ALFALFA SPROUTS: METHODS OF PRODUCTION, CURRENT RESEARCH AND ECONOMIC IMPORTANCE

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The use of germinated alfalfa (Medicago sativa L.) seed (sprouts) in salads and sandwiches is rapidly increasing in popularity throughout the United States and other parts of the world. The technique of germinating seed for use as edible sprouts is not new. Sprouted mung beans have been used by the Chinese for nearly five thousand years. Sprouts of various legumes and cereal grains have been used for many years as a source of ascorbic acid. In recent years sprouted alfalfa seed has become one of the most commercially important sprouts.

We have estimated the growth of the commercial alfalfa sprout industry in California during the past decade. Our figures are derived from estimates of the amount of alfalfa seed sold for sprouting. These estimates are probably somewhat inflated, because some of the alfalfa seed sold in California for sprouting is purchased by parties not involved in commercial sprouting in the State. These include growers in other states and individuals who grow sprouts for their own consumption. In 1970 the alfalfa sprout industry in California consisted of 3 major growers. The same year approximately 50,000 lbs. of alfalfa seed was sold for sprouting. The industry has literally exploded since 1970 (Table 1). It is now estimated to consist of up to 125 growers, and is consuming 1,450,000 lbs. of alfalfa seed a year. Farm value of sprouts produced from this seed is estimated to be 8,483,000 dollars. This exceeds the farm value in California of more commonly accepted vegetable crops such as parsley ($7.6 million) eggplant ($1.8 million), radish ($2.8 million), and lettuce excluding head lettuce and 'Romaine' ($7.3 million).

Sprouts may be a significant source of protein and other nutrients. Kylen and McCready (1975) reported a fresh weight protein content of 5.1 percent for alfalfa sprouts. They also studied the protein content of alfalfa seed and concluded that on a solids basis the protein content of the sprouts was higher than that of the seed. They attribute this to leaching of sugars, loss of seed coats, and protein synthesis during sprouting. Hamilton and Vanderstoep (1979) found some alfalfa sprouts to have a lower concentration of protein than seed on a dry weight basis. They reported that the crude protein content of sprouts grown under some conditions, however, was not significantly different from that of the ungerminated seed.

Patwardhan (1962) reported that sprouts are a good source of thiamine, riboflavin and niacin. Hamilton and Vanderstoep (1979) reported that during germination and sprouting of alfalfa seed ascorbic acid content increased as much as 3 to 4 times and riboflavin content increased as much as 3 times. Chen, Wells, and Fordham (1975) reported that the availability of certain mineral nutrients may be increased by sprout ing seed.

Seed germination rate and the fresh weight yield that can be obtained by sprouting are influenced by environment. Mayer and Poljakoff-Mayber (1975) reported that the optimum temperature range for germination can be influenced by the source of seed, genetic differences (both species and variety), and age of the seed. Respiration rate during germination is influenced by light. Mayer and Poljakoff-Mayber (1975) reported that as light intensity increases respiration can also be expected to increase.

Mayer and Poljakoff-Mayber (1975) state that the amount of water in contact with the seed influences germination. Excess water can induce seed dormancy resulting in poor germination.

Length of the sprouting period influences the nutrient composition of the sprouts. Hamilton and Vanderstoep (1979) reported an increase in moisture, ascorbic acid, and riboflavin contents with increased sprouting time, 3 to 5 days.

There are differences in germination and seedling growth due to cultivar. Heinrichs (1967) found significant differences in germination rate among alfalfa cultivars of diverse genetic origin. He stated that there is a trend for very winterhardy cultivars to portray a lower level of germination than non-hardy cultivars. Winterhardy

cultivars generally took longer to germinate than less winterhardy cultivars. Watter and Jensen (1970) grew seeds of 'Moapa' and 'Ranger' alfalfa for 22 days under similar conditions. Moapa seedlings emerged faster and were larger than Ranger. They concluded that the size of the Moapa seedlings is probably related to faster emergence and subsequent photosynthesis as well as inherently more seedling vigor than Ranger seedlings.

Many methods for growing sprouts have been reported (Anon, 1974; Fordham, et al., 1975; Larimore, 1975; Munroe, 1977; Patwardhan, 1962). The optimum temperature range reported for producing sprouts is 16-27 C (Fordham, et al., 1975; Larimore, 1975; Munroe, 1977). Recommended sprouting time for alfalfa is 1-6 days, or when the sprout is 1/3-2 in. long (Anon, 1974).

Several seed characteristics are important in sprouting. These include percentage germination, percentage hard seed, and seedling vigor. Germination percentages of 85 or greater are considered desirable. The lower the percentage of hard seed the better. Hard seed will not germinate as rapidly resulting in lower yield. Rapid germination or seedling vigor is preferred for sprouting. Rapid germination reduces the growing time required before marketing the sprouts and increases yield per unit of time.

Methods for growing sprouts are nearly as varied as the number of growers. For the home sprouter these include: a glass jar with cheesecloth over the top, a wooden tray covered with a moist towel, or a clay flower pot. There are two principle methods by which sprouts are commercially produced: 1) Sprouts are grown in large tubs which are flooded with water and drained several times a day. At maturity, sprouts are harvested, weighed, and packaged in plastic bags in which they are marketed. In the trade, these sprouts are referred to as "bagged sprouts." 2) Seeds are planted and grown in plastic trays with drainage holes in the bottom. Water is applied by overhead sprinklers. When sprouts are mature a lid is placed on the tray and they are marketed as such. This product is referred to as "live sprouts."

Whether produced on a small scale or on a commercial scale, sprouts are grown without soil or added nutrients. Commercially sprouts are grown in a controlled environment. This is the only way that a grower can consistently harvest a quality product.

We undertook an investigation that examined genetic and environmental influences on germination of alfalfa seed for human consumption. Six alfalfa cultivars representing a broad range in dormancy were germinated under varying environmental conditions including temperature, light duration, amount and frequency of water application, and number of days to harvest. Sprouts were evaluated for fresh weight (yield), nutritional value, and taste acceptability.

MATERIALS AND METHODS

Six alfalfa cultivars representing a broad range in fall dormancy were used in this study. 'Ranger' and 'Tempo' were the dormant cultivars used, semidormant cultivars were represented by 'Caliverde 65', 'AS-49' and '167', and 'Moapa 69' was the nondormant cultivar. Five experiments were conducted to test the environmental parameters under study. In each experiment three levels of one of the five environmental parameters were tested while all other parameters were held constant at the standard value. Each experiment consisted of three separate germination trials, one germination trial for each level of a parameter. Standard environmental conditions were 21 C, 24 hrs light, 8 liters quantity-of-water-applied, 1 hour water-application-interval, 6 days to harvest.

Temperatures of 16, 21, and 27 $\pm$ 1C were used. There was no diurnal fluctuation in temperature.

Light duration was the number of continuous hours per twenty-four hour period that sprouts were exposed to fluorescent light. Light durations of 0, 12, and 24 hours were used.

Water application was studied in two experiments: Quantity-of-water-applied per twenty-four hour period and water-application-interval. Quantity-of-water-applied was either 4, 8, or 12 liters per 0.5 kilograms of dry seed. Water-application-intervals included: 1) one hour--applying 1/24 of the total amount in each application; 2) two hours--applying 1/12 of the total amount in each application; and 3) 4.8 hours--applying 1/5 of the total amount in each application.

Number of days to harvest was measured from the time the seed first began soaking to the time sprouts were harvested for analysis. Sprouts were grown for 4, 6, and 8 day periods.

Fresh weight yields and percentage protein were measured for all samples

RESULTS AND DISCUSSION

Fresh weight yields of sprouts in the five experiments ranged from 71.8 g (6.5 g sprouts:1 g seed) to 147.7 g (13.4 g sprouts:1 g seed). Percentage protein on the basis of fresh weight of sprouts ranged from 1.8 to 5.7. Correlation coefficients were computed for fresh weight v.s. percentage protein. A significant negative correlation was found in every case. The r values were: -.964, -.748, -.762, -.693, -.975 for temperature, light duration, quantity-of-water applied, water-application-interval, and number of days to harvest, respectively.

Percentage protein of the sprouts measured on a dry weight basis was greater than the percentage protein in the ungerminated seed (Table 2). Total protein, however, decreased as the seed sprouted. The decrease in dry weight as the seed germinates more than compensates for the apparent increase in percentage protein measured on a dry weight basis. Our results do not support the conclusions of Kylen and McCready (1975), or Hamilton and Vandersteop (1979).

The optimum environments for producing sprouts of high quality or high fresh weight as determined by our results are listed in Table 3. Sprouts were grown under these two optimum environments and analyzed for more complete nutritional information (Table 4). Nutritional quality of sprouts grown under the environment defined for high quality was generally better than sprouts grown for maximum fresh weight.

CONCLUSION

Significant differences were found among cultivars and between environments for fresh weight and percentage protein of alfalfa sprouts. Optimum growing conditions were defined (Table 3) for producing sprouts of high quality and high fresh weight. Our data suggests that non dormant cultivars will produce greater fresh weight yields, but a lower percentage protein than dormant cultivars. There are, however, differences among cultivars within a dormancy group for the quality and quantity of sprouts produced.

Percentage protein of the sprouts measured on a dry weight basis was greater than the percentage protein in the ungerminated seed. Total protein, however, decreased as the seed sprouted.

A significant negative correlation was consistently found between fresh weight and percentage protein. In practical terms this means that if the consumer is to obtain alfalfa sprouts of high quality, the grower likely will have to sacrifice yield.

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Table 1. Alfalfa seed production, alfalfa seed sold for sprouting, total sprouts produced, and farm value of sprouts sold in California in 1970, 1975, and 1979.

Year	Total Seed Production		Seed Sold for Sprouting*	Total Sprouts Produced*	Farm Value *
	United States	California			
	----------1,000 lbs----------				(1,000 dollars)
1970	137,977	44,260	50	450	225
	91,405	29,325	400	3,600	2,340
	105,515*	39,060*	1,450	13,050	8,483

* Estimated

Table 2. Total protein content of seed and sprouts, and percentage protein of sprouts on a dry weight basis from 100 g of seed of six alfalfa cultivars.*

Cultivar	Protein from 100 grams of seed		
	Seed (g)	Sprouts (g)	Sprouts (%)
Ranger	35.4	28.2	40.7
	38.6	26.7	42.9
Caliverde 65	38.1	26.5	41.2
AS-49	37.3	29.4	42.8
	38.5	29.8	43.1
Moapa 69	39.8	30.2	43.5
Mean	37.9	28.5	42.4
$S_{\bar{x}}$	0.1	0.3	0.1
CV	2.4	7.7	2.4

* Sprouts grown under standard environmental conditions.

Table 3. Optimum environmental conditions for producing alfalfa sprouts of high quality or high fresh weight.

	Quality	Fresh weight
Temprature (C)	16	21
Light duration (hr)	12	0
Quantity-water-applied (l)	12	
Water-application-interval (hr)	2	1
Number-of-days-to-harvest	4	6

Table 4. Fresh weight and nutrient composition on a fresh weight basis of alfalfa sprouts grown from 11 grams of seed in optimum environments for fresh weight and quality.

	Optimum Environment	
Character	Quality	Fresh Weight
Fresh weight (g)	51.6	141.5
Protein (%)	6.6	2.8
Fat (%)	1.5	.3
Fiber (%)	1.7	1.0
Ash (%)	.7	.4
Magnesium (%)	.06	.03
Calcium (%)	.04	.02