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UTRIENT CONTENT OF HYDROPONICALLY SPROUTED BARLEY

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STRACT

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Barley grain was sprouted hydroponically in the light at 21°C for 1—7 days. Samples re freeze-dried, ground through a 1-mm screen and analyzed for proximate nutrients, ino acids, minerals and fatty acids. During sprouting, weights of dry matter (DM), rch (NFE) and gross energy decreased markedly ($P < 0.05$). A smaller reduction in tein weight also occurred. Weights of ash and fat increased slightly and fibre increased rkedly with increased sprouting time. Among the amino acids, weights of cystine, tamic acid and proline decreased, whilst aspartic acid and alanine increased. There was light gain in Cu, Na and Zn due to the mineral content of the water source. The fatty d concentration showed a significant ($P < 0.05$) positive relationship with growth iod.

These results indicate that the younger the sprout, the greater its nutrient weight. us, it would appear that Day 1 sprouts are nutritionally superior to Day 4 sprouts ich are currently being fed to livestock. It would also appear that field-sprouted grain, ich is analogous to Day 1 sprouts in terms of gross physical appearance, would have a nimal loss of nutrients.

TRODUCTION

Early work on the nutritive value of sprouted grain proved contradictory some investigators found improvements in livestock performance cCandlish and Struthers, 1939; and Paterson, 1938; Tinsley, 1938, both as ed by Leitch, 1939), while others observed no effect (Reading, 1925; stock, 1937; Fishwick, 1937; Schmidt et al., 1937; all as cited by Leitch, 39).

Thomas and Reddy (1962) investigated the benefit of giving sprouted oats dairy cows. The hydroponic systems used in their experiments were more dern than the early systems, in that these units were now insulated, ernally illuminated, thermostatically controlled and electrically powered, th the growing cycle reduced from 10 to 7 days. However, these modern- tions did not seem to improve the finished product, as Thomas and Reddy

(1962) found no improvements in milk production or milk quality when cows were fed on such sprouted grains.

A new hydroponic unit now available utilizes a 4-day growth cycle in order to maximize the capacity of the machine. Also, a nutrient solution is no longer added to the water owing to the expense involved compared to the small improvement in nutrient content of the sprouts (Trubey et al., 1969). With the advent of this new hydroponic system there has been renewed interest in the nutritional value of sprouted barley. The nutrient composition of barley sprouted in the dark for malting purposes has been well documented. However, there has been limited research on the nutrient composition of light-sprouted barley.

Results from hydroponic culture may also have an application relative to field-sprouted grain caused by wet weather conditions at harvest. Some workers have found no difference in performance of livestock fed on sprouted and non-sprouted grain (Bull and Peterson, 1969; Farlin et al., 1971; Rowland et al., 1978) while Falen and Peterson (1969) reported an increase in the metabolizable energy (ME) of Gaines wheat when the diet contained a combination of sprouted and non-sprouted grain. Grain sprouted for 1 or 2 days hydroponically may thus be comparable to grain sprouted in the field.

Owing to the scarcity of information on the nutrient content of sprouted grains, experiments were conducted to assess the nutrient profile of barley sprouted for 1—7 days in a controlled hydroponic system. Although it is known that vitamin concentration changes during sprouting, no attempt was made to assay vitamins.

MATERIALS AND METHODS

Hydroponic unit

The hydroponic sprouting chamber employed is a highly-insulated, thermostatically-controlled and electrically-powered unit, measuring 3.0 × 1.2 × 2.4 m. Four banks of double fluorescent tubes give an illumination of 590 lux. Grain was sprayed with water for 15 min every 4 h and the temperature maintained at 21°C. A nutrient solution was not added to the spray water.

Grain preparation

Feed grade barley (2.5 kg) was pre-wetted with an equal volume of water and then distributed on to 91.5 × 30.5-cm white plastic trays in the hydroponic unit. Growth period was from 1 to 7 days. Samples were collected each day, freeze-dried, ground through a 1-mm mesh screen and stored in tightly sealed glass jars at room temperature. Three samples of dry barley were prepared similarly to serve as controls. All nutrient analyses were conducted on the dry, ground samples.

Nutrient analysis

Dry matter (DM), crude protein (CP), crude fibre (CF), ash and mineral concentrations of sprouted and non-sprouted barley were determined by the Association of Official Analytical Chemists (A.O.A.C.) (1975) methods. Nitrogen-free extract was calculated by subtracting the summation of DM, CP, CF, fat and ash from 100. Total lipids were extracted using a chloroform:methanol mixture as described by Kuksis et al. (1980). Triglyceride fraction was extracted using the method described by A.O.A.C. (1975) and its fatty acid components were separated as outlined by DeMan (1968). Cystine and methionine were determined by the performic acid procedure reported by Hirs (1967). The remaining amino acids were analyzed according to the instruction manual for the Beckman Amino Acid Analyzer, Model 119B (1975). Gross energy was determined by adiabatic bomb calorimetry (Parr Instrument Co., Illinois).

Dry-matter loss (DML) was determined by sprouting 3 trays of 1 kg barley seed and freeze-drying the entire contents of the trays. Three, 1-kg samples of dry grain were freeze-dried and their average dry-matter weight served as a control. The DML was assumed to be the difference between the DM weight of the control and test samples.

Statistical analysis

A completely randomized design with three replications of eight treatments of growing period was employed. The relationship between growth period of 0–7 days and nutrient content was analyzed using orthogonal polynomials (Steel and Torrie, 1980). Where applicable, the resulting regression equation was also determined. The 5% level of probability was assumed to be the maximum value for significance. All data from the analyses are expressed on a dry-matter basis, unless otherwise stipulated. Day 0 equates to unsprouted barley.

RESULTS AND DISCUSSION

Germination of the barley varied between 60 and 65%. Reading (1935) and Paterson (1938), both as cited by Leitch (1939), reported similar germination rates with commercial-grade corn. Seed-grade grain has a much higher germinating capacity, but the cost is prohibitive.

Fresh weight increased from 1.72 times the original seed weight, after sprouting for 1 day, to 5.7 fold after 7 days. This increase is due to the large uptake of water experienced during germination. After 1 day of sprouting, the white tip of the radicle is visible. By 3 days, the radicle has branched and the blade inside the sheath has turned green. After 4 days, a green blade has protruded above the sheath and the roots of the kernels have formed a definite mat with other kernels. From 1 to 7 days, the main visible change is the increase in root length and thickness.

Proximate analysis

There was an increase in concentrations of crude fibre, ash, total lipids and protein by 61, 26, 25 and 17%, respectively, and a 15% decrease in nitrogen-free extract (NFE) of Day 7 sprouts as compared to unsprouted barley. Similar results were obtained by McCandlish and Struthers (1939), Thomas and Reddy (1962), Hillier and Perry (1969) and Trubey et al. (1969).

The above changes in nutrient profile are misleading, since they only describe the alterations in the proportion of nutrients during barley growth. A change in weight of any one nutrient leads to proportional changes in others. Analysis of the relationship between length of growth cycle and nutrient weights showed different results. As shown in Table I, major decreases in weights of DM, gross energy (GE) and NFE occur after sprouting barley for 3 days. After 7 days, only 82%, 75% and 66% of DM, GE and starch remains.

Starch is catabolized to soluble sugars for use in respiration and cell-wall synthesis (James, 1940). If the seedlings are grown without light or at too low a light intensity, photosynthesis is non-existent or minimal (Hillier and Perry, 1969; Bidwell, 1974) and the seedling must rely on its starch and fat reserves to meet its energy demand. The light intensity inside the hydroponic unit was too low for appreciable photosynthesis and, therefore, the amount of protein also occurred. After 6 days, protein weight had decreased starch accounts for 53—67% of the dry weight of barley seed (Kent-Jones and Amos, 1967), any decrease in the amount of starch would cause a corresponding decrease in DM.

Besides the major reductions already mentioned, a smaller reduction in amount of protein also occurred. After 6 days, protein weight had decreased by 7.3%. McCandlish and Struthers (1939) and Thomas and Reddy (1962) reported similar decreases in sprouted maize and oats, respectively, when the grain was sprouted for 10 and 6 days, respectively. Leaching of nitrogenous substances (Mayer and Poljakoff-Mayber, 1975) could explain the decrease of protein. It is not known why the amount of protein should appear to increase after 7 days (Table I).

Fibre in sprouted barley increased markedly with time. Since fibre is a major constituent of cell walls (Bonner and Varner, 1965; Bidwell, 1974), increased fibre content is probably related to the number and size of cell walls as the plant grows (James, 1940; Mayer and Poljakoff-Mayber, 1975). Carbohydrates for fibre synthesis are provided by the catabolism of starch (James, 1940) and deamination of amino acids (Folkes and Yemm, 1958).

There was a significant increase in the weights of ash and total lipids with time. The change in the weight of ash will be discussed later, along with mineral composition. The increase in the weight of total lipids could be due to the increase in structural lipids associated with plant growth (Bidwell, 1974). Ching (1972, as cited by Tluczkiewicz and Berendt, 1977) reported

Nutrient weights of 1.026 kg barley dry matter sprouted for various lengths of time

Nutrient	Day of sprouting								Coefficient ± S.E.		Constant	RSD	R^2 $P <$
	0	1	2	3	4	5	6	7					
Ash (g)	28.7	27.9	28.9	28.6	27.9	31.3	31.4	33.2	$+0.66x$	± 0.162	27.4	±1.814	0.43
S.E.	±1.46	±0.64	±0.28	±0.30	±1.88	±0.84	±0.60	±0.69					0.0005
Dry matter (g)	1026	1008	996	957	902	885	867	839	$-28.7x$	± 2.21	1036	±24.84	0.88
S.E.	±7.0	±21.6	±3.9	±2.8	±22.6	±24.3	±3.8	±12.3					0.0001
Gross energy (MJ)	16.5	16.2	15.8	15.4	14.2	13.6	13.2	12.4	$-0.62x$	± 0.038	16.8	±0.424	0.92
S.E.	±0.03	±0.36	±0.05	±0.05	±0.38	±0.36	±0.03	±0.25					0.0001
Crude fibre (g)	55.6	56.8	59.6	55.8	66.8	86.7	94.5	119	$-4.95x$	± 1.823	57.6	±5.622	0.95
S.E.	±5.32	±1.26	±1.54	±0.60	±1.77	±3.68	±2.71	±3.1	$+1.95x^2$	± 0.250			0.0001
Crude protein (g)	131	128	130	131	121	123	122	130	$+4.34x$	± 3.198	129	±4.394	0.39
S.E.	±2.6	±3.0	±2.5	±1.0	±3.4	±2.4	±0.9	±1.2	$-2.46x^2$	± 1.110			0.016
									$+0.26x^3$	± 0.010			
Nitrogen-free extract (g)	777	758	750	706	654	608	580	514	$-38.2x$	± 2.09	802	±23.46	0.94
S.E.	±2,6	±17.0	±3.0	±3.6	±16.4	±16.5	±2.0	±10.4					0.0001
Total lipids (g)	34.4	36.6	27.8	35.4	32.2	35.2	37.6	42.0	$-2.50x$	± 1.056	35.3	±3.256	0.50
S.E.	±0.68	±2.05	±1.52	±1.1	±1.47	±1.05	±1.23	±1.66	$+0.49x^2$	± 0.145			0.0006

TABLE II

Amino acid weights of 1.026 kg barley dry matter sprouted for various lengths of time (g)

Amino acid	Day of sprouting								Regression coefficient ± S.E.	Regression constant	RSD	R^2 $P <$
	0	1	2	3	4	5	6	7				
Alanine ($\times 10^{-1}$)	0.42	0.39	0.45	0.52	0.52	0.51	0.46	0.57	$+0.02x \pm 0.006$	0.42	0.070	0.28
S.E.	±0.041	±0.055	±0.026	±0.070	±0.015	±0.032	±0.024	±0.026				0.008
Amino butyric acid	0.61	1.00	1.35	1.75	1.29	1.00	1.76	1.82	$+0.13x \pm 0.046$	0.87	0.511	0.26
S.E.	±0.072	±0.304	±0.476	±0.113	±0.340	±0.100	±0.402	±0.016				0.010
Arginine	5.07	5.11	4.61	4.63	4.66	4.48	4.28	4.62	$-0.09x \pm 0.028$	4.99	0.299	0.34
S.E.	±0.101	±0.250	±0.541	±0.043	±0.092	±0.066	±0.132	±0.228				0.004
Aspartic acid	5.89	6.32	5.92	6.13	7.01	7.47	6.48	8.26	$+0.27x \pm 0.075$	5.73	0.839	0.83
S.E.	±0.607	±0.483	±0.600	±0.293	±0.450	±0.275	±0.273	±0.529				0.001
Cystine	1.81	1.55	1.79	1.17	1.13	0.98	1.33	1.37	$-0.30x \pm 0.104$	1.89	0.322	0.37
S.E.	±0.133	±0.036	±0.193	±0.144	±0.149	±0.159	±0.075	±0.351	$+0.03x^2 \pm 0.014$			0.007
Glutamic acid	23.7	23.1	21.2	20.3	19.2	14.9	15.2	15.9	$-1.36x \pm 0.170$	23.9	1.907	0.74
S.E.	±1.95	±0.49	±1.16	±0.55	±0.76	±0.36	±1.62	±0.170				0.0001
Glycine	4.76	4.30	4.32	4.27	4.47	4.28	4.02	4.33	$-0.05x \pm 0.036$	4.52	0.403	0.08
S.E.	±0.613	±0.11	±0.050	±0.143	±0.142	±0.159	±0.121	±0.168				0.169
Histidine	3.02	2.91	2.69	2.55	2.31	2.78	2.37	2.35	$-0.09x \pm 0.052$	2.93	0.582	0.11
S.E.	±0.517	±0.410	±0.505	±0.254	±0.057	±0.600	±0.163	±0.054				0.106
Isoleucine	4.01	4.12	4.85	4.24	3.88	3.76	3.76	4.48	$-0.03x \pm 0.052$	4.23	0.579	0.01
S.E.	±0.182	±0.213	±0.188	±0.309	±0.434	±0.289	±0.495	±0.118				0.620
Leucine	7.84	8.15	8.00	8.10	6.53	7.01	7.08	7.72	$-0.13x \pm 0.097$	8.00	1.092	0.07
S.E.	±0.356	±0.371	±0.10	±0.510	±1.10	±0.561	±0.358	±0.227				0.202

Lysine	3.98	4.02	4.19	4.00	4.23	4.00	4.02	4.53	+0.04x	± 0.041	3.96	0.453	0.05
S.E.	±0.509	±0.351	±0.373	±0.269	±0.173	±0.250	±0.165	±0.101					0.291
Methionine	2.05	2.05	2.19	1.47	1.65	1.75	2.14	1.76	−0.03x	± 0.034	2.00	0.386	0.04
S.E.	±0.115	±0.095	±0.244	±0.274	±0.248	±0.292	±0.151	±0.065					0.356
Phenylalanine	7.37	6.26	6.47	6.44	5.24	5.65	6.47	5.36	−0.21x	± 0.117	6.90	1.284	0.13
S.E.	±1.195	±0.380	±0.999	±0.685	±0.251	±1.11	±0.780	±0.179					0.092
Proline	10.5	11.3	10.5	9.79	9.01	7.17	7.57	6.53	−0.69x	± 0.071	11.4	0.791	0.81
S.E.	±0.49	±0.11	±0.71	±0.139	±0.102	±0.159	±0.272	±0.501					0.0001
Serine	5.14	4.10	3.92	3.86	4.08	3.66	3.50	5.18	−0.06x	± 0.098	4.36	1.10	0.02
S.E;	±1.442	±0.106	±0.225	±0.145	±0.073	±0.181	±0.116	±0.220					0.547
Threonine	4.52	3.33	3.32	3.35	2.55	3.31	3.12	4.37	−0.04x	± 0.108	3.61	1.213	0.00
S.E.	±1.341	±0.071	±0.184	±0.201	±1.10	±0.175	±0.143	±0.894					0.749
Tyrosine	4.39	3.85	3.98	3.79	3.02	3.05	3.64	3.30	−0.15x	± 0.067	4.14	0.749	0.18
S.E.	±0.558	±0.424	±0.800	±0.293	±0.255	±0.559	±0.334	±0.026					0.040
Valine	4.86	5.14	5.18	5.26	5.88	4.96	4.57	5.34	+0.006x	± 0.0470	5.13	0.528	0.00
S.E.	±0.089	±0.072	±0.220	±0.294	±0.210	±0.351	±0.326	±0.276					0.905

an increase in phospholipid content when grains germinate. Carbohydrates from starch degradation can be used as precursors for fatty-acid synthesis (Mayer and Poljakoff-Mayber, 1975).

Amino acid analysis

Concentrations of aspartic acid, alanine, lysine, threonine, glycine, and γ-amino-butyric acid increased in a linear fashion, while concentrations of proline and glutamic acid decreased linearly with increased sprouting time. Concentrations of the other amino acids analyzed did not change according to a relationship with time. Similar changes were obtained by Folkes and Yemm (1958), Smith (1972), Dalby and Tsai (1976) and Alexander (1982).

As mentioned previously, the change in proportions of amino acids is not representative of the true change in the weights of amino acids. Once dry-matter loss is considered, aspartic acid and alanine were the only amino acids to really increase in weight with increasing sprouting time and correspondingly, glutamic acid, proline, arginine and cystine weights diminished (Table II). Weights of the remaining amino acids varied among sprout ages, although there was no consistent trend with germination period (Table II).

Changes observed here in amino acid weight reflect processes of seed development when barley is germinated without an exogenous source of nitrogen; protein stored in the endosperm is catabolized to amino acids, some of which provide nitrogen for amino-acid synthesis in the embryo and carbon skeletons for respiration and cell-wall synthesis (Folkes and Yemm, 1958). Glutamic acid and proline provide 90% of the nitrogen available for amino acid synthesis (Folkes and Yemm, 1958).

Mineral analysis

Concentrations of Mg, Mn, Na, P and Zn increased linearly with increased sprouting time. Concentrations of K and Fe varied among the different sprout ages, but were not related to growth period. Ca concentration did not change during sprouting. Table III indicates the absolute changes in mineral weights which occur when 1 kg of barley is sprouted for 0—7 days. Weights of Cu, Mg, Na and Zn increased, while the weight of P decreased linearly with germination period. Weights of Fe, K and Mn varied with sprout age, but did not yield a significant relationship with germination period (Table III). Sprouting did not affect absolute Ca content.

The increase in Cu and Zn could be the result of leaching from the galvanized racks and brass nozzles within the sprouting unit. The water source was relatively high in Na (118.2 mg l^{-1}), which explains the increase in weight of Na of the sprouts. The decrease in P is probably due to the leaching of phosphorus compounds (Cook, 1962).

Mineral weights of 1.026 kg barley dry matter sprouted for various lengths of time

Mineral	Day of sprouting								Regression coefficient ± S.E.	Regression constant	RSD	R^2 $P <$
	0	1	2	3	4	5	6	7				
Ca (g)	0.24	0.33	0.32	0.30	0.27	0.31	0.29	0.34	+0.005x ± 0.0056	0.28	0.0625	0.04
S.E.	±0.047	±0.059	±0.038	±0.014	±0.018	±0.010	±0.019	±0.052				0.357
Cu (mg)	4.06	6.94	7.29	6.99	5.55	10.6	8.58	10.7	+0.75x ± 0.152	4.96	1.704	0.53
S.E.	±1.165	±0.802	±0.601	±0.616	±0.444	±0.54	±0.807	±0.302				0.0001
Fe (mg)	63.0	68.1	72.9	102	84.5	70.5	73.6	75.1	+1.04x ± 1.70	72.6	19.13	0.02
S.E.	±3.63	±2.89	±2.49	±25.7	±9.62	±5.16	±4.85	±4.17				0.546
K (g)	5.13	4.71	4.62	3.39	4.76	4.55	4.28	4.42	−0.07x ± 0.067	4.73	0.751	0.05
S.E.	±0.199	±0.224	±0.227	±0.980	±0.254	±0.216	±0.189	±0.138				0.297
Mg (g)	1.40	1.31	1.30	1.39	1.44	1.38	1.42	1.43	+0.01x ± 0.006	1.34	0.06	0.17
S.E.	±0.027	±0.028	±0.005	±0.051	±0.021	±0.059	±0.030	±0.021				0.047
Mn (mg)	19.0	18.8	17.8	18.4	17.7	17.9	19.7	18.8	+0.03x ± 0.087	18.4	0.974	0.00
S.E.	±0.24	±0.86	±0.36	±0.50	±0.05	±0.68	±0.44	±0.21				0.768
Na (g)	0.22	0.37	0.41	0.67	0.70	1.62	1.47	2.04	+0.26x ± 0.024	0.02	0.276	0.84
S.E.	±0.044	±0.005	±0.010	±0.109	±0.090	±0.059	±0.146	±0.240				0.0001
P (g)	5.37	5.18	5.25	5.11	4.89	4.77	4.86	4.87	−0.08x ± 0.018	5.32	0.202	0.18
S.E.	±0.015	±0.145	±0.014	±0.098	±0.247	±0.143	±0.045	±0.071				0.0002
Zn (mg)	41.8	45.0	50.2	52.6	48.9	58.4	57.3	67.6	+3.13x ± 0.371	41.8	4.17	0.76
S.E.	±1.27	±1.20	±1.71	±1.76	±1.63	±1.34	±1.43	±4.09				0.0001

TABLE IV

Fatty acid concentration of sprouted barley expressed as total fatty acid of the triglyceride portion of fat (dry matter basis)

Fatty acid (%)	Day of sprouting								Regression coefficient ± S.E.	Regression constant	RSD	R^2 $P <$
	0	1	2	3	4	5	6	7				
Linoleic	57.4	58.1	58.0	57.6	56.8	58.1	54.6	55.1	$-0.44x \pm 0.150$	58.5	1.58	0.30
S.E.	±0.58	±0.58	±0.42	±0.55	±0.56	±1.51	±1.83	±0.79				0.009
Linolenic	6.02	6.38	6.42	5.55	5.43	7.59	7.74	8.11	$+0.30x \pm 0.103$	5.62	1.08	0.30
S.E.	±0.260	±0.504	±0.201	±1.345	±0.311	±0.315	±0.127	±0.990				0.010
Oleic	14.4	13.1	13.3	14.0	13.3	12.8	12.5	13.1	$-0.15x \pm 0.074$	13.8	0.778	0.16
S.E.	±0.19	±0.28	±0.42	±0.47	±0.47	±0.90	±0.61	±0.16				0.062
Palmitic	21.3	22.0	21.4	23.5	22.7	21.7	22.4	22.4	$+0.12x \pm 0.149$	21.8	1.585	0.02
S.E.	±0.180	±0.16	±0.31	±1.30	±0.31	±1.50	±1.75	±0.26				0.483
Stearic	0.69	0.50	0.60	0.63	0.81	1.20	0.97	1.04	$+0.08x \pm 0.020$	0.49	0.195	0.50
S.E.	±0.125	±0.023	±0.078	±0.109	±0.113	±0.250	±–	±0.064				0.0005

atty acid analysis

Fatty acids, expressed as a percentage of the total fatty acid content of e triglyceride fraction of fat, are recorded in Table IV. The changes in oncentrations of linoleic, linolenic and stearic acids showed a significant < 0.05) linear relationship with sprouting time. Palmitic acid concentration did not change during sprouting and oleic acid concentration varied nong sprout ages without yielding a significant relationship with sprouting eriod (Table IV).

Table V summarizes nutrient weights after sprouting 1 kg of barley seed y matter. These data indicate that numerous changes occur in nutrient ofile of barley during sprouting, with most of these changes following a ecific relationship with sprouting time. For example, weights of dry atter (DM), starch (NFE) and energy decreased linearly during the 7 days sprouting, whilst crude fibre (CF) increased quadratically. Weight of crude otein decreased during 6 days of sprouting, but appeared to increase after days.

BLE V

utrient weights after sprouting 1 kg barley dry matter (g)

ay	DM	Ash	CF	CP	Lysine	NFE	Lipid
	Mean S.E.	Mean S.E.	Mean S.E.	Mean S.E.	Mean S.E.	Mean S.E.	Mean S.E.
	1000 ± 0.0	27.9 ± 1.28	54.1 ± 4.85	127 ± 2.2	3.87 ± 0.470	757 ± 6.6	33.5 ± 0.52
	974 ± 13.2	28.2 ± 1.33	54.9 ± 1.06	124 ± 2.0	3.89 ± 0.352	733 ± 10.6	29.5 ± 2.98
	970 ± 3.8	27.2 ± 0.62	58.1 ± 0.87	127 ± 2.4	2.75 ± 0.387	731 ± 3.0	28.1 ± 0.27
	932 ± 2.7	28.1 ± 0.27	54.4 ± 0.58	128 ± 1.0	3.76 ± 0.161	688 ± 3.5	27.8 ± 0.30
	878 ± 22.1	27.8 ± 0.30	65.1 ± 1.73	118 ± 3.3	4.11 ± 0.168	637 ± 16.0	27.1 ± 1.84
	862 ± 23.7	27.2 ± 1.84	84.4 ± 3.58	120 ± 2.4	3.81 ± 0.327	592 ± 16.0	30.5 ± 0.81
	844 ± 3.7	30.5 ± 0.81	92.0 ± 2.64	119 ± 0.8	3.91 ± 0.162	566 ± 2.0	30.6 ± 0.59
	817 ± 12.0	30.6 ± 0.59	116.0 ± 3.06	126 ± 1.2	4.41 ± 0.097	501 ± 10.1	32.3 ± 0.67

Because these changes in nutrients are related to time, the younger the rout, the greater its nutrient weight. Thus, it would appear that Day 1 routs are nutritionally superior to Day 4 sprouts, which are currently being ven to livestock by producers using such hydroponic sprouting systems. It ould also appear that field-sprouted grain, which is analogous to Day 1 routs in terms of gross physical appearance, would have a minimal loss of utrients. The feeding value of these Day 1—7 sprouts is reported in a subquent publication (Peer and Leeson, 1985).

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