THE EFFECT OF AGING TIME AND TEMPERATURE ON VACUUM PACKAGED BEEF[a/]

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Shelf life of fresh meat has been a perpetual problem in the meat industry. Every operation of the meat business focuses its attention on retarding spoilage and reducing moisture loss. Many of the limitations of distribution and marketing have resulted from shelf life problems. Although temperature and humidity control allow extended shelf life, the fundamental prerequisite of prolonged shelf life is that the product entering the system be of high quality. Therefore by supplementing sanitation, temperature and humidity control with a controlled environment through vacuum packaging, fresh meat shelf life could be extended. Reduced oxygen concentration or vacuum packaging as is commonly known, has been used extensively and offers a tremendous potential in meat packing. The objectives of this study were to obtain time/temperature relationships with respect to the physical, chemical and organoleptic changes that take place during the aging of vacuum packaged beef.

MATERIALS AND METHODS

One steer and two vasectomized bulls, weighing 410, 600, and 610 Kg. respectively, and of similar age (20 to 24 months) were obtained from the University of Guelph herd. The animals were from similar managerial background and were slaughtered in accordance with commercially accepted practices. After a 24 hour chill period at a temperature of 1 C, the L. dorsi and B. femoris muscles were dissected from both sides.

The L. dorsi muscles were divided into 10 portions, and the B. femoris muscles were divided into 7 portions. Treatments were randomly allotted to these samples. The L. dorsi muscle was held at 1.7 C for 6, 11 and 21 days; at 7.2 C for 4, 6 and 11 days; at 12.8 C for 2, 3, and 4 days. One sample obtained one day post-mortem was used as a control for initial readings. The B. femoris muscle was held at 1.7 C for 6, 11 and 21 days; at 7.2 C for 4, 6 and 11 days. One sample obtained one day post-mortem was used as a control for initial readings. All the treatments with the exception of the control were vacuum packaged in an oxygen and water impermeable bag (Saran, Polyvinylidene Chloride) sealed and heat shrunk. Packaged samples were labelled according to their respective treatments and placed in coolers adjusted to the respective temperatures.

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The effect of aging beef muscle at different times and temperature was evaluated in terms of the percent shrinkage, brightness of colour, the percent free water, pH, the percents water and salt soluble proteins, palatability panel evaluation, and the Warner-Bratzler shear test. The percent shrinkage was calculated as the difference between the initial and final weight divided by the initial weight. Initial and final (30 minutes after exposure to air) color readings were taken on a photo-electric brightness meter (Ernst Schutt jun. Laboratories, Gottingen, West Germany). These results were reported as the percent change in reflectance. The percent free water was obtained following the method of Wierbicki and Deatherage (1958). The initial and final pH of each sample were taken in duplicate using a Beckman-Zeromatic pH meter with glass electrodes. A ten-gram ground meat sample was first extracted with 100 ml. of water and then re-extracted with 100 ml. of 0.6 M KCl solution to obtain the water soluble and salt proteins respectively as determined by the Biuret method (Gornall et al. 1949, and Layne, 1960).

Two 1-inch steaks from each experimental sample were broiled in a preheated oven to an internal temperature of 69.5 ± 1.5 C. One steak was used for a palatability panel evaluation of flavor, juiciness, tenderness, and overall satisfaction using the nine point Hedonic Scale method (Peryam and Pilgrim, 1957). A six member panel was used. Four 1.27 cm. cores were taken from the central portion of the second steak in a medial-lateral line and a recording Warner-Bratzler shear apparatus (Voissey et al. 1965) was used to obtain shear values which were expressed in kilograms per 1.27 cm. core.

This study was conducted according to an incomplete factorial experiment with each animal serving as a replication. An attempt to fit a regression model was not successful because of the limited muscle size restricting the number and kind of treatment combinations used. Therefore, to provide some measure of statistical confidence, the maximum least significant range (L.S.R.) of Duncan's new multiple range test (Steel and Torrie, 1960) was used. The maximum L.S.R. was used to provide a base above which all responses were considered to be significantly greater ($P < .05$) than the initial condition.

RESULTS AND DISCUSSION

Only the data for the L. dorsi muscle is included, in graphic form (Figures 1, 3, 5, 7, 9, 11, 13, 15, 17, and 19), in this paper. However, reference is made to selected data from the B. femoris muscle for comparative purposes.

Percent shrinkage (Figs. 1 and 2): There was a general increase for both muscles with longer periods of storage. The maximum losses obtained for the L. dorsi and B. femoris muscles stored for 21 days

at 1.7 C was 1.1% and 2.9% respectively. It appeared that minimum shrinkage can be obtained by either keeping samples at a low temperature (1.7 C) for a period not exceeding two weeks or at a higher temperature not exceeding four days.

Color changes (Figs. 3 and 4): The B. femoris muscle exhibited greater changes (3.8% at 21 days) than did the L. dorsi muscle (1.0% at 21 days). Color was acceptable for the L. dorsi for all treatments. The only significant change for the B. femoris was the 21 days treatment at 1.7 C. Generally the vacuum packaging of both muscles and then subjecting them to different temperatures and aging periods were not detrimental to fresh meat color development.

pH (Figs. 5 and 6): Initial mean pH values (24 hours post-mortem) for the L. dorsi and B. femoris muscles were 5.64 and 5.63 respectively. The pH generally increased up to six days and remained relatively constant at about 5.75 to 5.80 for the L. dorsi muscle. With the B. femoris muscle there was an increase in pH up to six days and a slight drop at 11 days. At 21 days at 1.7 C there was a slight increase up to 5.79.

Percent Free Water (Figs. 7 and 8): The percent free water was about 44% for both muscles one day post-mortem. There was an apparent decrease at different rates at the different temperatures up to six days of storage and then there appeared an increase with the extended storage periods. The B. femoris muscle appeared to have a higher percent free water than the L. dorsi muscle.

Water and salt soluble protein (Figs. 9 and 10): At one day post-mortem water and salt soluble protein concentrations were low for both muscles. The water soluble protein content generally increased, but at 1.7 C after 11 days there was a slight decrease. The salt soluble protein content increased but then declined. The rates of increase and decrease varied depending on temperature.

Flavor (Figs. 11 and 12): Treatments had no significant effect in improving the flavor scores of the two muscles. However, the L. dorsi showed the greatest improvement.

Juiciness (Figs. 13 and 14): Juiciness scores during aging of the L. dorsi muscle was improved. Aging at 12.8 C for three days and at 1.7 C for 21 days gave a similar score of 7.6. Aging at 7.2 C for 11 days and 12.8 C for four days were similar with scores of 7.3. With the B. femoris muscle there was no improvement in juiciness scores due to treatment.

Tenderness (Figs. 15 and 16): There were significant improvements in the tenderness scores during aging for both muscles. Aging the L. dorsi muscle for three days at 12.8 C and for 21 days at 1.7 C gave similar scores of 7.6 and 7.7 respectively compared to 4.6 for the control.

Aging the same muscle for 11 days at 1.7 C and 7.2 C gave similar results to that aged four days at 12.8 C. Likewise aging the B. femoris muscle at 7.2 C for 11 days produced a steak with a higher tenderness score than one aged at 1.7 C for 21 days. The B. femoris was found to be relatively less tender than the L. dorsi muscle.

Overall palatability (Figs. 17 and 18): The L. dorsi muscle aged for three or four days at 12.8 C had a score of 7.2 C which was similar to that aged 11 or 21 days at 1.7° C and that aged 11 days at 7.2 C. All of these results were significantly different when compared to the control (score = 5.4). The B. femoris aged for 21 days at 1.7 C had a score of 6.7 compared to the control which was 5.8. A score of 6.3 was found for those samples aged at 1.7 C for 11 days and at 7.2 C for 6 and 11 days.

Warner-Bratzler shear values (Figs. 19 and 20): Objective tenderness measurements using a recording Warner-Bratzler shear apparatus indicated that shear values significantly decrease with increasing aging period with the exception of the 2 day period at 12.8 C for the L. dorsi muscle and the 6 day period at 1.7 C for the B. femoris muscle. With the L. dorsi muscle minimum shear values of 3.7, 3.8 and 3.9 kgs. per 1.27 cm. core were found when samples were held at 1.7 C for 21 days, at 7.2 C for 11 days and at 12.8 C for 4 days respectively. With the B. femoris muscle minimum shear values of 4.7 and 4.4 kgs. per 1.27 cm. core were found with samples held at 1.7 C for 21 days and at 7.2 C for 11 days.

CONCLUSIONS

Aging of the L. dorsi muscle at 12.8 C for 3 to 4 days produced a steak of similar palatability to one aged for 21 days at 1.7 C. The B. femoris muscle aged at 7.2 C for 11 days produced a steak with a higher tenderness score, but lower scores for flavor, juiciness and overall satisfaction than samples aged at 1.7 C for 21 days. However, these differences were not significantly different.

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FIGURE 1. PERCENT SHRINKAGE DURING AGING OF THE L. dorsi MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

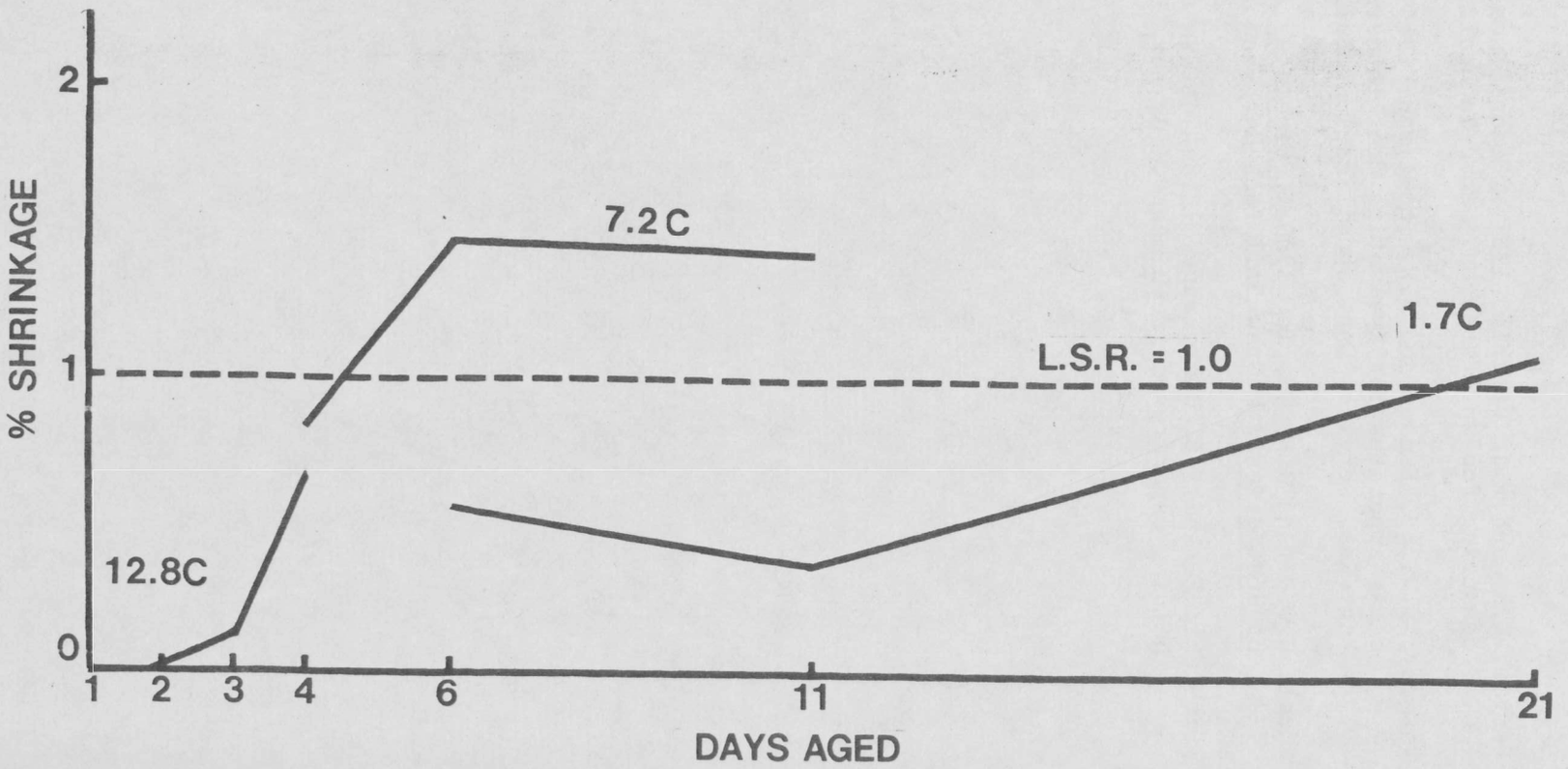


FIGURE 2. PERCENT SHRINKAGE DURING AGING OF THE B. femoris MUSCLE AT DIFFERENT TIMES AND TEMPERATURES

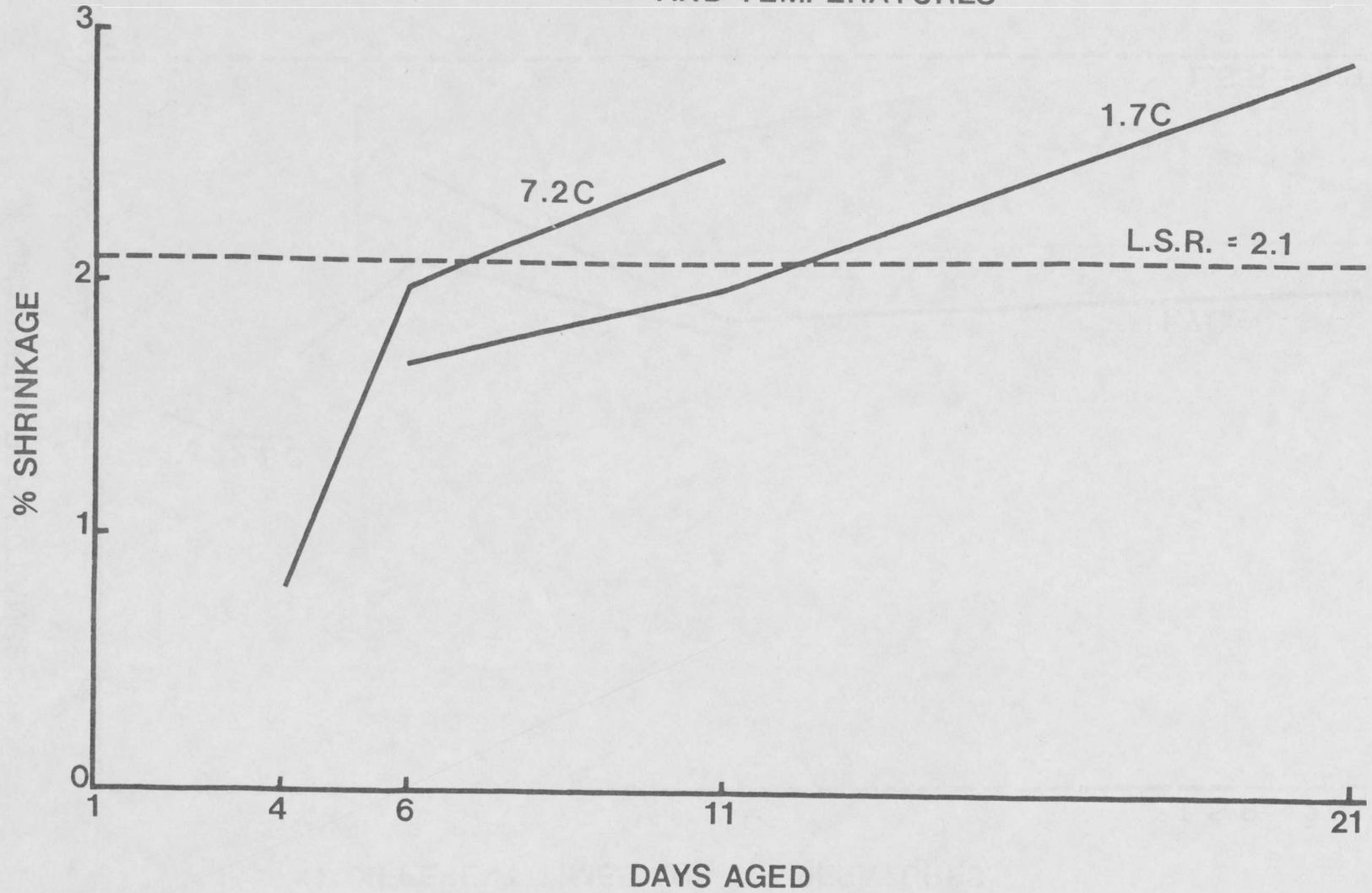


FIGURE 3. COLOR CHANGES DURING AGING OF THE L. dorsi MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

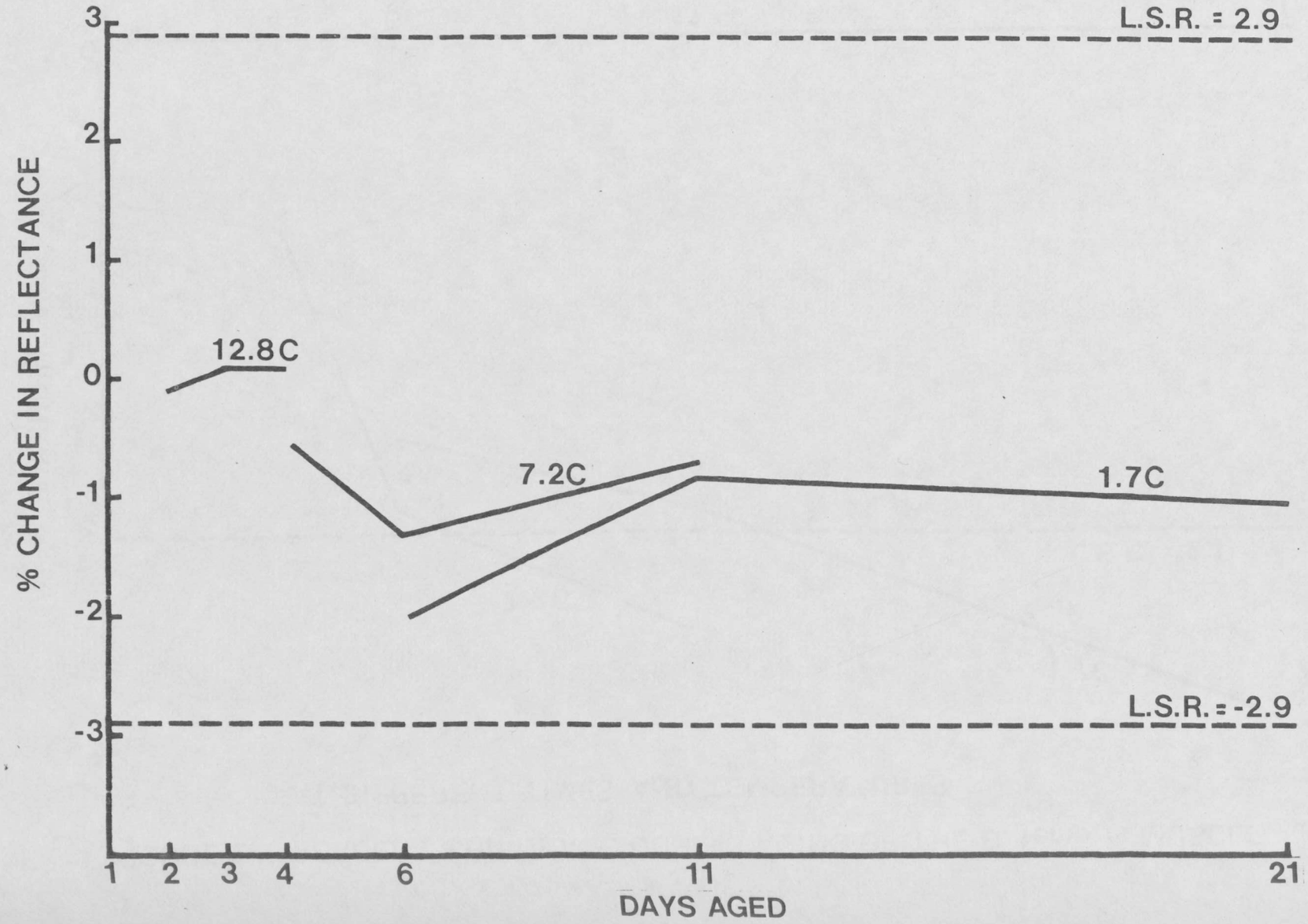


FIGURE 4. COLOR CHANGES DURING AGING OF THE B. femoris MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

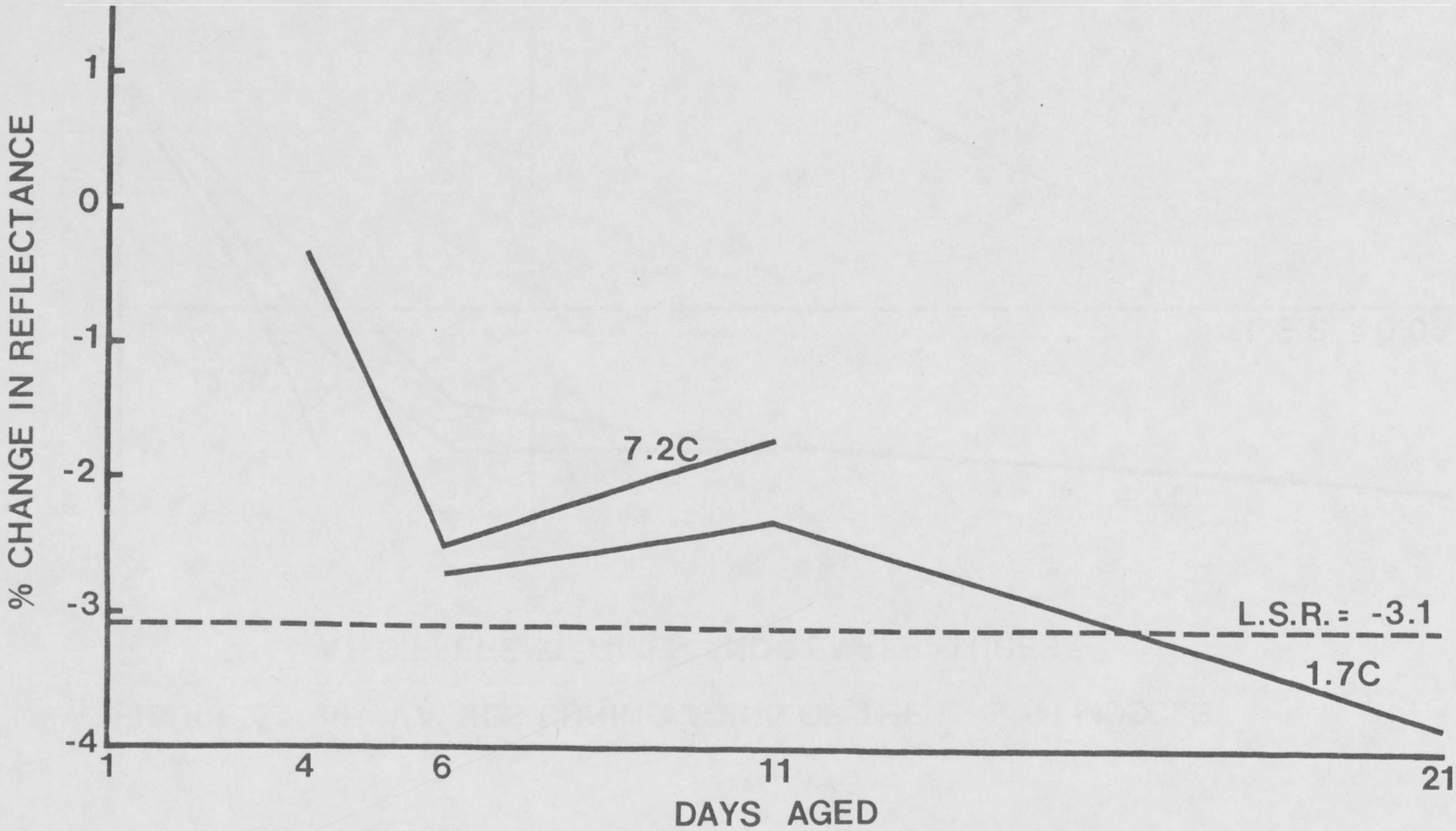


FIGURE 5. pH VALUES DURING AGING OF THE L. dorsi MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

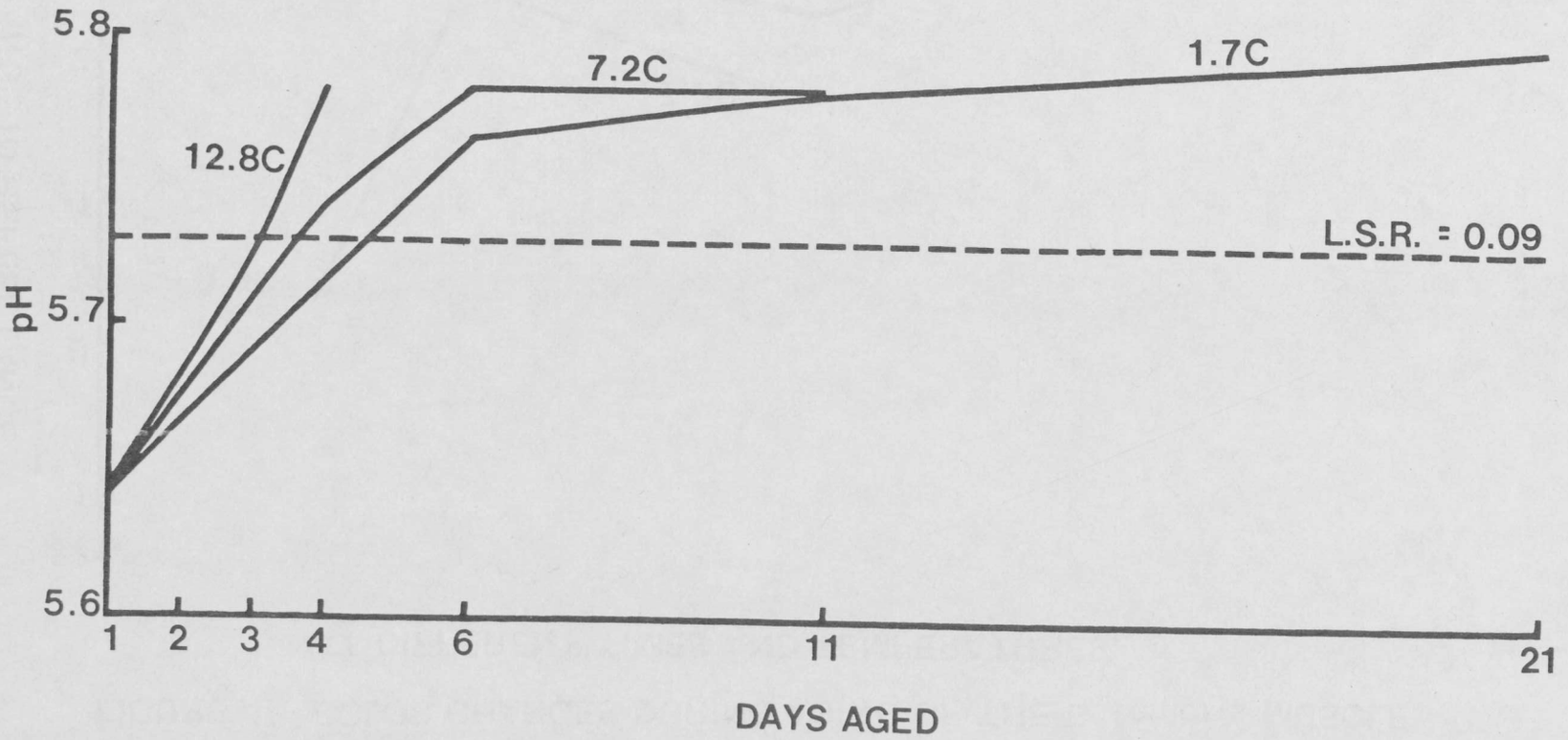


FIGURE 6 pH VALUES DURING AGING OF THE B. femoris MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

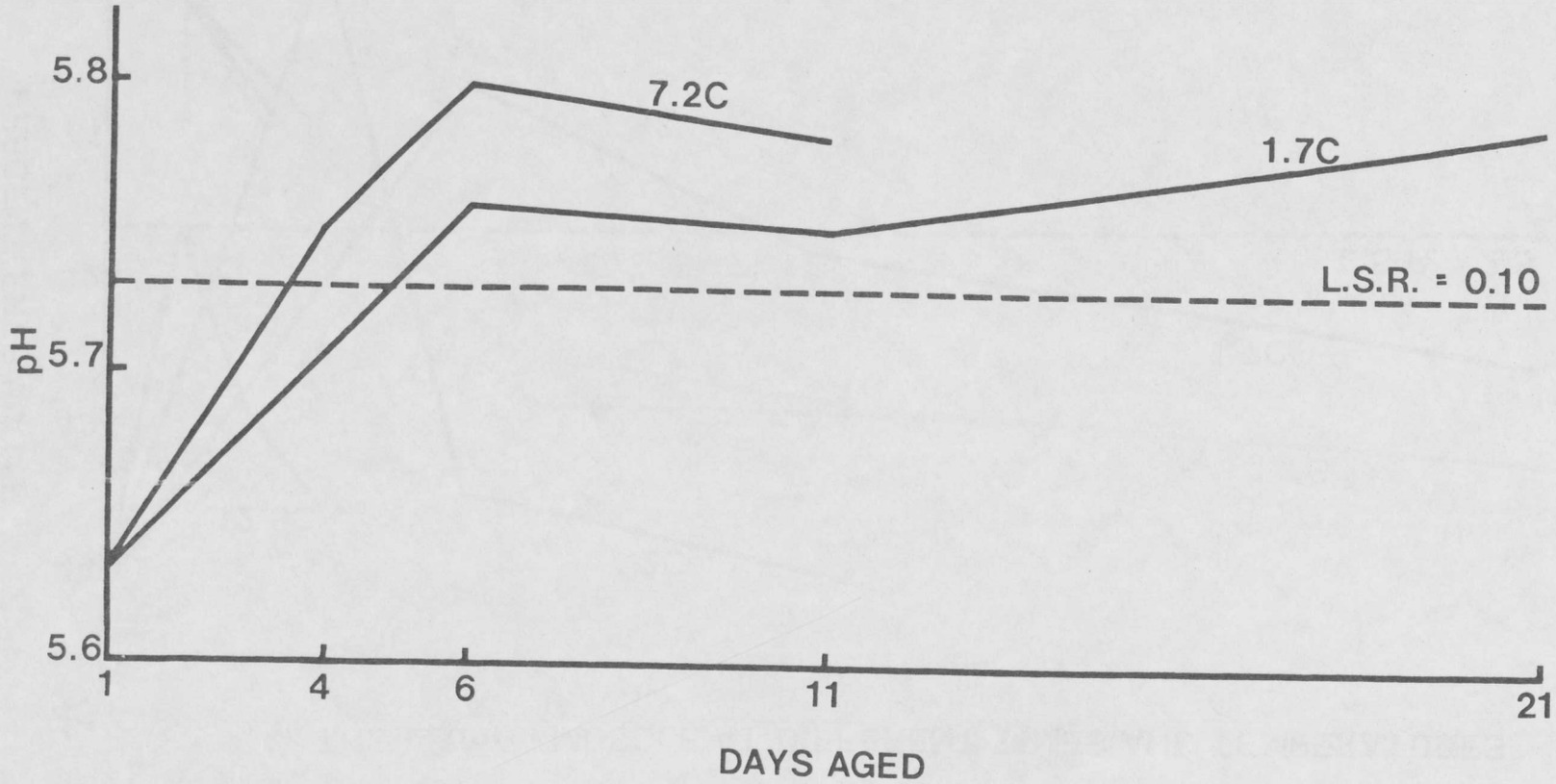


FIGURE 7 CHANGES IN PERCENT FREE WATER DURING AGING OF THE L. dorsi MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

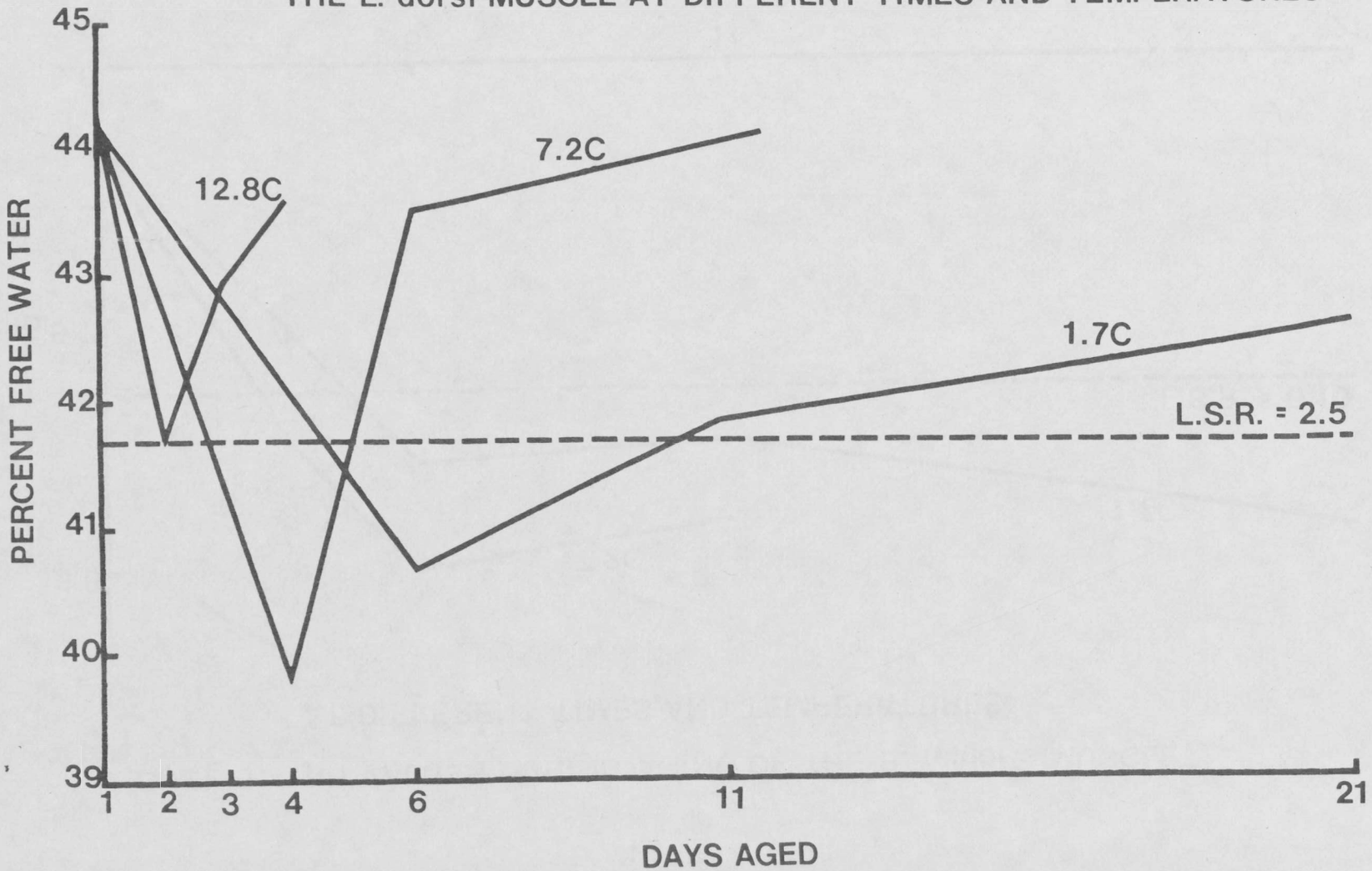


FIGURE 8. CHANGES IN PERCENT FREE WATER DURING AGING OF THE B. femoris MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

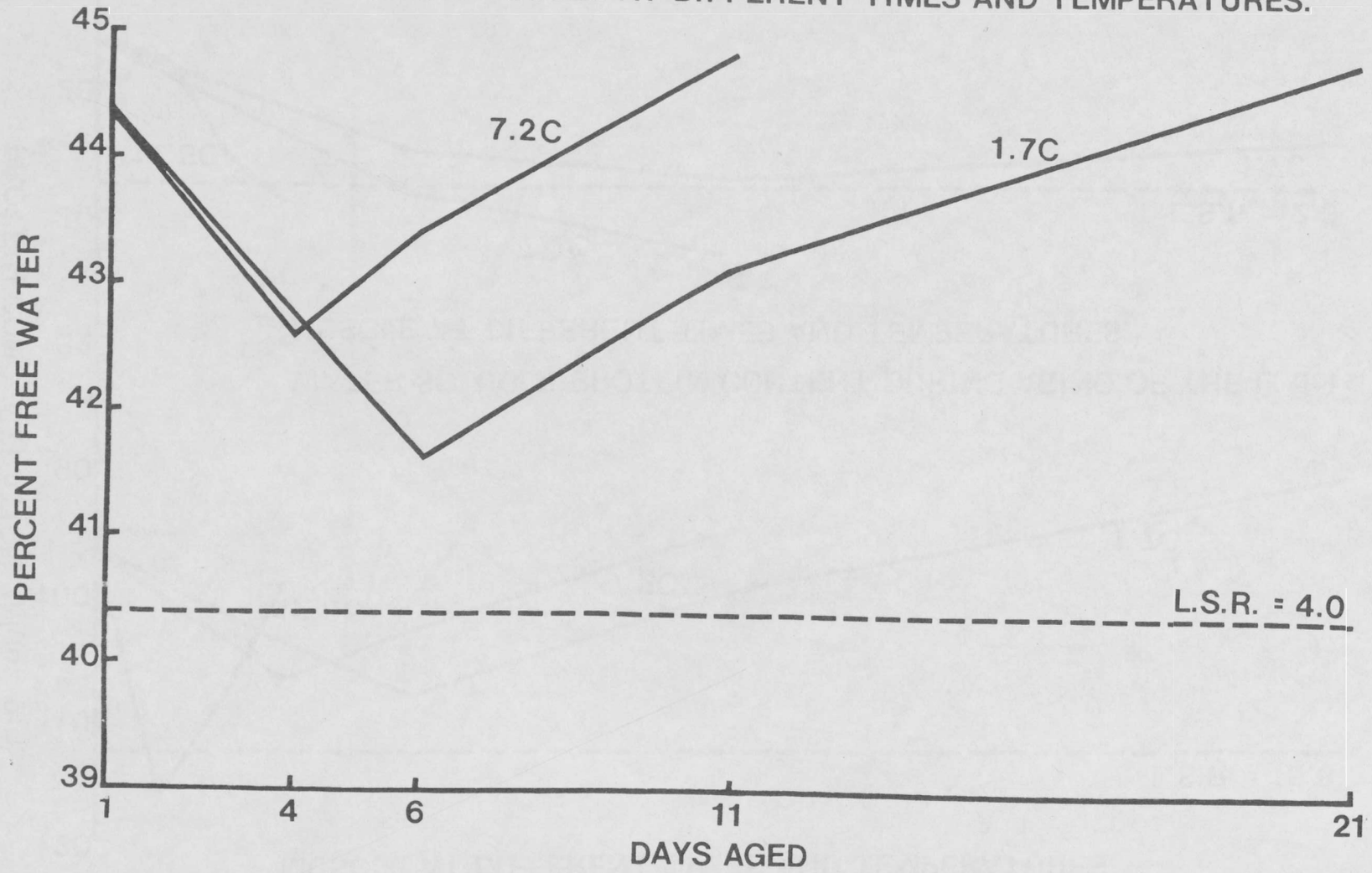


FIGURE 9 SALT SOLUBLE PROTEIN CONTENT DURING AGING OF THE L. dorsi MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

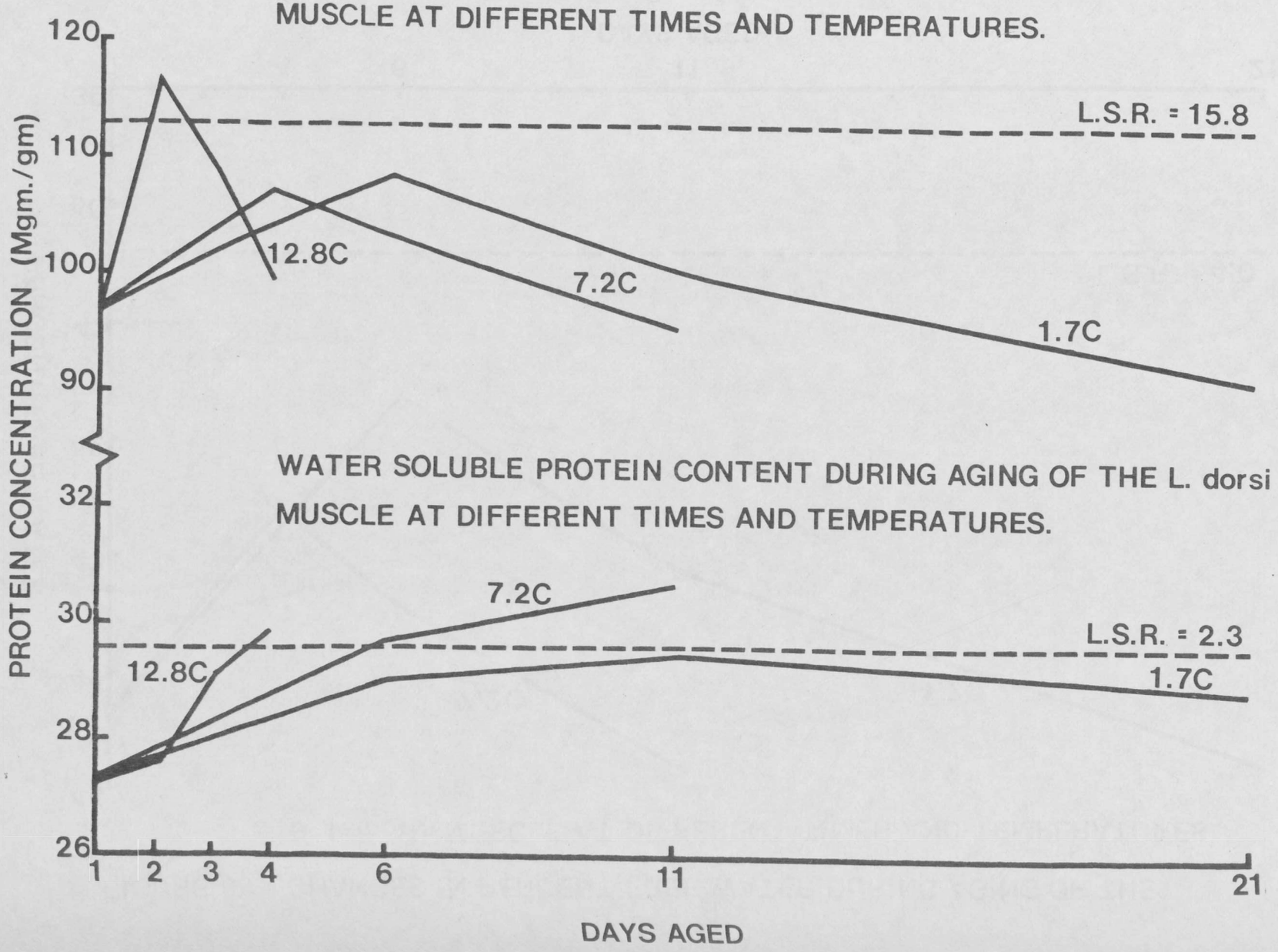
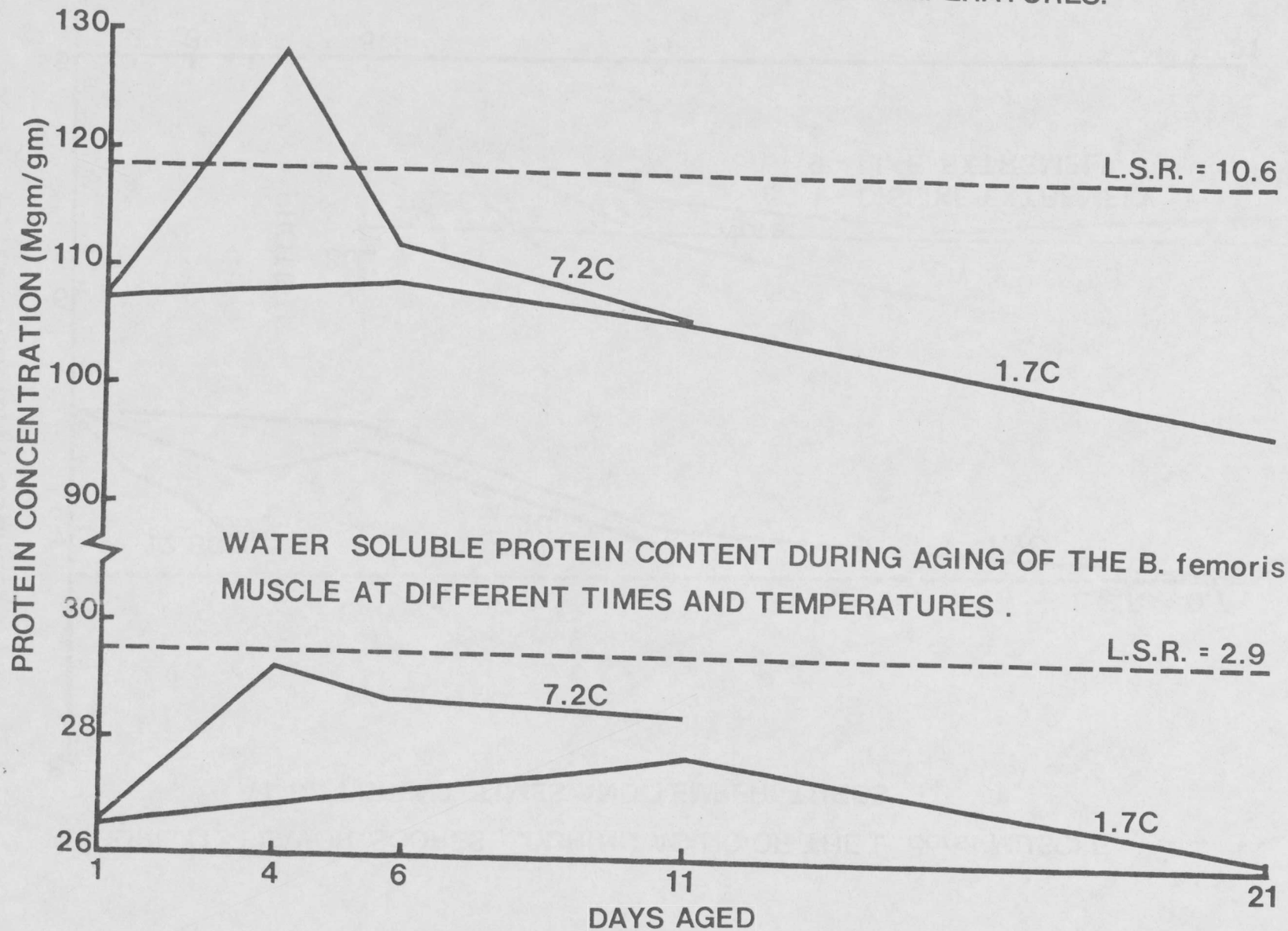
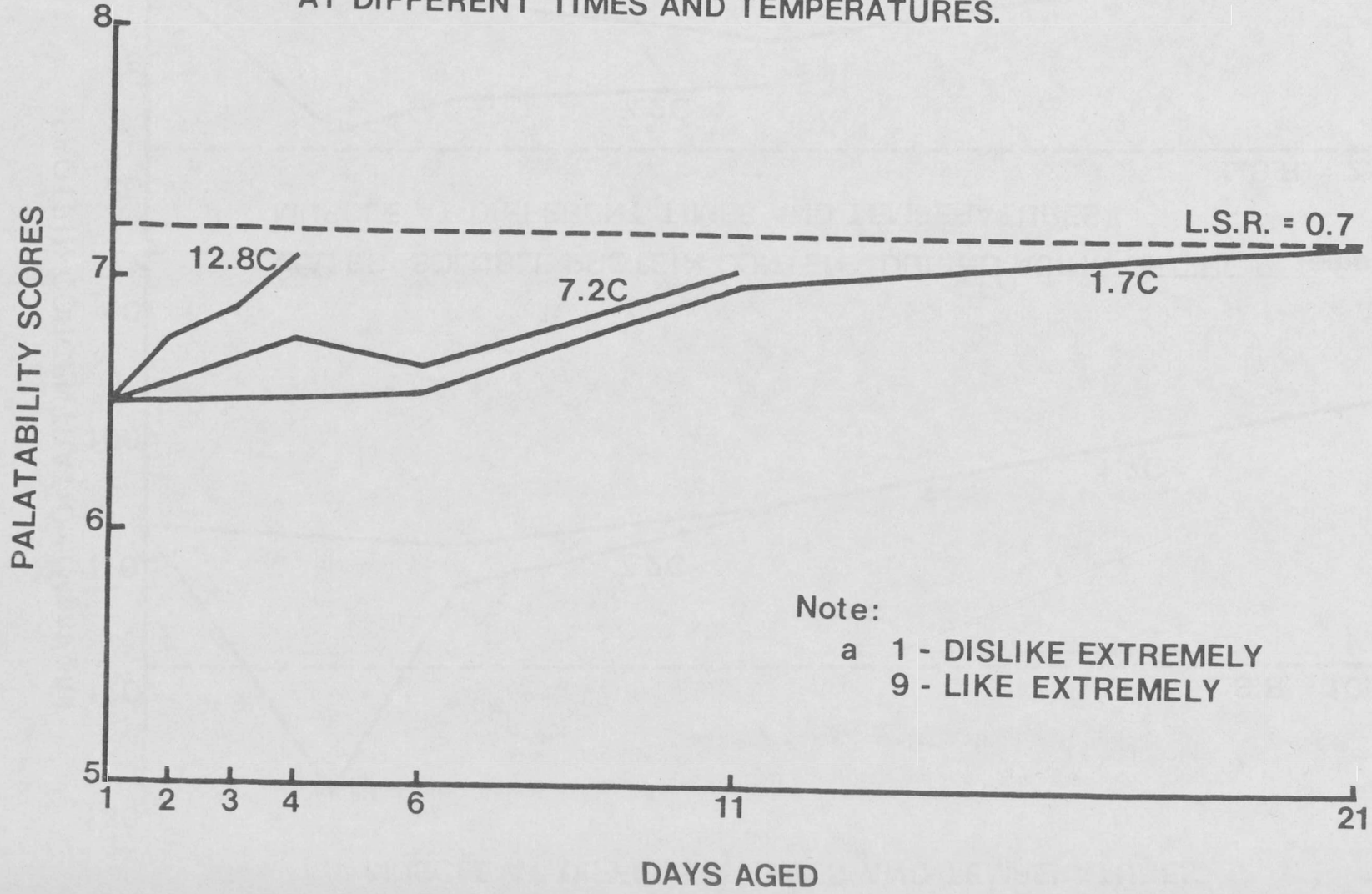


FIGURE 10. SALT SOLUBLE PROTEIN CONTENT DURING AGING OF THE B. femoris MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.



WATER SOLUBLE PROTEIN CONTENT DURING AGING OF THE B. femoris MUSCLE AT DIFFERENT TIMES AND TEMPERATURES .

FIGURE 11. FLAVOR SCORES [a] DURING AGING OF THE L. dorsi MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.



Note:

a 1 - DISLIKE EXTREMELY
9 - LIKE EXTREMELY

FIGURE 12. FLAVOR SCORES [a] DURING AGING OF THE B. femoris MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

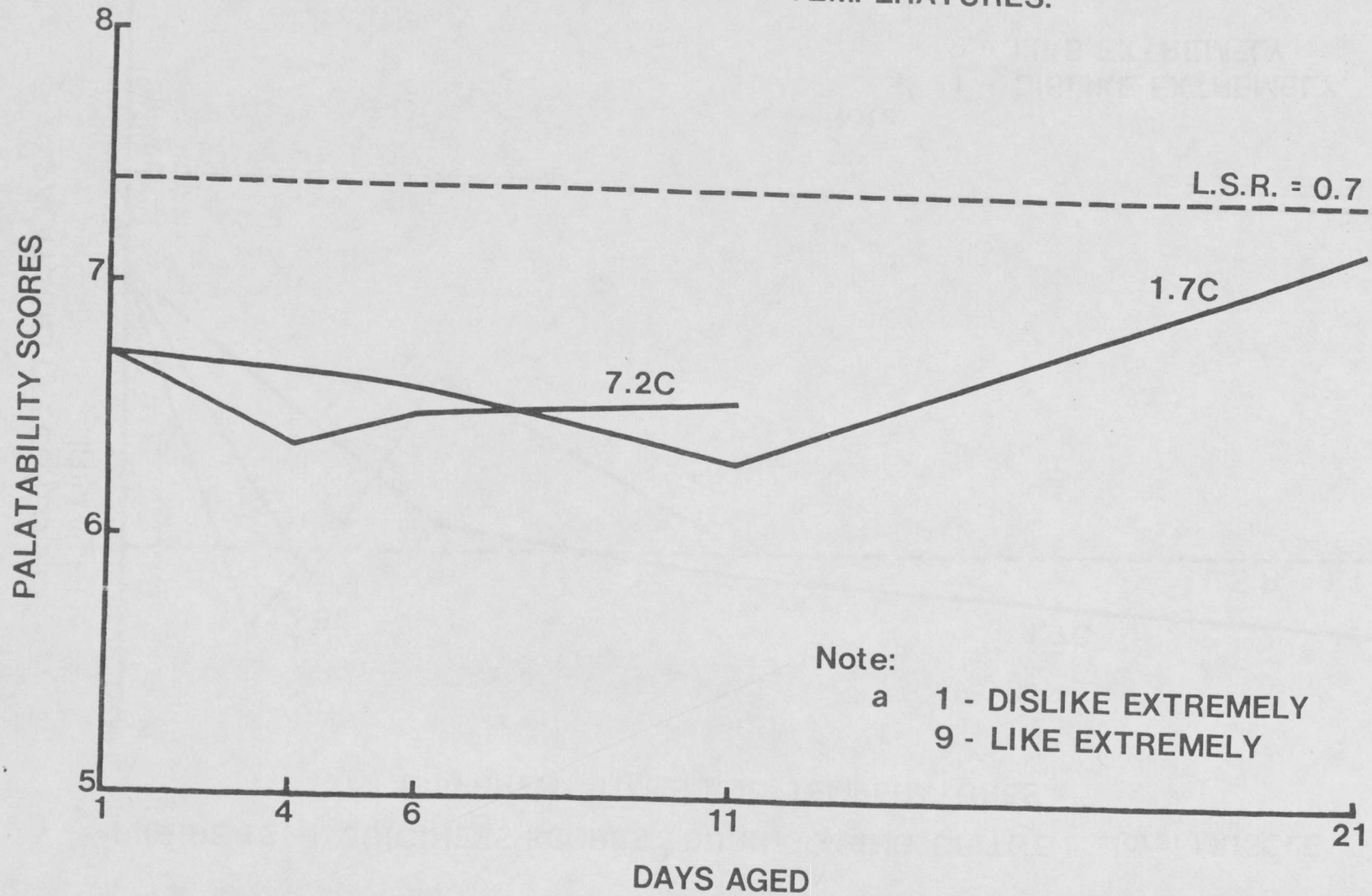


FIGURE 13. JUICINESS SCORES[a] DURING AGING OF THE L. dorsi MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

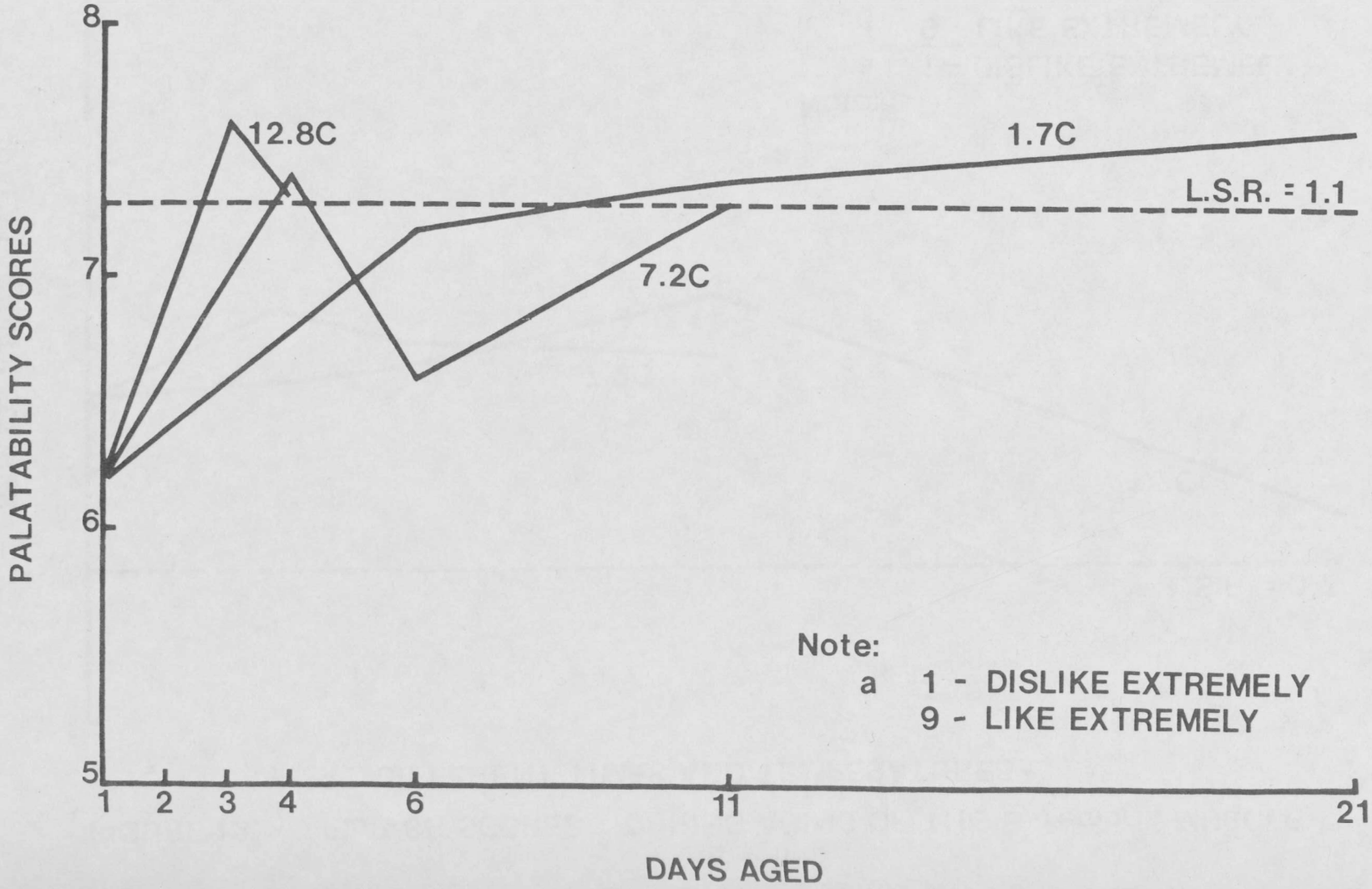


FIGURE 14. JUICINESS SCORES[a] DURING AGING OF THE B. femoris MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

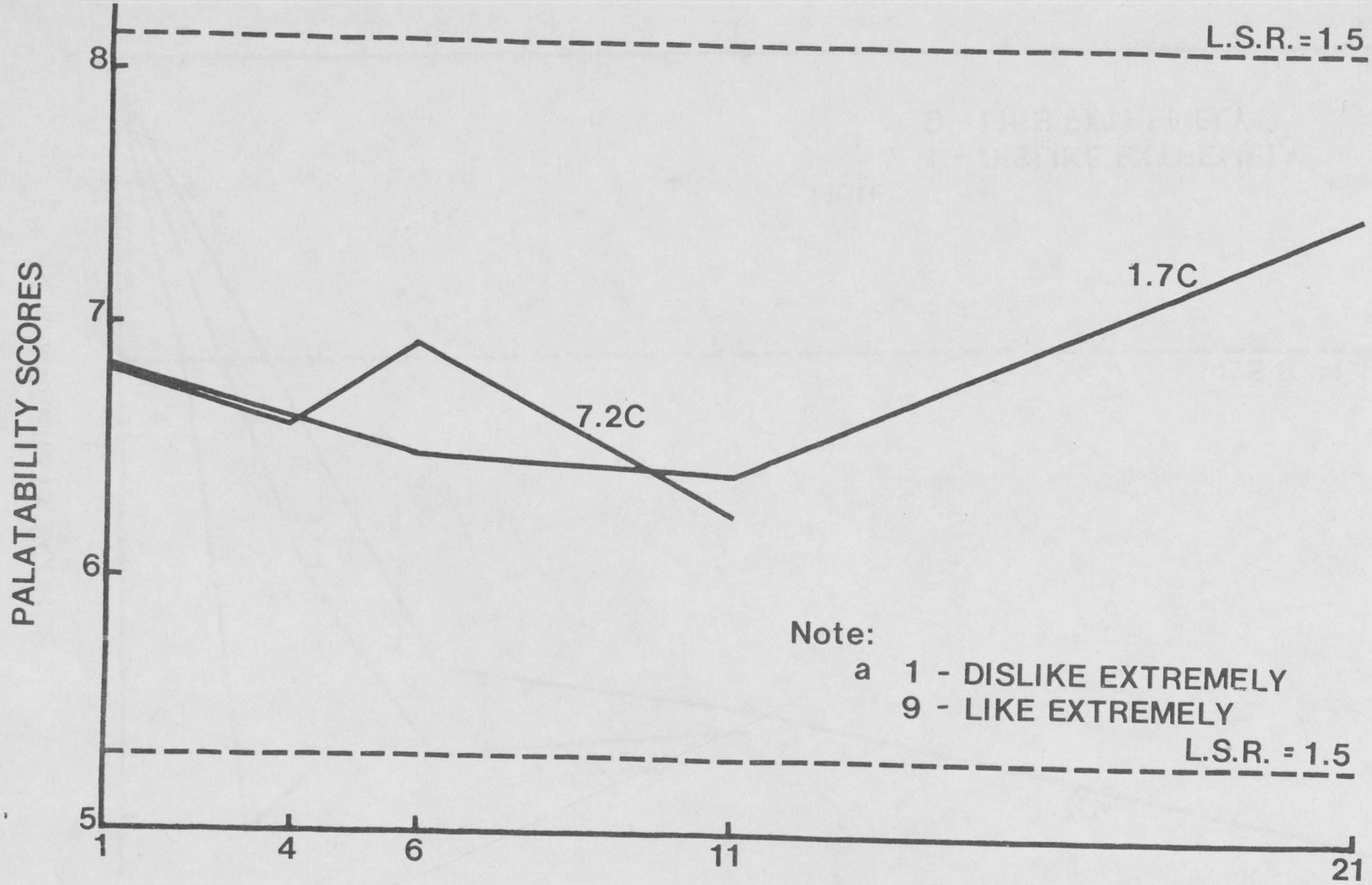


FIGURE 15. TENDERNESS SCORES[a] DURING AGING OF THE L. dorsi MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

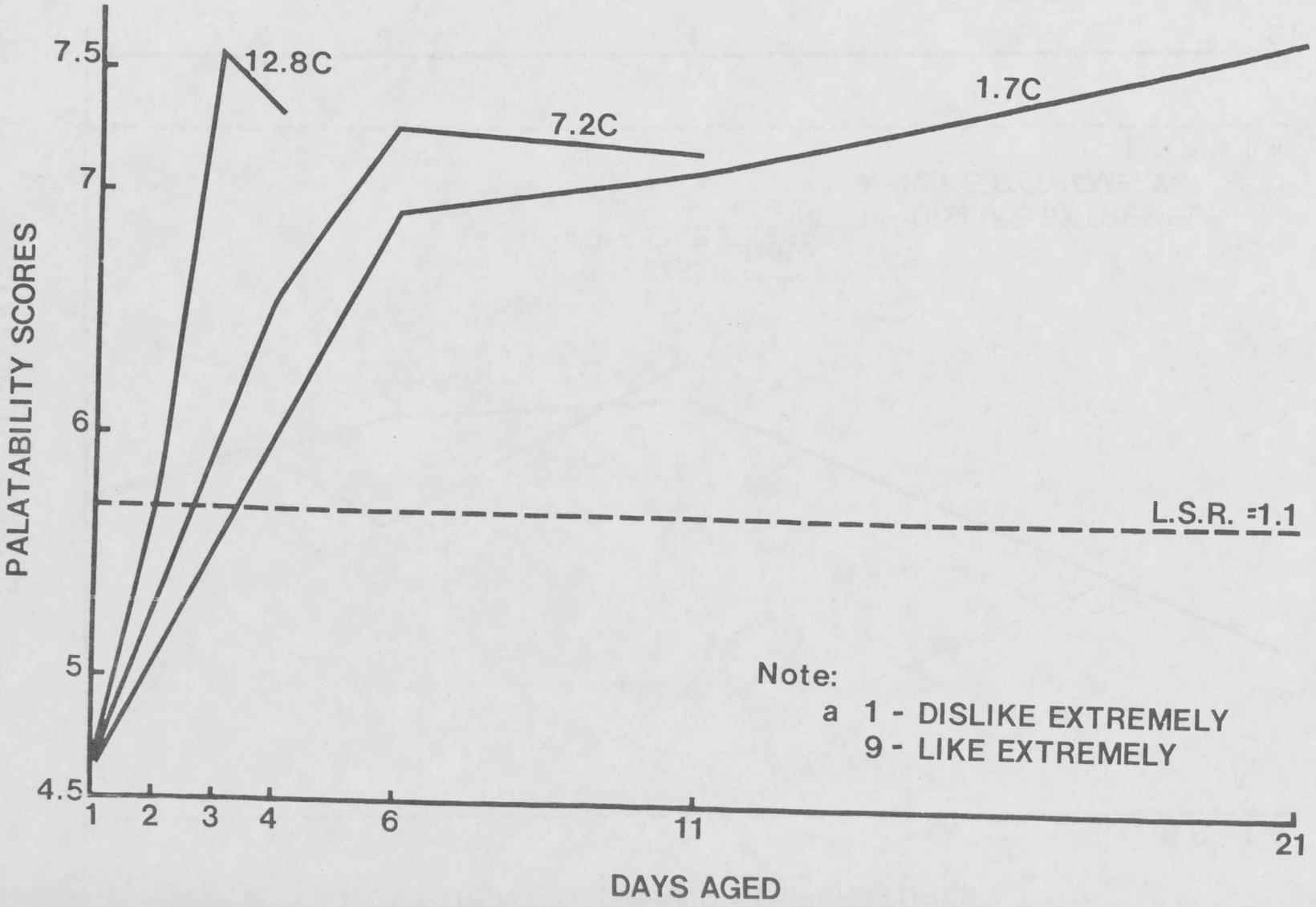


FIGURE 16. TENDERNESS SCORES[a] DURING AGING OF THE B. femoris MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

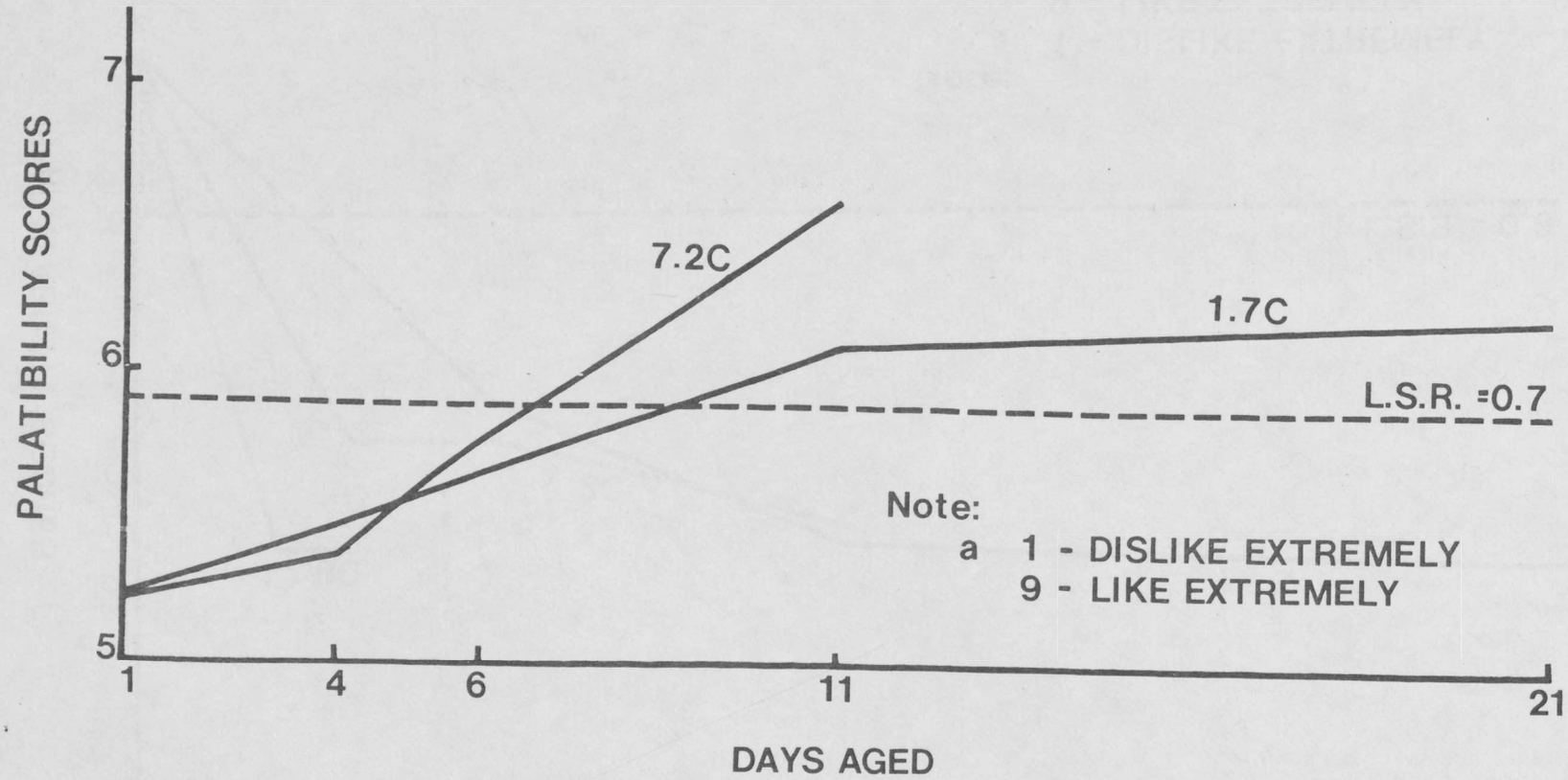


FIGURE 17. OVERALL PALATABILITY SCORES[a] DURING AGING OF THE L. dorsi MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

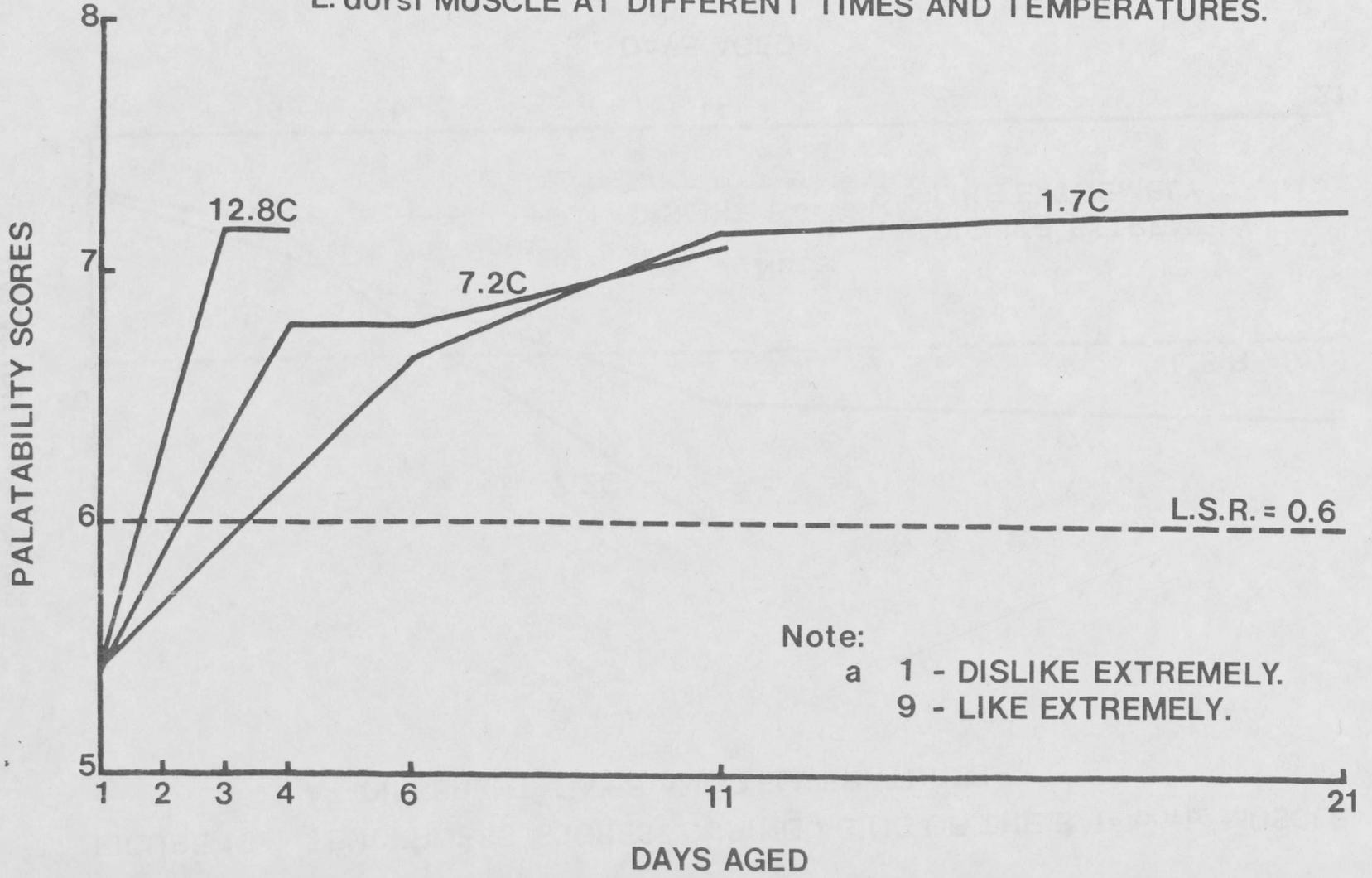


FIGURE 18. OVERALL PALATABILITY SCORES[a] DURING AGING OF THE B. femoris MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

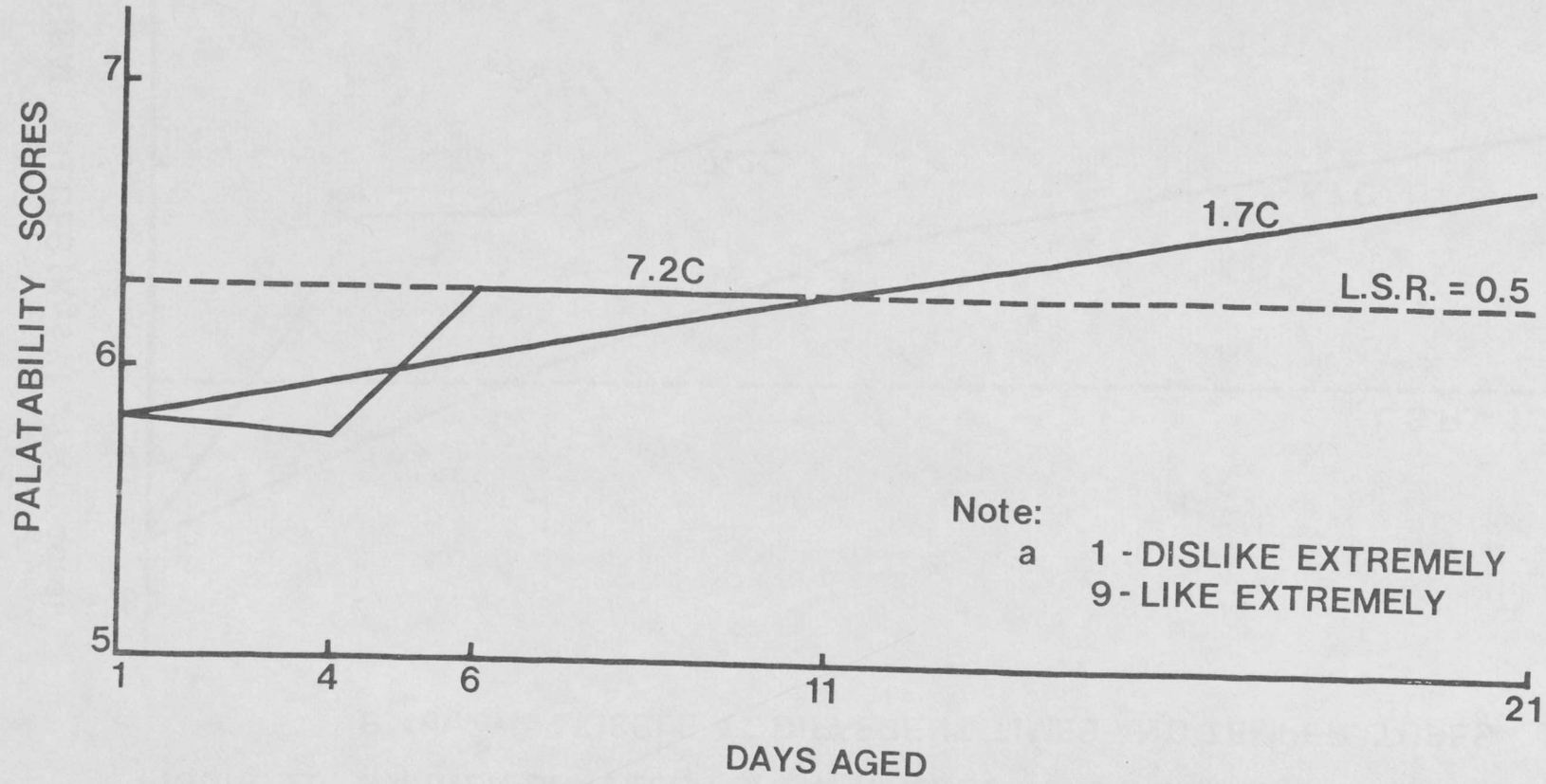


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FIGURE 20. WARNER BRATZLER SHEAR VALUES DURING AGING OF THE B. femoris MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.

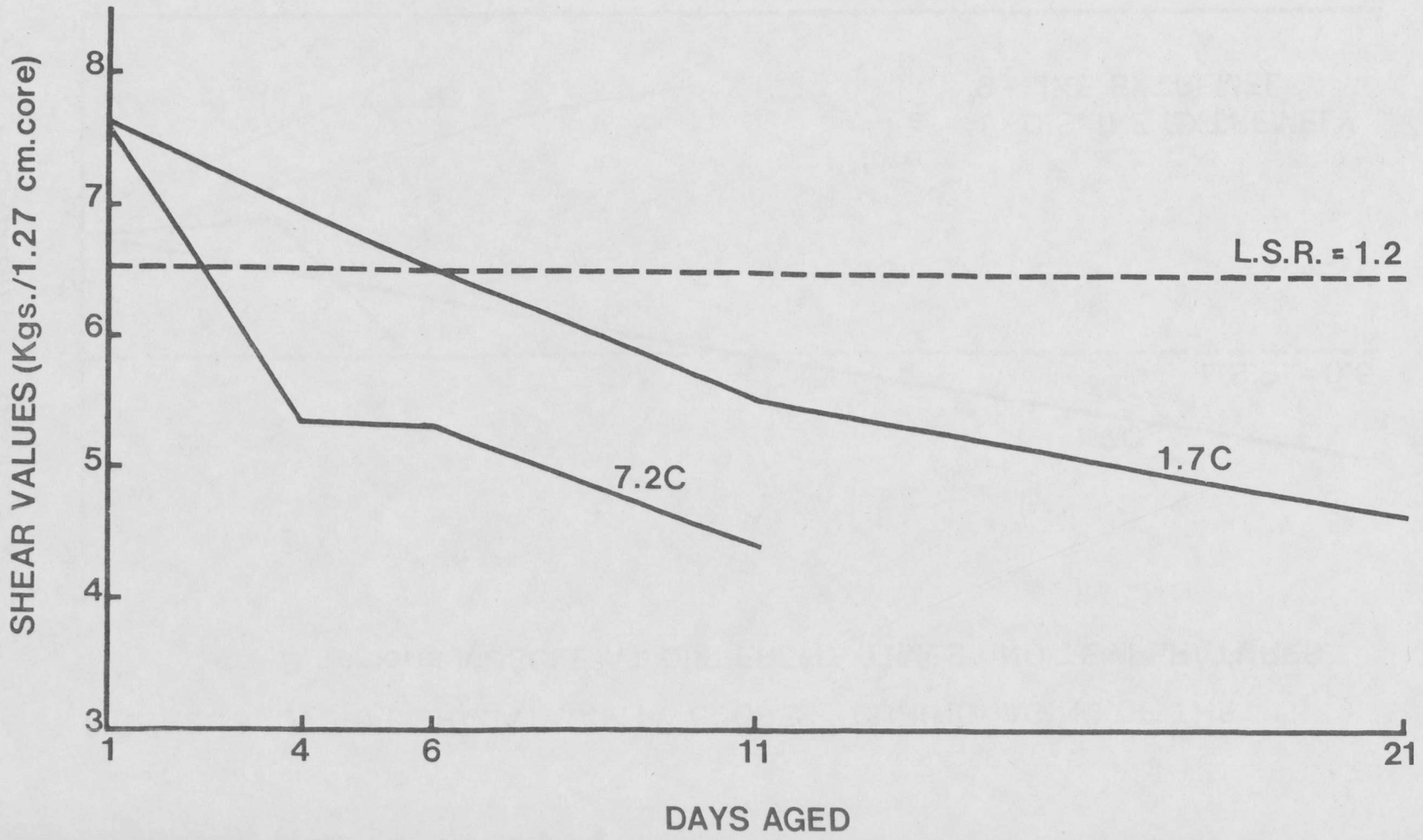

FIGURE 19. WARNER BRATZLER SHEAR VALUES DURING AGING OF THE L. dorsi MUSCLE AT DIFFERENT TIMES AND TEMPERATURES.