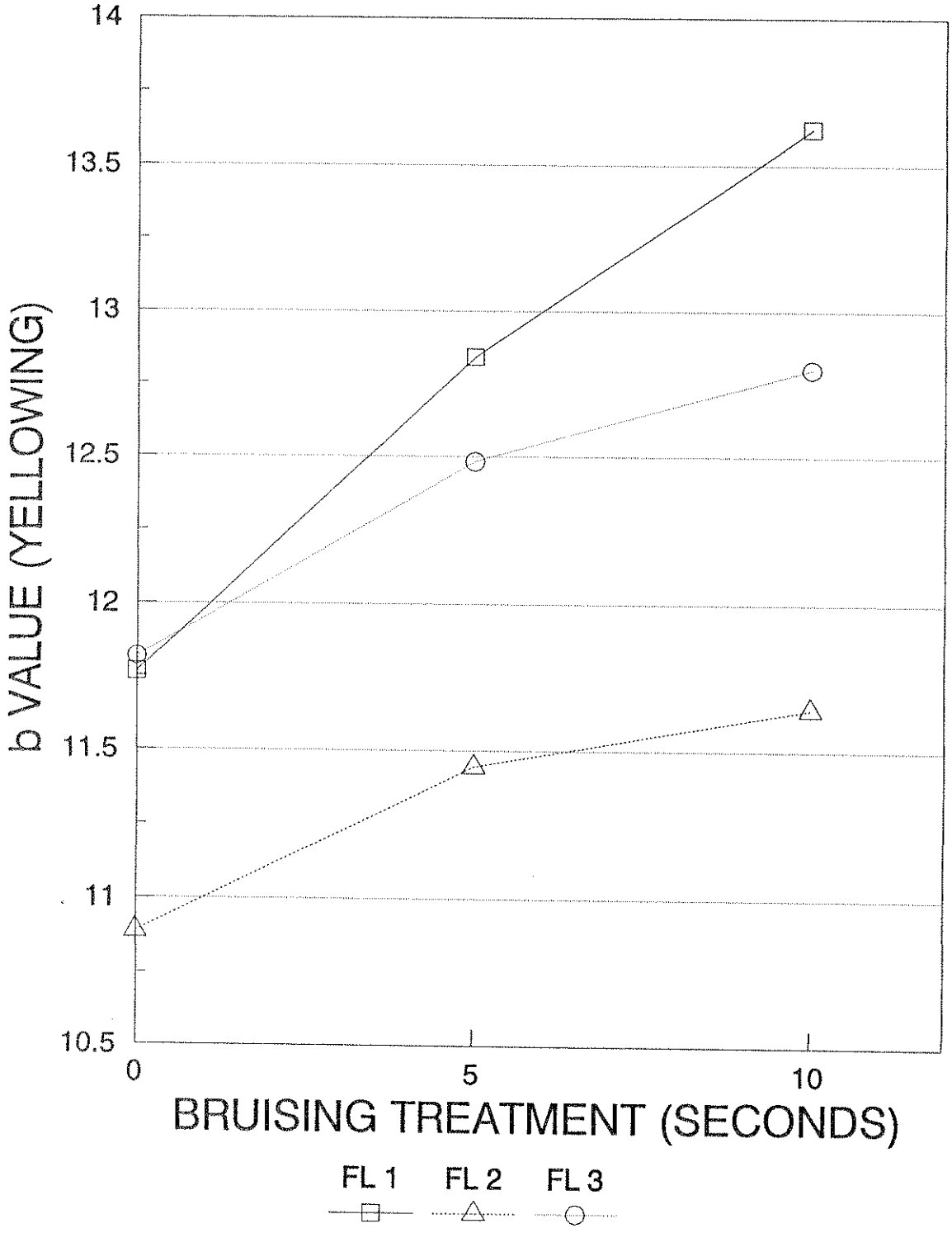


Fig. 22

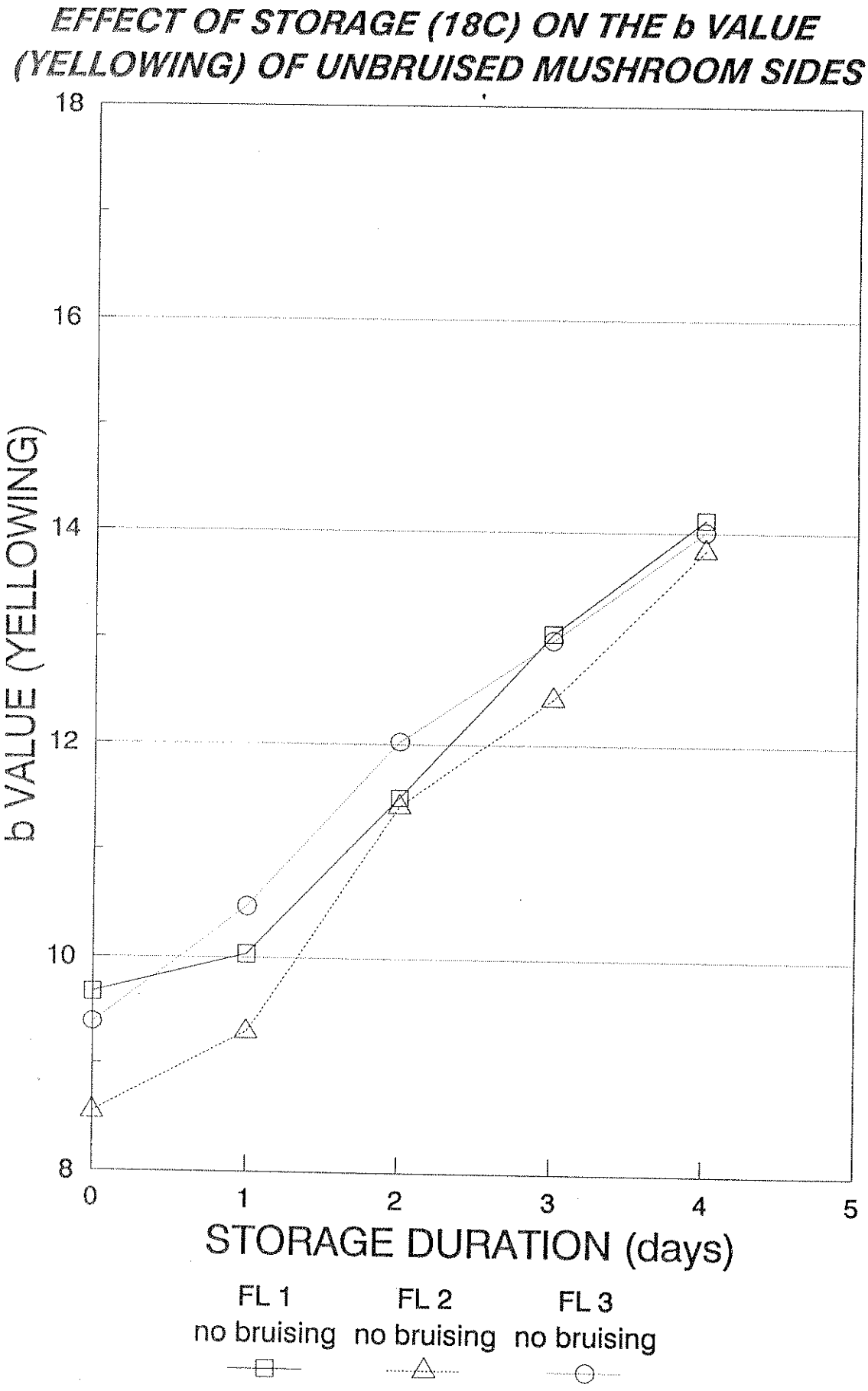
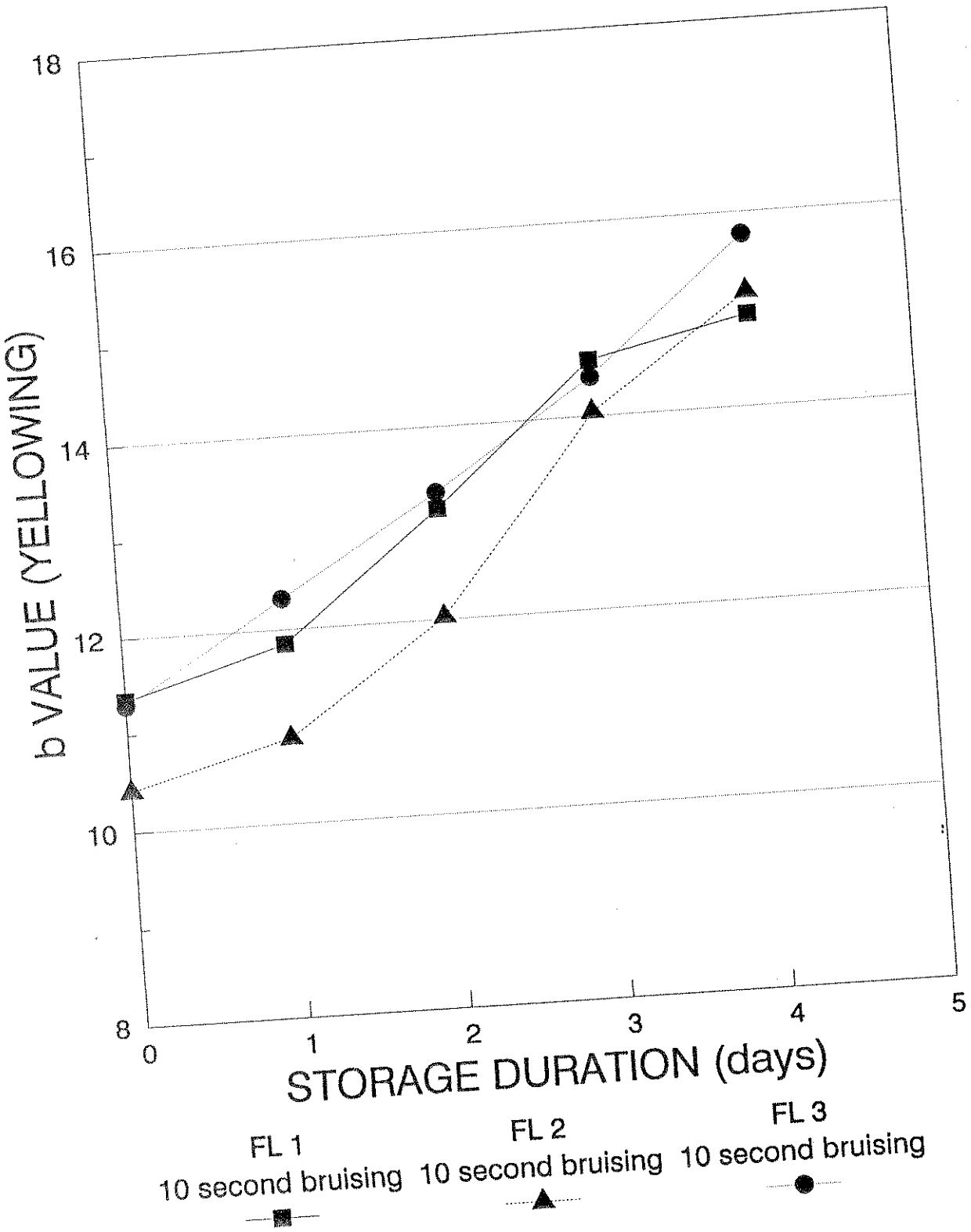

EFFECT OF STORAGE (18C) ON THE b VALUE
(YELLOWING) OF UNBRUISED MUSHROOM SIDES
b VALUE (YELLOWING)
18
16
14
12
10
8
0
1
2
3
4
5
STORAGE DURATION (days)
FL 1
no bruising
FL 2
no bruising
FL 3
no bruising

Fig. 23

EFFECT OF STORAGE (18C) ON THE b VALUE (YELLOWING) OF BRUISED MUSHROOM SIDES (10sec bruisung)



MUSHROOM DEVELOPMENT

Fig. 24

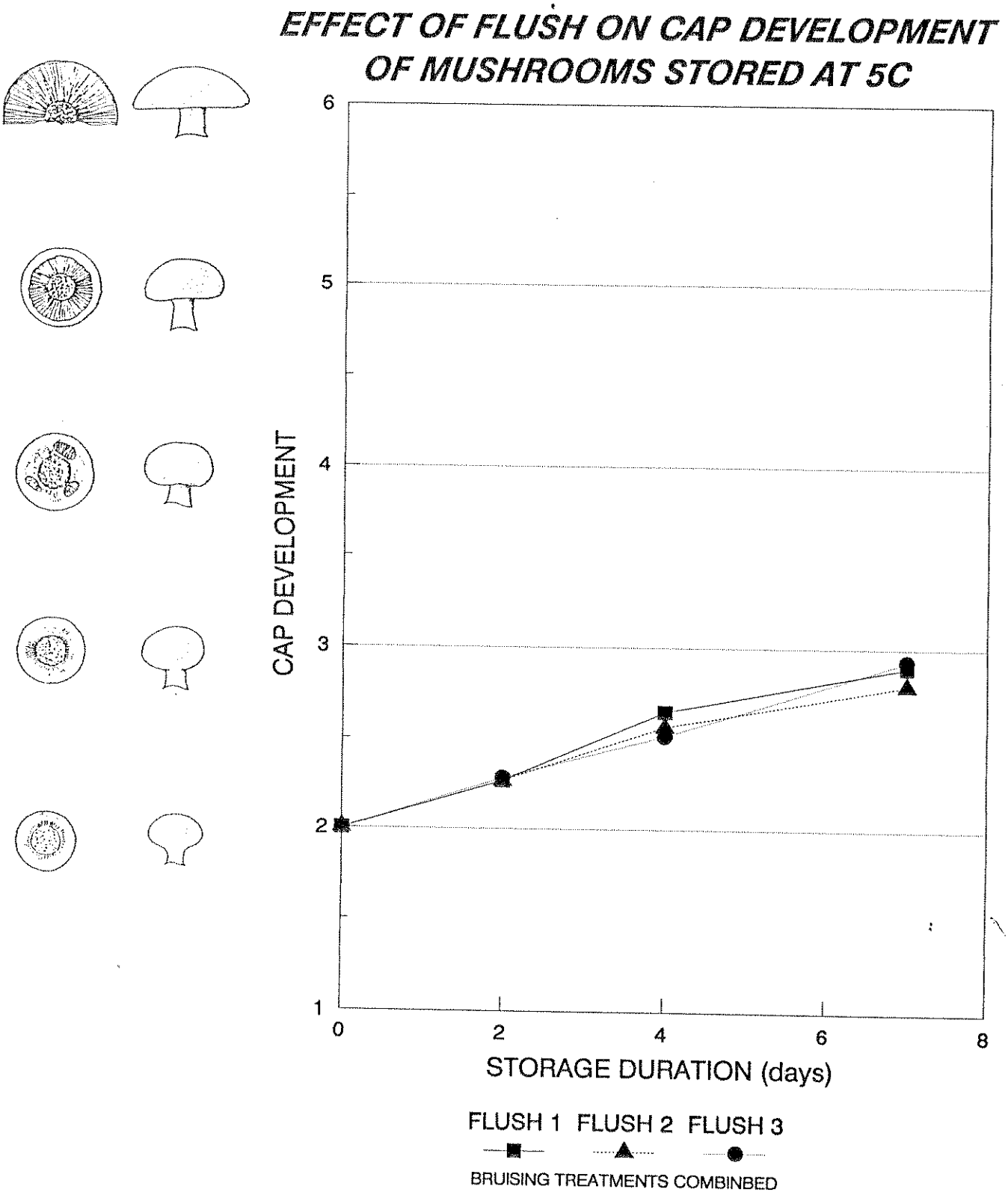
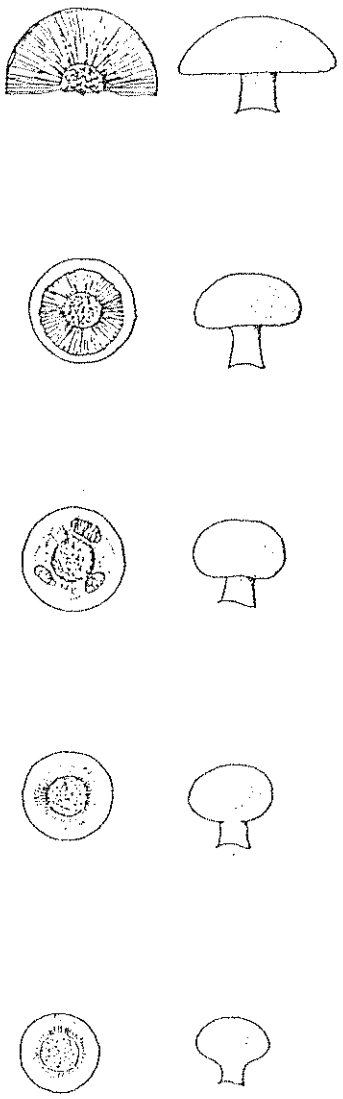

EFFECT OF FLUSH ON CAP DEVELOPMENT
OF MUSHROOMS STORED AT 5C
CAP DEVELOPMENT
6
5
4
3
2
1
0
2
4
6
8
STORAGE DURATION (days)
FLUSH 1 FLUSH 2 FLUSH 3
BRUISING TREATMENTS COMBINBED

Fig. 25



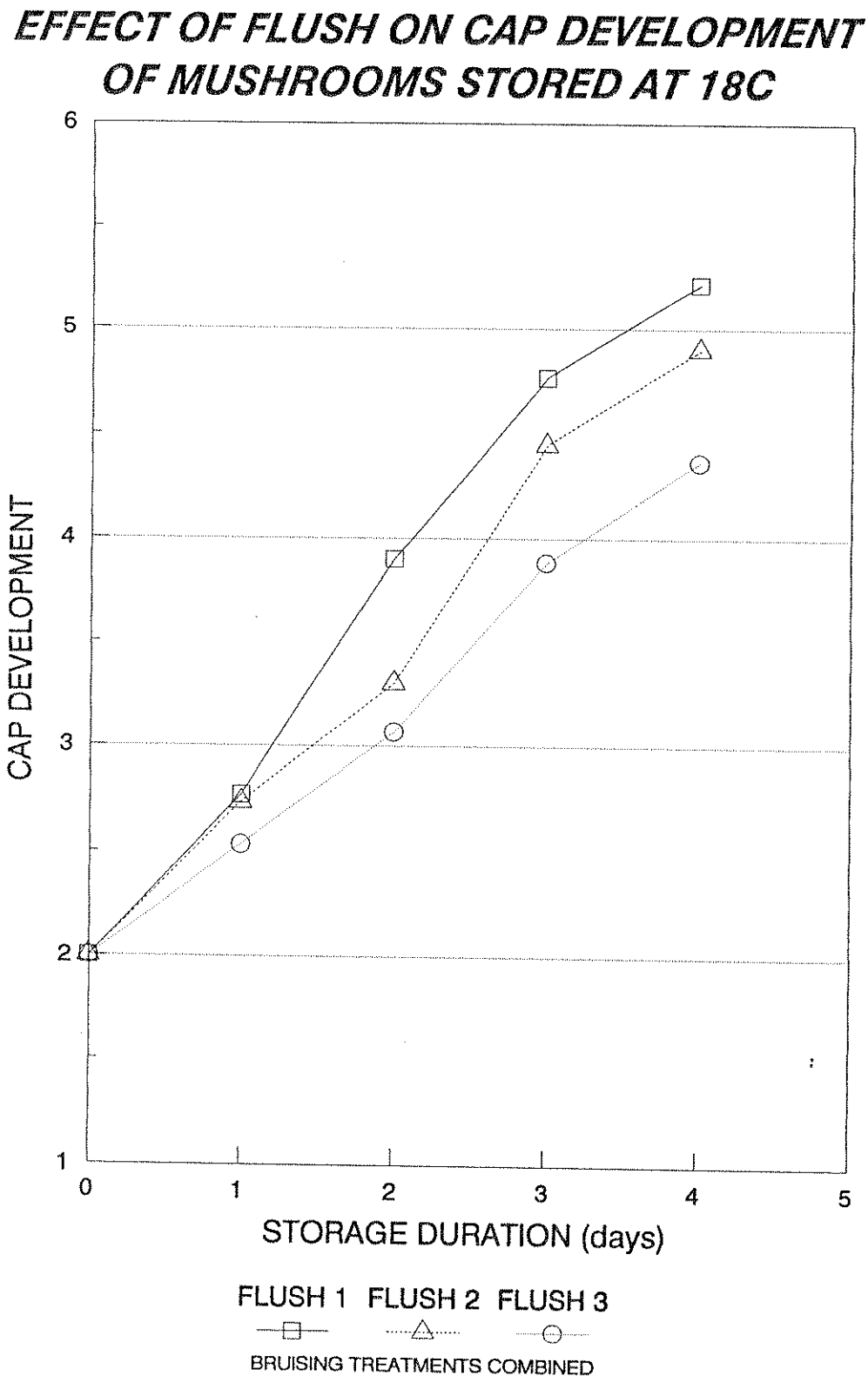
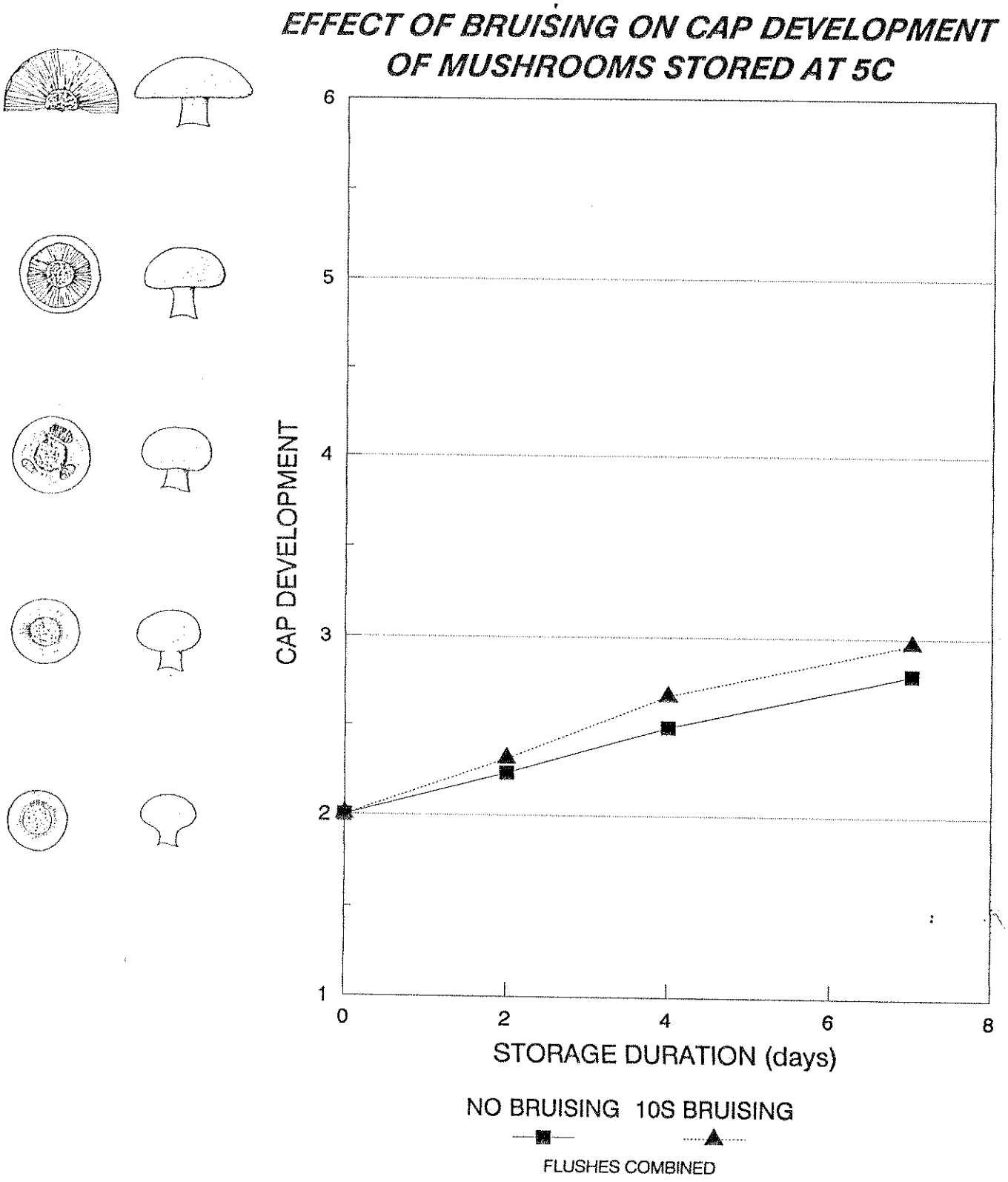

EFFECT OF FLUSH ON CAP DEVELOPMENT
OF MUSHROOMS STORED AT 18C
CAP DEVELOPMENT
6
5
4
3
2
1
0
1
2
3
4
5
STORAGE DURATION (days)
FLUSH 1 FLUSH 2 FLUSH 3
BRUISING TREATMENTS COMBINED

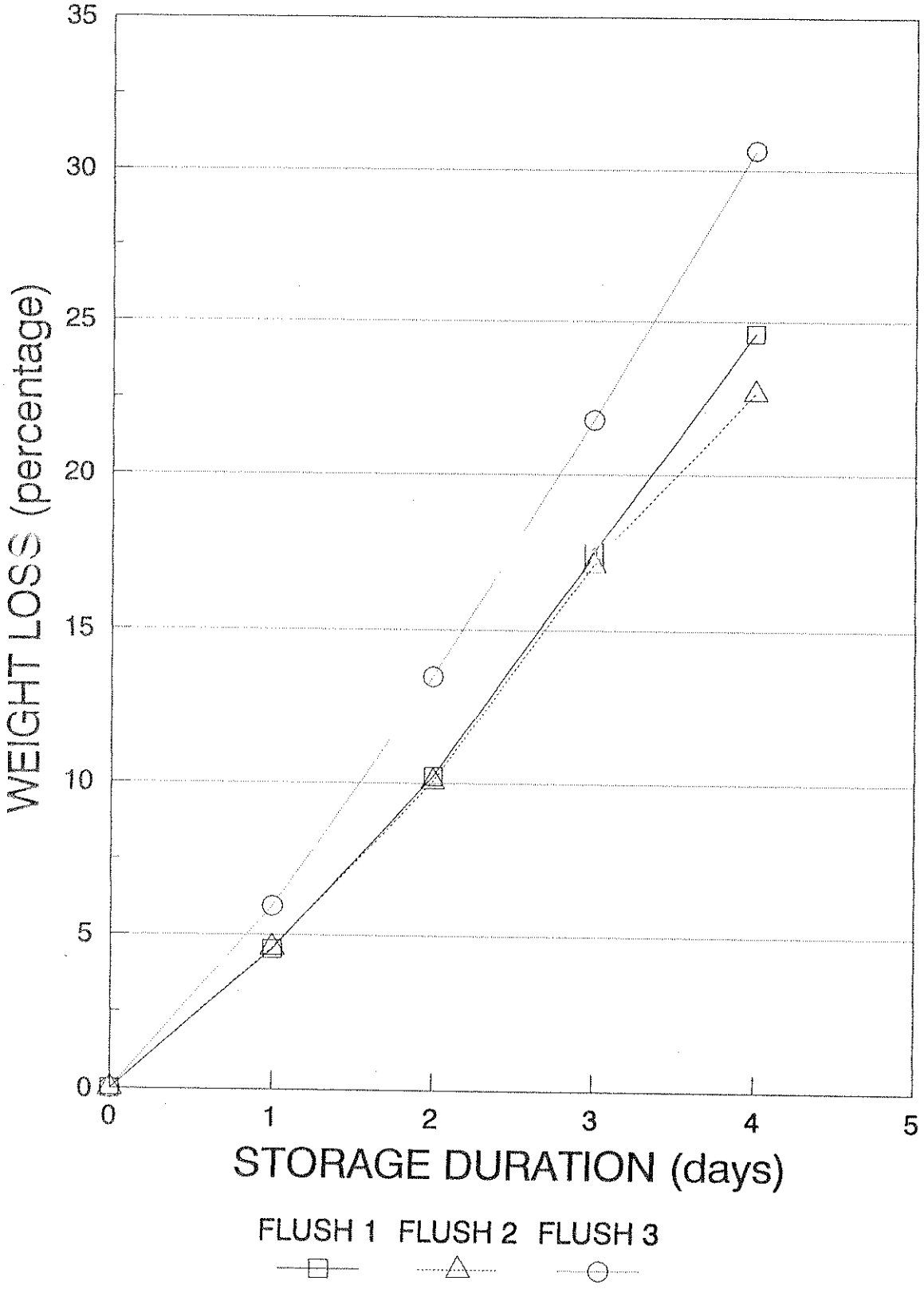
Fig. 26


EFFECT OF BRUISING ON CAP DEVELOPMENT
OF MUSHROOMS STORED AT 5C
CAP DEVELOPMENT
6
5
4
3
2
1
0
2
4
6
8
STORAGE DURATION (days)
NO BRUISING
10S BRUISING
FLUSHES COMBINED

MUSHROOM WEIGHT LOSS

Fig. 29

EFFECT OF FLUSH ON THE WEIGHT LOSS OF MUSHROOMS STORED AT 18C



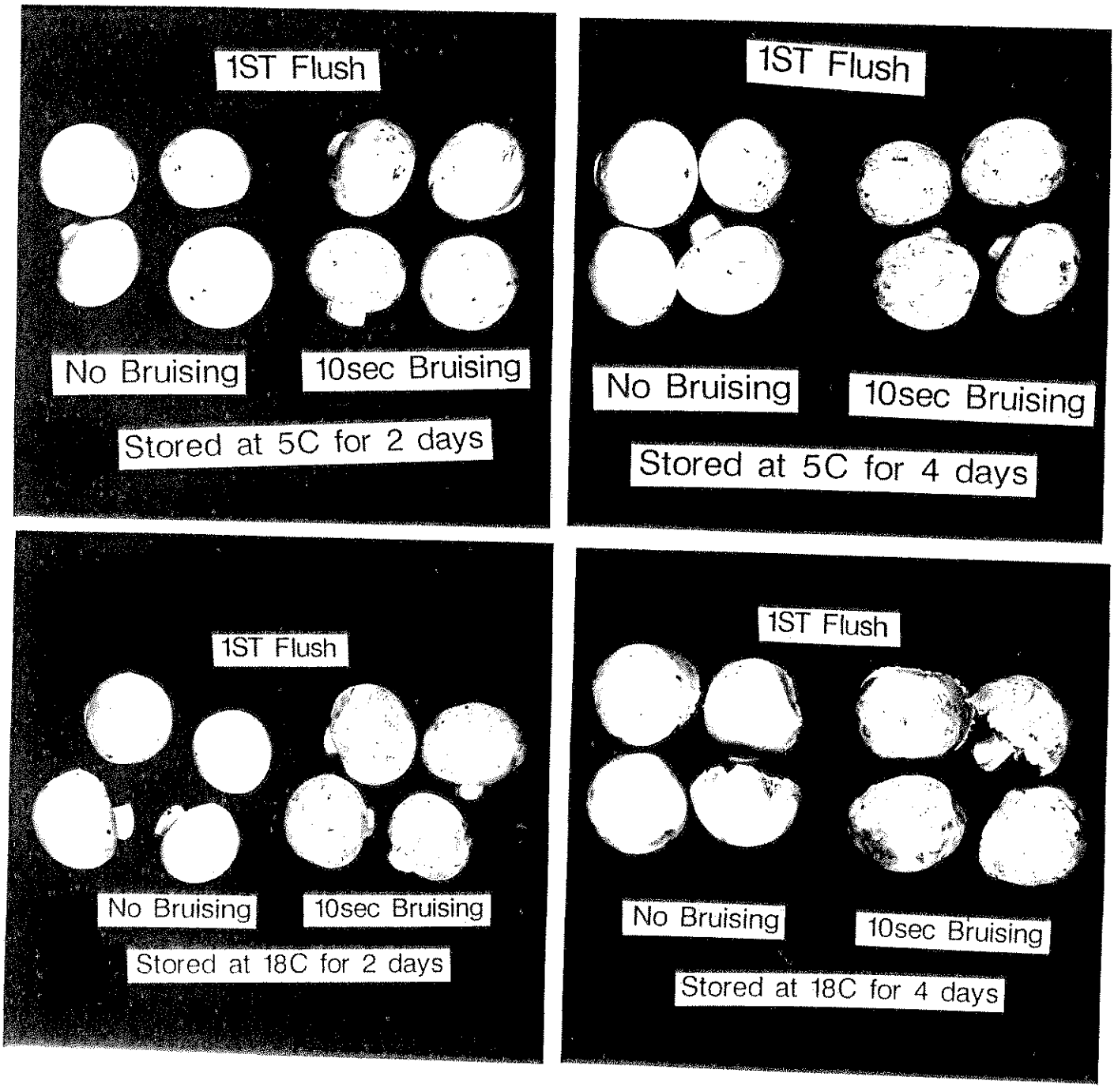
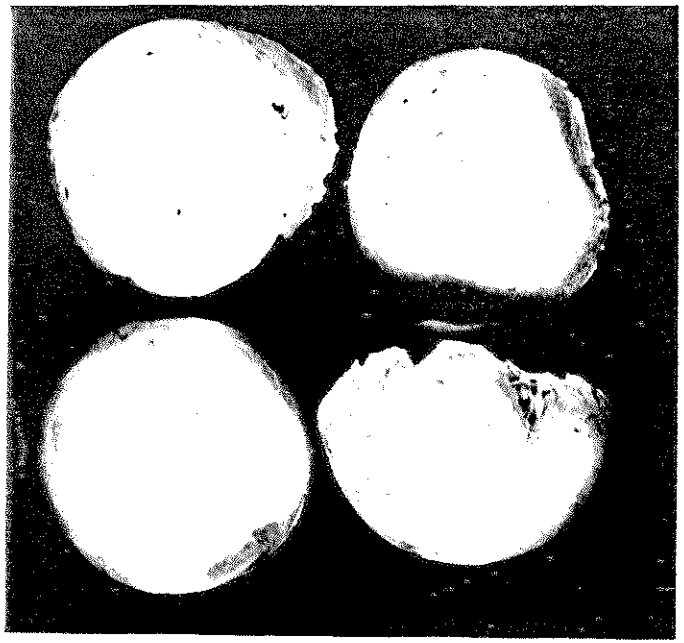
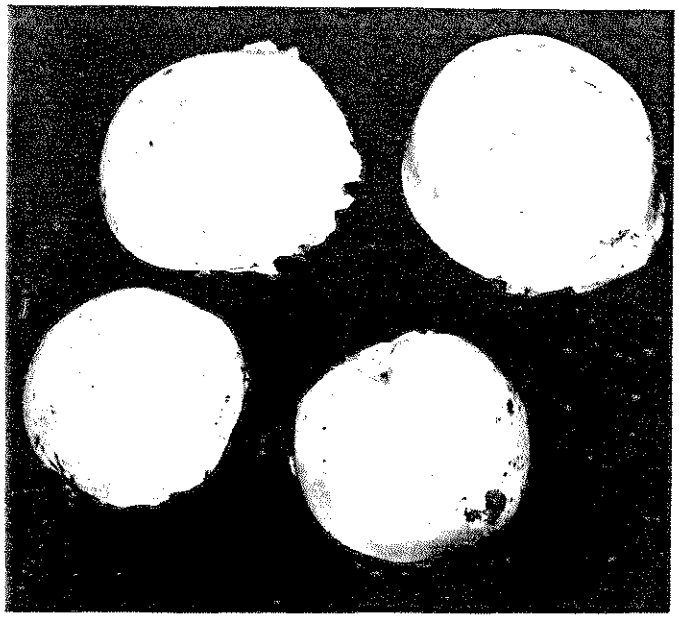


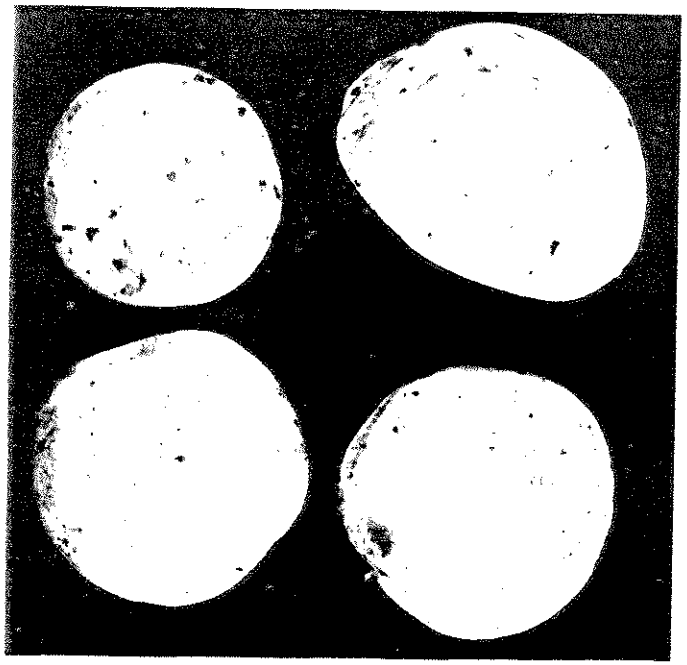
Photo 1, Bruised and unbruised first flush mushrooms after 2 and 4 days storage at 5°C and 18°C.



Flush 1



Flush 2



Flush 3

Photo 2, Unbruised first, second and third flush mushrooms after 4 days storage at 18°C

Fig. 28

EFFECT OF FLUSH ON THE WEIGHT LOSS OF MUSHROOMS STORED AT 5C

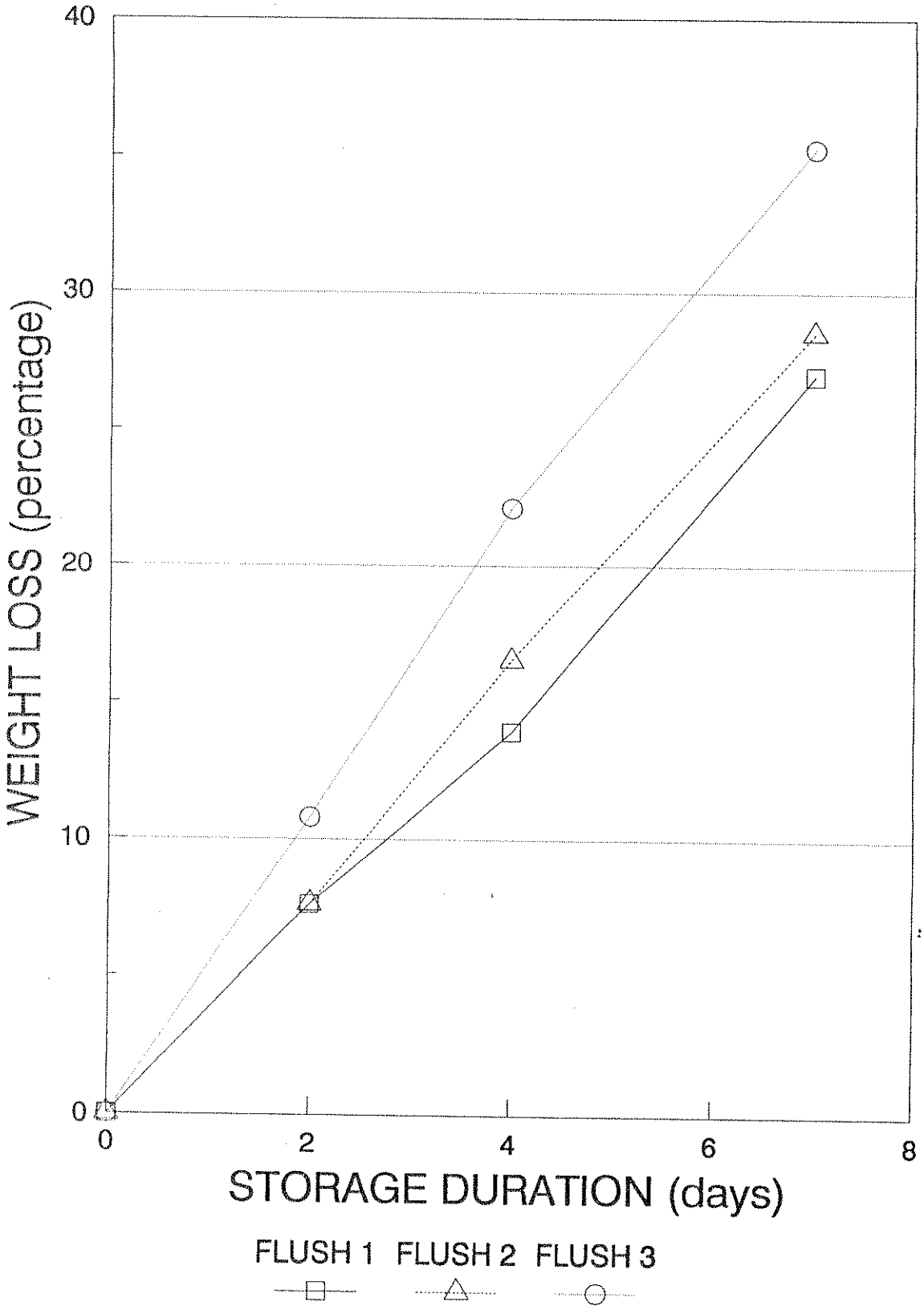
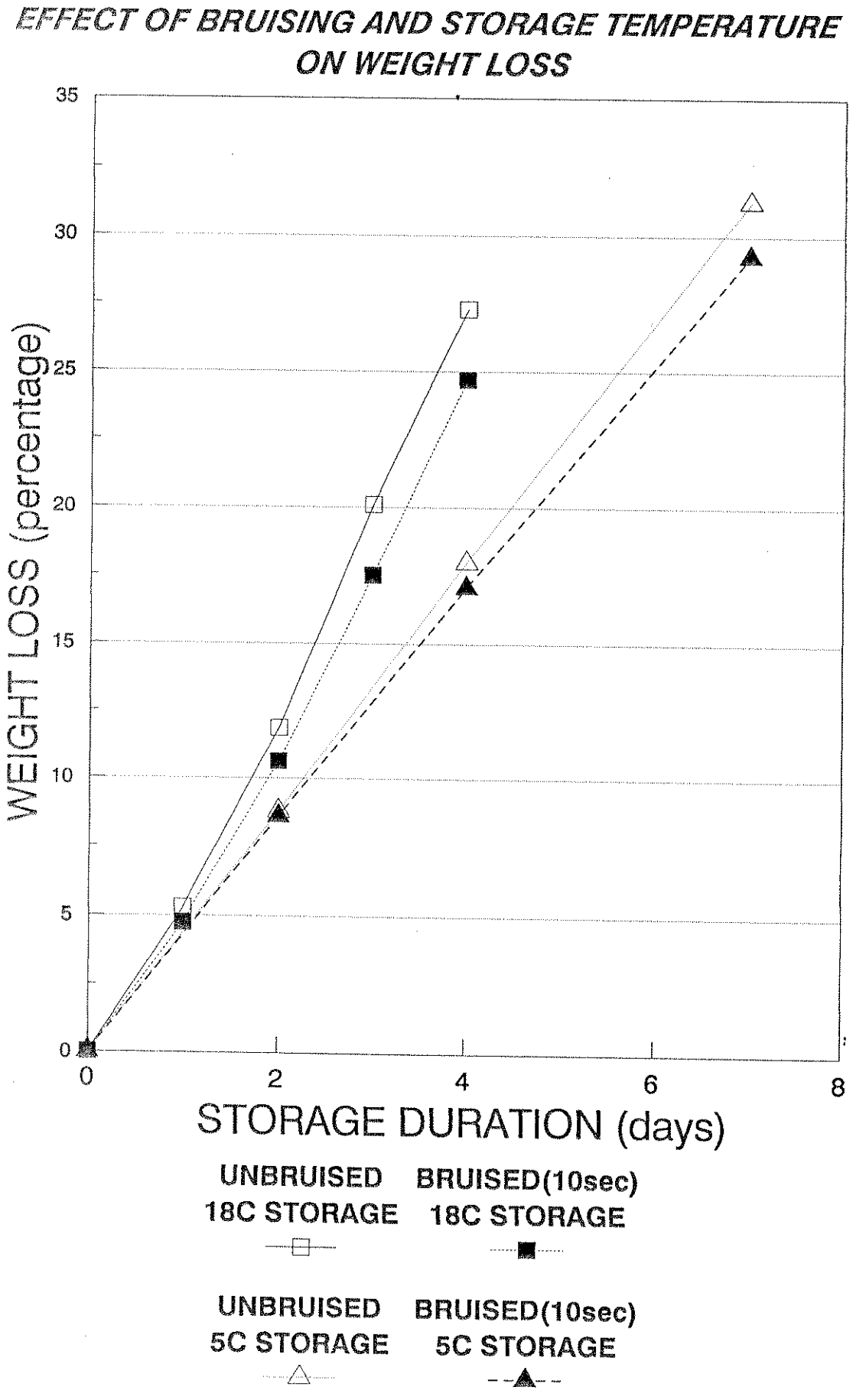


Fig. 27


EFFECT OF BRUISING AND STORAGE TEMPERATURE ON WEIGHT LOSS
WEIGHT LOSS (percentage)
35
30
25
20
15
10
5
0
0
2
4
6
8
STORAGE DURATION (days)
UNBRUISED 18C STORAGE
BRUISED(10sec) 18C STORAGE
UNBRUISED 5C STORAGE
BRUISED(10sec) 5C STORAGE