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Distribution of Fiber Content in Asparagus Cultivars[1]

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Abstract. **Analysis of spears of 9 cultivars of asparagus (*Asparagus officinalis* L.) revealed differences in fiber content between cultivars. The least fiber was found in 'MSU-1', 'Mary Washington', and 'U.C. 72', and the most in 'N.J. Improved' and 'U.C. 711'. There were significant differences in fiber content in the 5 sections of spear studied; the tip (10 cm) portion of spear had the least while the bottom section (17.5 – 20.0 cm from the tip) had the most fiber.**

Asparagus, an important vegetable crop in Michigan, is primarily processed as a "cuts and tips" pack. Most of the spears harvested for processing are "snapped," i.e. the spear is bent causing it to break at the point where fiber ceases to be objectionable, thus leaving in the field 2-3 cm of the spear which is normally high in fiber.

Fiber content of asparagus spears is an important factor in asparagus quality because it affects edibility. If fiber, which results from thickly lignified cell walls in the pericycle and vascular bundles of the spear, constitutes more than 0.25% of the fresh wt, the spear is considered to be unacceptable for consumption (1, 9). This standard (0.25%) was obtained, by comparing the fiber content of spears, determined by the blender method (10), with spear sections classified as objectionable using the "fork test," i.e. spear cannot be cut with a fork.

Studies (1, 2, 4, 7, 9, 10) have shown that fiber content in the spear increases basipetally. Large diam spears were usually less fibrous (on a percentage basis) than thin ones, and spears less than 1.0 cm in diam were shown to have 3X as much fiber as those 1.9 cm in diam, at a comparable distance from the tip of equal length spears (1, 9).

The rate and duration of spear growth affects its fiber content (3, 5). The amount of fiber appears to increase with an increase in the duration of the growth. A preliminary study showed that fiber content in spears of 'Mary Washington' asparagus was less when grown at 21.1° to 26.6°C than when grown from 10.0° to 15.5°. The rate of spear growth was faster at the higher range. Raising the air temp, heating the soil, or covering the ground with plastic, have also been shown (3) to increase the rate of spear growth and result in harvestable spears with a low fiber content.

Rainfall has also been related (5) to fiber content; as the amount of rainfall increased during spear growth, the spears contained less fiber.

The objective of this study was to determine and compare the distribution of fiber in the spears of 9 asparagus cultivars: 'U.C. 66', 'U.C. 72', 'U.C. 309', 'U.C. 711', 'Mary Washington', 'MSU-1', 'N.J. 44 x 22', 'N.J. 51 x 22', and 'N.J. Improved'. The plots were established at the Michigan State University Sodus Experiment Station in 1967 by planting 1 year old crowns at 2 within row spacings, 22.9 cm and 45.7 cm (9 and 18 inch), with 122 cm (4 ft) between rows. The experimental design was a split-plot with 3 replications; spacing being the main plot and cultivars the subplot. Since, in this study, crown spacing did not affect fiber content the data from both spacings were combined making 6 replications/cultivar.

Random samples of 5 marketable spears (30/cultivar) 20 cm in length ranging in diam from 0.95 – 1.58 cm (3/8 – 5/8 inch) were collected from harvests made on May 10, June 17, and June 25, 1973. Spears were then placed in plastic bags and frozen until analyzed. The spears at the first harvest were snapped while those of the last two were cut at ground level.

Fiber content was determined for the tip 10 cm, and 4 successive 2.5 cm sections of each spear using a slightly modified procedure of the blender method (10). Each spear section was weighed and cooked for 15 min in boiling water, then macerated with 200 ml water for 2 min in a blender. The mixture was filtered with a 30 mesh screen to separate out the fiber, which was then dried at 100°C for 2 hr and weighed. Statistical analyses were done separately for each section of each spear, but harvest dates were compared statistically only for spears harvested by cutting on June 17 and 25.

Spears harvested by snapping on May 10 (Table 1) had less fiber in comparable spear sections than did those harvested by cutting on the other 2 harvest dates. Although this difference may have resulted from the method rather than the time of harvest the trend in fiber content exhibited by the cultivars was the same as the trends from the 2 later harvest dates.

There were no significant differences in fiber content between cultivars in the top 4 sections of the snapped spears from the May 10 harvest. However, there were significant differences between cultivar in fiber content of the basal spear section and in the fiber content of the whole spear. 'MSU-1' had the least fiber in the whole spear and 'N.J. Improved' which had the most fiber, was the only one that had a portion of spear that was considered to be unacceptable. The fiber content in the basal section of 'N.J. Improved' was significantly higher than all cultivars except 'U.C. 711' and 'N.J. 44 x 22'.

There were differences in fiber content between cultivars in each of the top 4 sections of spear from the June 17 harvest. The basal sections were not different and the basal 2 sections of all cultivars were classified as inedible. This means that at best, spears cut at ground level on this date would have to have the bottom 5 cm of each spear discarded. 'U.C. 711' and 'N.J. Improved' each had only 10 cm of usable spear and in the second spear section from the tip had significantly more fiber than 4 other cultivars. The tip 10 cm of 'U.C. 711' contained significantly more fiber than the tip of 'MSU-1' and 'MSU-1' also had the least fiber in the 2nd spear section. 'MSU-1', 'Mary Washington' and 'U.C. 72' all had significantly less total fiber/spear than did 'N.J. Improved'.

There were no significant differences between cultivars in the fiber content of comparable sections for spears harvested June 25. 'U.C. 66' and 'U.C. 72' had 17.5 cm and the other cultivars had only 15 cm of usable spear. The trends for low and high fiber content among cultivars were the same at this harvest as in the 2 previous harvests.

There were no differences between cultivars, or harvest date x cultivar interactions for spears cut at ground level on June 17 and 25. Significant differences in fiber content did occur between sections of the spear and there was an interaction between harvest date x spear section interaction (Table 2). Fiber in the 2nd and 3rd sections from the tip (10.0 – 15.0 cm) was the same, the tip (10.0 cm) had the lowest fiber content; and the basal 2 sections of the spear (15 – 20 cm from the tip) were highest in fiber. The mean fiber percentage for the 2 harvest dates also showed significant differences between spear sections.

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Table 1. Percentage of fiber in spear sections of 9 asparagus cultivars, harvested in 1973.

Cultivar	% fiber					Mean total fiber/ spear
	Distance from the tip (cm)					
	0.0–10.0[z]	10.0–12.5	12.5–15.0	15.0–17.5	17.5–20.0	
	Harvested May 10, (spears snapped)					
U.C. 66	.068 a[y]	.067 a	.083 a	.094 a	.125 bc	.082 ab
U.C. 72	.047 a	.096 a	.065 a	.069 a	.125 bc	.072 ab
U.C.309	.054 a	.092 a	.079 a	.084 a	.113 bc	.078 ab
U.C. 711	.059 a	.101 a	.095 a	.108 a	.195 ab	.100 ab
Mary Washington	.032 a	.072 a	.052 a	.056 a	.076 c	.052 ab
MSU-1	.027 a	.047 a	.053 a	.056 a	.107 bc	.022 b
N.J. 44 x 22	.061 a	.090 a	.073 a	.087 a	.186 abc	.091 ab
N.J. 51 x 22	.052 a	.068 a	.085 a	.094 a	.071 c	.070 ab
N.J. Improved	.055 a	.105 a	.107 a	.102 a	*.288 a*[x]	.114 a
	Harvested June 17, (spears cut at ground level)					
U.C. 66	.064 b	.169 bc	.214 ab	*.543 ab*[x]	*.794 a*	.293 ab
U.C. 72	.079 ab	.160 bc	.127 b	*.321 b*	*.792 a*	.240 b
U.C. 309	.101 ab	.227 ab	.238 ab	*.483 ab*	*.704 a*	.305 ab
U.C. 711	.163 a	*.306 a*	*.261 ab*	*.398 ab*	*.594 a*	.313 ab
Mary Washington	.097 ab	.146 bc	.167 b	*.353 ab*	*.755 a*	.261 b
MSU-1	.054 b	.087 c	.173 b	*.357 ab*	*.654 a*	.256 b
N.J. 44 x 22	.128 ab	.228 ab	.250 ab	*.427 ab*	*1.092 a*	.363 ab
N.J. 51 x 22	.124 ab	.212 abc	*.275 ab*	*.751 a*	*.795 a*	.377 ab
N.J. Improved	.121 ab	*.316 a*	*.355 a*	*.681 ab*	*1.045 a*	.427 a
	Harvested June 25, (spears cut at ground level)					
U.C. 66	.102 a	.149 a	.165 a	.231 a	*.605 a*[x]	.224 a
U.C. 72	.128 a	.159 a	.164 a	.190 a	*.502 a*	.217 a
U.C. 309	.121 a	.195 a	.170 a	*.276 a*	*.694 a*	.266 a
U.C. 711	.163 a	.218 a	.211 a	*.360 a*	*.805 a*	.280 a
Mary Washington	.108 a	.135 a	.163 a	*.320 a*	*.805 a*	.257 a
MSU-1	.079 a	.127 a	.126 a	*.259 a*	*.563 a*	.213 a
N.J. 44 x 22	.145 a	.216 a	.182 a	*.288 a*	*.658 a*	.278 a
N.J. 51 x 22	.091 a	.134 a	.138 a	*.292 a*	*.493 a*	.213 a
N.J. Improved	.123 a	.157 a	.143 a	*.378 a*	*.697 a*	.271 a

[z]The statistical analysis performed separately for each section of the spear.
[y]Mean separation for spear sections by Duncan's multiple range test, 5% level.
[x]Italics indicates inedible spear section.

Throughout the study, 'N.J. Improved' and 'U.C. 711' were consistently high in fiber content, and 'MSU-1', 'U.C. 72' and 'Mary Washington' had low amounts of fiber.

Cultivars differed in the distribution of the fiber within their spears in that some cultivars had 20.0 or 17.5 cm of usable spear while others had only 10.0 or 12.5 cm (Table 1). This indicates that it may be possible to select for high amounts of usable spear and therefore, more edible tonnage per acre. Results of other studies (11, 12) showed that the low fiber cultivars had a greater marketable yield than those high in fiber

The distribution of fiber in the spear found in this study is in agreement with the findings of other investigators (1, 7, 8, 9, 10). The fact that the 2nd and 3rd sections of the spear (10.0 – 12.5 cm and 12.5 – 15.0 cm) did not show significant differences in fiber content, indicates that fiber determinations by the blender method (10) could be made on fewer sections than sampled here.

When cut at ground level all cultivars had sufficient fiber in the basal sections of the spear to render them inedible. This agrees with the results of Segerlind and Herner (9), that the fiber content is high in the basal section of the spears harvested too close to the ground, and in spears longer than 18.75 cm (7.5 inch). It is this basal 2.5 cm of spear from the cut spears that is left in the field when a spear is harvested by "snapping." The findings of this study point out the importance of "snapping" the spears properly when harvesting by hand. If "snapped" improperly at ground level, a portion of the spear will be unacceptable for consumption. It is also obvious that adjustment of the level of the cutting bar above the ground during mechanical harvesting is necessary to ensure the harvest of spears at a length which provides the longest edible spear possible.

The average fiber content of the whole spear should not be used to determine spear acceptability. Spears averaging less than 0.25% have inedible portions due to the distribution of the fiber (Table 1). For example the total fiber percentage for the entire spear of 'MSU-1', 'N.J. 51 x 22', 'U.C. 66', and 'U.C. 72' harvested June 25 would indicate that the entire spear was acceptable, yet, there are some spear sections with less than 0.25%. There is no way that averaging fiber content for the whole spear can make unacceptable sections edible. Conversely, there are spears that have a mean fiber content above 0.25% with portions of the spear that are acceptable. Because of the variability between cultivars in the distribution of fiber, the mean fiber content is not always the best indicator of the amount of edible spear. However, in this study the cultivar with the highest fiber content had the least amount of edible spear.

Evaluation of asparagus cultivars or the selection of materials to be used in a breeding program must take into account the distribution of the fiber through the length of the spear, rather than the total or average content of the whole spear. Knowing the distribution of fiber in a spear and knowing the differences in fiber content between cultivars, should make it possible for growers and processors to produce a higher quality product.

Table 2. Average percentage of fiber in 5 sections of spears of 9 asparagus cultivars, harvested by cutting at ground surface on 2 dates in 1973.

Harvest date	% fiber in 5 sections of spear				
	Distance from the tip (cm)				
	0.0–10.0	10.0–12.5	12.5–15.0	15.0–17.5	17.5–20.0
June 17	.104 g[z]	.206 e	.229 de	.480 c	.803 a
June 25	.118 g	.165 f	.162 f	.288 d	.647 b
Mean	.111 u[y]	.186 t	.196 t	.384 s	.725 r

[z]Mean separation for fiber content at both dates by Duncan's multiple range test, 5% level.
[y]Mean separation for spear sections by Duncan's multiple range test, 5% level.

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Quality Deterioration of Southernpeas in Commercial Operations[1]

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Abstract. **Mechanically harvested southernpeas (*Vigna unguiculata* (L.) Walp cv. Purple Hull Pink Eye lost substantial green color within 2 – 3 hours after harvest. Color loss was greater at higher temperature. Color changes were more closely related to O_2, CO_2, acetaldehyde and ethanol concentration in the load atmosphere than to endogenous ethylene concentrations. Solids and total sugar content decreased after harvest and were not affected by product temperature within the range studied. Flavor and off-flavor acceptability ratings were closely related to time from harvest, product temperature and load atmosphere O_2 and CO_2 concentrations, but were not closely associated with ethylene, acetaldehyde or ethanol concentrations.**

The quantity of commercially frozen southernpea totaled 10.7 million kg in 1973, a 65% increase over 1968 (11). The increase in quantity of frozen southernpeas and the location of production areas at greater distances from processing plants have been partially responsible for the rapid shift from stationary vining operations to the use of mobile pea combines. The combining or shelling procedure damages the immature fruits and may cause accelerated deterioration as reported with *Pisum sativum* L. (6). Southernpeas are harvested during the summer when field temp may approach 38°C. Deterioration in product quality may be extremely rapid at these elevated temp. The frozen southernpea industry has had difficulty in obtaining sufficient USDA Grade A product because of low color scores. This problem has resulted in a proposed revision of the *United States Standards for Grades of Frozen Field Peas and Frozen Black-eye Peas* (10), to require 10% "obvious green" seed instead of the 50% "tinge of green" requirement of the present Grade A standard.

Most postharvest studies of southernpeas have concentrated on carbohydrate (2, 3, 4, 5, 8) and ascorbic acid (4) changes, although neither of these factors have a direct economic effect on the industry. Virtually no information is presently available on postharvest quality changes of commercially harvested southernpeas since the transition to shelling by combine. We, therefore, ascertained the rate and degree of postharvest deterioration of southernpeas under typical commercial conditions and determined the relationship of ambient and product temp and composition of the atmosphere in truck-loads of peas to quality changes.

Commercial harvesting and handling operations consisted of cutting and windrowing the plants and vining the peas with green pea combines. Shelled peas were transferred from storage bins on the combines to open-bed, 18 ton trucks for transport about 90 km to the processing facility. Peas from the first 3 combine storage bins transferred to each truck were used as replications. The trucks were equipped with an air scoop to provide forced ventilation through the load during transit.

Gas and product samples were collected at 1-hr intervals from each replication until the trucks were loaded. Samples were also collected after the product arrived at the processing facility. Thermister probes (YSI Model 401) and sections of Tygon tubing (6.4 mm ID) were inserted into the loads 60 cm above the truck floor and 60 cm to the side of the air duct. Samples of the atmosphere within the loads were drawn through the Tygon tubing with a hand vacuum pump and collected in 1 ml gas-tight syringes. We used a Bendix Model 2500 gas chromatograph for O_2, CO_2, ethylene, acetaldehyde and ethanol analyses. Molecular Sieve 5A and Porapak T were used for O_2 and CO_2 separation. Porapak Q was used for acetaldehyde and ethanol separation. Activated alumina was used for ethylene separation. We determined O_2 and CO_2 concn with a thermal conductivity detector and acetaldehyde, ethanol and ethylene concn by flame ionization. Product samples were taken from each replication with a grain probe, immediately cleaned, blanched 3 min in boiling water and frozen on dry ice. Product quality analyses consisted of measurement of percentage of green seed, total solids, alcohol insoluble solids (A.I.S.), total and reducing sugars and evaluation by a taste panel. Samples for the 4-member taste panel evaluation were prepared as outlined in the grade standards (10).

Preliminary tests during the 1974 harvest season indicated that the initial temp of shelled peas closely paralleled ambient air temp during morning harvests. Product and ambient air temp were similar during afternoon harvests on overcast days; however, product temp was often 5 to 10°C higher than ambient air temp on clear days. The small differences between air and initial product temp reflect overcast conditions during this test (Table 1). Changes in product temp after harvest were not related to changes in air temp, which agrees with results reported for sweet corn (9). The rate of temp increase of the peas was 3 times as rapid when its initial temp was 30°C (afternoon harvest) as when it was 25° (morning harvest). Forced ventilation from the air scoop on the truck substantially lowered the temp during transit. The magnitude of product temp reduction by forced ventilation was similar to that reported for sweet corn (9).

The composition of the atmosphere in the loads was affected by product temp and time from harvest (Table 1). Oxygen content of the atmosphere around the peas harvested at 25°C remained constant while the truck was in the field (3 hr). Oxygen decreased and CO_2 increased rapidly when the peas were harvested at 30°. The faster increase in CO_2 level of the afternoon harvest was attributed to a higher product temp at harvest and a more rapid temp increase. Acetaldehyde and ethanol concn of the afternoon harvest increased while the truck was in the field and decreased during transit. Ethylene concn differences could not be attributed to either time or product temp. The high ethylene concn at the 0-hr period was attributed to ethylene accumulation during the 30 to 45 min the peas were in the combine storage bins.

Reducing sugar content of the peas

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