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Plant Cover Stimulates Quicker Dry Matter Accumulation in "Early" Potato Cultivars without Affecting Nutritional or Sensory Quality

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Abstract: "Early" potato crops are grown in the Mediterranean basin and are marketed from March to June, well before main-crop potato in the spring–summer growth period. Different growing technologies have been implemented to enhance potato "earliness" to achieve a better market price, but at the same time, the applied technologies may influence yield and quality of the 'early potato'. The main goal of this study was to investigate differences in "early" potato nutritional and sensory characteristics after oil-frying influenced by location and plant covering in five potato cultivars. The present investigation was carried out at two planting locations during two seasons. The application of a plant cover significantly increased the potato tubers' dry matter, starch, and sugar content in the second season. Sensory analysis of the oil-fried "early" potatoes revealed no differences between potatoes grown with or without the plant cover. We also observed significantly higher dry matter content in potatoes grown at the Split location in the second year, while no differences in the sensory scores between oil-fried potatoes grown at the investigated locations were observed. By employing a plant cover or by choosing a warmer planting location the desired potato maturity level could be reached in less time, and one could more effectively exploit the "early" potato market. By employing such techniques there should be no loss in yield, nutritional or sensory quality of potato tubers.

Keywords: potato; location; plant cover; mineral content; dry matter; *Solanum tuberosum* L.

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1. Introduction

Global potato production has a weight of 359 million tones, followed by other vegetables such as tomatoes, watermelon, and sweet potato [1]. Wide acceptance of potato as an edible crop and its adaptability to different climates led to its high consumption worldwide [2]. The cultivated potato belongs largely to one botanical species, with thousands of cultivars differing in size, shape, color, texture, cooking characteristics, and taste [3].

Early potatoes are defined as "potatoes harvested before they are completely mature, marketed immediately after harvesting and of which skin can be easily removed without peeling" [4]. "Early" potato crops are widely grown in the Mediterranean basin and are marketed from March to June, well before main-crop potatoes grown in the spring–summer growth period [5].

A raw potato tuber is rich in nutrients, vitamins and minerals that are essential health properties [6,7]. Potatoes also contain important amounts of other phytonutrients, including protein, fiber, complex carbohydrates, carotenoids, and are one of the primary suppliers of polyphenols in the human diet [8]. A medium-sized raw potato contains high levels of potassium and nearly half the daily adult requirement of vitamin C [9].

Modern potato cultivars are bred to fulfill consumer demands or for further processing in the food industry. They offer a wide range of cooking characteristics suitable for various types of thermal processing and are adjusted to highlight other ingredients or be consumed as a complete meal [3]. Potato is considered one of the most popular vegetables worldwide and can be consumed in many ways, including being boiled, roasted, baked, fried, or steamed [10]. "Early" tubers contain higher amounts of phytonutrients compared to mature tubers and are considered a delicacy when steamed or boiled [11]. In Croatia, "early" potatoes are regularly consumed oil-fried and are considered to be a "special" dish. In Italy, "early" potatoes are consumed in 51.7% of households, which spend 9.1% of their income on potatoes [12].

Technology for growing potatoes is adjusted to eliminate stress that may be caused by water and nutrient supply, but the environmental conditions during crop production have been reported to have significant impact on growth, yield, and quality of harvested potato [13].

In some parts of the Mediterranean basin, early potato production could be challenged by environmental temperatures in the first vegetative stages [14]. Enhancement of potato earliness could be achieved either by choosing early cultivars [15] or by using row covers [16]. Row covers are especially useful as protection from possible early spring frosts, since both covering and mulching with artificial materials enhances average air temperatures on the soil surface as well as 10 cm into the soil [17]. The application of different agricultural practices could affect the quality of potato [18].

Potato heat processing is responsible for the creation of characteristic sensory profiles of potato products [19]. During potato oil-frying, high temperatures cause partial evaporation of water and oil adsorption, replacing some of the lost water [20]. Therefore, potatoes with higher dry matter content (20–22%) and lower reducing sugar content (up to 3 mg/g) are preferred for oil-frying because they develop better texture, higher yields, and lower oil absorption during the process [21].

The objective of this study was to investigate the impact of plant covering and different planting locations on the early accumulation of dry matter in five potato cultivars, as well as the effects on the "early" potato nutritional properties and sensory characteristics after oil-frying.

2. Materials and Methods

2.1. Treatments and Experimental Design

A two-year field trial was conducted in the Mediterranean region of Croatia at two locations—Pula (44°51′ N, 13°51′ E) and Split (43°30′ N, 16°30′ E). At the first location, in Pula, planting was conducted on February 13th and February 23rd, and in Split it was conducted on February 26th and February 25th in the first and second years, respectively. A two-factorial experiment was designed as split-plot in three replications. The first factor being the main plot with different potato cultivars and the second factor being the sub-plot with or without direct covering. The main plot was 3.5 m in width and 10.5 m in length (36.75 m^2) and consisted of four rows.

Potato cultivars used in the first trial year were: Adora, Berber, Jerla, and Red Scarlet. In the second trial year, Adora was replaced by Vivaldi. Adora is classified as a very early cultivar, Berber and Jaerla as early, and Read Scarlet and Vivaldi are medium early cultivars (HZPC, Holland B.V., Joure, The Netherlands). Adora, Berber, Jerla and Vivaldi have a yellow skin color, whereas Red Scarlet has red skin color. The second factor in the experiment was usage of non-woven covers and comparisons with uncovered crops. Material used for cover was Lutrasil® (Freudenberg, Weinheim, Germany), 17 g/m^2 in weight. At the time of planting, covers were placed on the soil surface and removed 50 and 30 days after germination in the first and second year, respectively. Whole potato tubers (diameter 28–35 mm) were planted at a distance of 0.75 m between and 0.35 m within rows (4.08 plants/m^2). Only the two middle rows were used for sampling.

2.2. Soil Properties and Agricultural Management Practice

At Pula, the experiments were carried out on Terra rossa, a type of red clay soil produced by the weathering of limestone and dolomites, with a soil texture of 40.7% sand, 26.4% silt, and 30.9% clay. Other soil characteristics were as follows: pH 7.2, organic matter 1.5%, P_2O_5 45.8 mg/100 g soil, and K_2O 16.2 mg/100 g soil. The experiment in Split was conducted on an anthropogenic, carbonate, deep clay-loamy soil on sandstone and marly soil, with a soil texture of 28% sand, 32.6% silt and 39.4% clay. Other soil characteristics were as follows: pH 7.6, organic matter 2.1%, P_2O_5 6.0 mg/100 g soil, and K_2O 31.8 mg/100 g soil. The average air temperatures in Pula and Split during both seasons are presented in Figure 1.

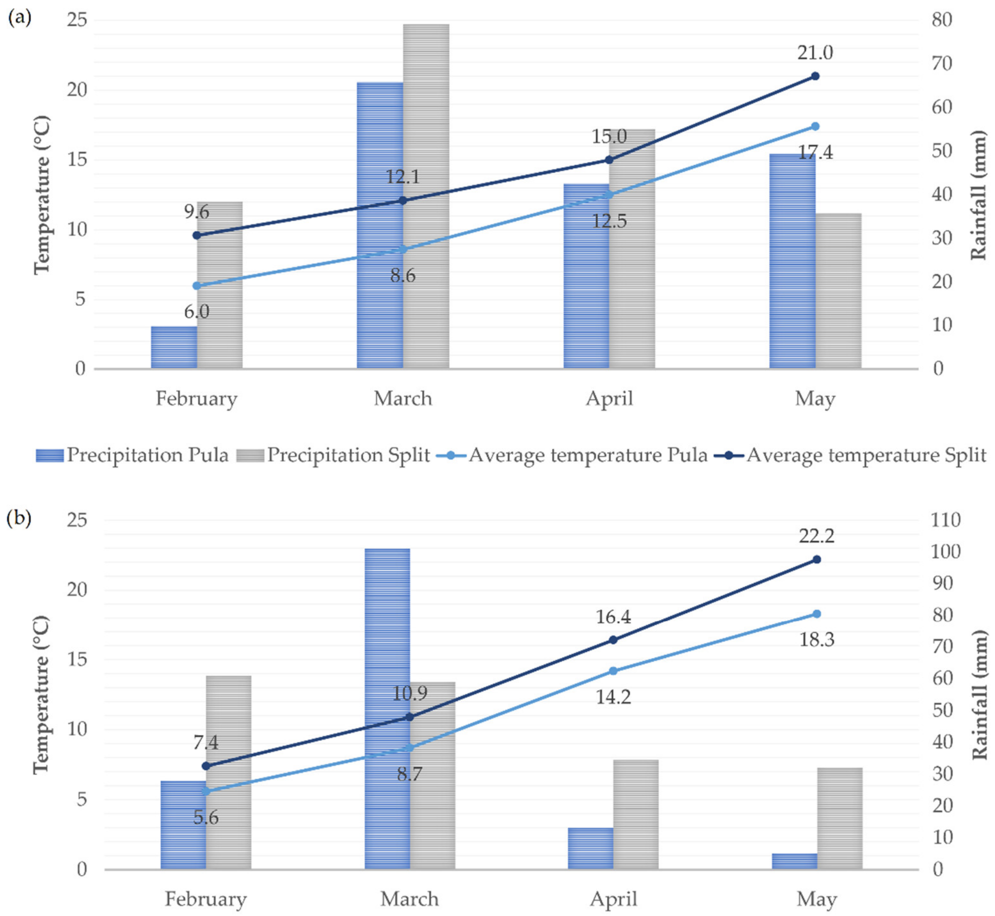

Figure 1. Average air temperatures and rainfall in the (**a**) first and (**b**) second year at the Pula and Split locations.

The experimental fields in both seasons were plowed to a depth of 30 cm, and 735 kg ha^{-1} of mineral fertilizer 7N-6.1P-17.4K was incorporated into the soil. Subsequently, herbicide (Sencor WG70 at 1 kg ha^{-1}, active substance metribuzin) was applied to the soil with a rotary cultivator. The inter rows were hoed once before plants reached 15 cm in height and the plants were mound before canopy closure. A fungicide (Ridomil Gold at 2.5 kg ha^{-1}, active substance metalaxyl m and mancozeb) and insecticide (Actar 25 WG 0.07 kg ha^{-1}, active substance thiamethoxam) were applied according to crop monitoring once or twice during a season. The crop was irrigated by drip irrigation (T-tape; T-Systems International, San Diego, CA, USA), with an emitter spacing at 20 cm (capacity of 1 L h^{-1}) as needed.

Tubers were harvested manually, 60 days after germination of covered plants, which in Pula was on June 2nd and May 25th, and in Split on May 27th and May 25th in the first and second seasons, respectively.

Only healthy, well-shaped tubers of marketable size (diameter 35–80 mm) were used for chemical analysis and sensory evaluation.

2.3. Tuber Mineral Composition

The tubers were washed, dried with tissue paper, weighed, and diced. Finally, a portion was oven-dried at 65 °C until constant weight. The dehydrated material was ground, passed through a 1 mm sieve, and subsequently used for the determination of minerals. In this study, five mineral elements (N, P, K, Mg, Ca) were analyzed. Approximately 0.5 g of the oven-dried material was mineralized in a muffle furnace at 550 °C for 12 h. After cooling, the resulting ash was dissolved using hydrochloric acid (HCl). Phosphorus was determined with the vanadate-molybdate yellow color method using a UV–visible spectrophotometer (Cary 50 Scan, Varian, Palo Alto, CA, USA) at 420 nm. Potassium was determined using flame photometry (model 410 flame photometer, Sherwood Scientific, Cambridge, UK). The other minerals (Ca and Mg) were determined by atomic absorption spectrometry (Spectraa 220, Varian, Palo Alto, CA, USA). The nitrogen content was determined by Kjeldahl digestion with a Kjeltec System 1026 (Tecator, Höganas, Sweden). The tuber protein content was obtained by multiplying the obtained results with the factor 6.25. Quantification of individual minerals in the samples was performed using calibration curves. Data are expressed as g or mg kg^{-1} of dry weight (DW).

2.4. Soluble Carbohydrates and Starch Analysis

The content of soluble carbohydrates was analyzed separately by high-performance liquid chromatography (HPLC). The procedure was fully described by Štampar et al. [22]. Briefly, samples for sugar determination (glucose, fructose, and sucrose) were prepared from 1.5 kg of fresh tubers and then divided into three subsamples. They were converted into pulp individually by a mixer and homogenized with Ultra-Turrax T-25 (Ika-Labortechnik, Staufen, Germany). The tuber puree (10 g) was diluted to 50 mL with ultra-pure water and centrifuged at 6000× g for 15 min. The extract was filtered through 0.45 µm Millipore filters prior to analysis. Sugars analyses were performed by injecting 20 µL of the sample extract on an Aminex HPX-87C column held at 85 °C at a flow rate of 0.6 mL/min, with ultra-pure water as eluent. Sugars present in each sample were identified and quantified against retention times and peak areas of analytical standards, respectively. Standards for sucrose, glucose and fructose were obtained from Fluka Chemical (New York, NY, USA).

The percentage of starch was calculated by specific weight. Briefly, the weight of 10 potato tubers was determined both in air and after their immersion in water. The specific weight was calculated according to Vasanthan et al. [23].

2.5. Vitamin C

The concentration of L-ascorbic acid was measured as reported by Tausz et al. [24]. Briefly, L-ascorbic acid was extracted from 200 mg of lyophilized tuber tissue with 5 mL of cold 1.5% (w/v) metaphosphoric acid containing 1mM EDTA. The mixture was homogenized (T-25 Ultra-Turrax) for 50 s in an ice bath. All extraction procedures were performed in dim light. After filtration through 0.2 µm Minisart SRP 15 filter, extracts were subjected to isocratic HPLC analysis on a Spectra-Physics HPLC system equipped with Spectra Focus UV-VIS detector and a Lichrosorb RP-8 (250 × 4.6 mm) column with an Lichrosorb RP-8 (50 × 4.6 mm) precolumn (Alltech Associaties, Inc., Deerfield, MA, USA) using methanol/water (1/3, v/v) containing 1 mM hexadecylammoniumbromide and 0.05% (w/v) sodium dihydrogen phosphate monohydrate (pH 3.6) as solvent, at a flow rate of 1 mL/min, with a run time of 20 min, and photometric detection at 248 nm. Identification of ascorbic acid was achieved by comparing the retention time as well as by the addition of a standard. The concentration of ascorbic acid was obtained with the external standard method.

2.6. Sensory Evaluation

Potato tubers of uniform shape and size were used for sensory evaluation within 5 days after harvest. The tubers were peeled of, cut into strips, and fried in hot sunflower oil at 180 °C for 15 min. The fried strips were drained for 30 to 60 s, salted, and served hot to panelists.

Sensory attributes were assessed by a trained sensory panel (15 trained panelists). The panels consisted of 60% women and 40% men, aged 30 to 48 years. Panelists were trained in flavor and texture attributes of fried potatoes. Samples were coded and served to panelists randomly in white shallow ceramic plates. Between samples, panelist were served with room temperature tap water.

The sensory attributes were assessed on a 5-point numerical scale with overall impression being the only exception (10 point). Sensory descriptors were as follows: odor intensity (1—no odor, 5—excellent), crispness (1—too crispy or not crispy, 5—optimal), texture (1—bad, 5—optimal), overall taste (1—unacceptable, 5—excellent), overall appearance (1—bad, 5—excellent), and overall impression (1—bad, 10—excellent).

2.7. Data Analysis

Factorial analysis of variance (ANOVA) was applied on all data and the data set was split according to harvest year and analyzed separately. Means were separated by Tukey's high significant difference (HSD) test where the F-test was significant. Additionally, partial least square (PLS) classification was performed on the data. Statistica version 13.4 (Tibco Inc., Palo Alto, CA, USA) was used for all statistical analyses.

3. Results

3.1. Yield and Dry Matter

Total yield was found to be significantly different according to planting location, where higher yields were obtained in Pula compared to Split in both harvest years (Tables 1 and 2). The application of the plant cover was not significantly different for the total tuber yield in both years (Tables 1 and 2). In the first year, yield was significantly higher for Berber and Red Scarlet compared to Jerla, while in the second year, Berber and Red Scarlet had significantly higher yield compared to Jerla and Vivaldi (Tables 1 and 2).

Dry matter content was found to be significantly different between planting locations only in the second harvest year, where tubers grown in Split had significantly higher dry matter content than tubers grown in Pula (Tables 1 and 2). The interaction between cultivar and location was significant for dry matter content in the second year of the study (Table 3), where only Vivaldi achieved the significantly higher dry matter content in Split compared to Pula (Table 4). Similarly, the effect of the plant cover was significant only in the second harvest year, where plants grown with the cover yielded tubers with higher dry matter content (Table 2). In both harvest years, dry matter content of tubers was influenced by cultivars, where Berber exhibited the highest dry matter content followed by Adora and Jerla in the first year, and Vivaldi and Jerla in the second year, with slight differences (Tables 1 and 2).

Table 1. Nutritional properties of potato tubers affected by location, plant cover and cultivar in the first year of growing.

Nutritional Parameters	Location			Cover †			Cultivar				
	Split	Pula	*p*-Value	Yes	No	*p*-Value	Adora	Berber	Jerla	Red Scarlet	*p*-Value
Yield (t/ha)	30.0 ± 7.8	33.1 ± 7.2	<0.001 *	15.3 ± 8.5	16.1 ± 7.3	0.134	29.6 ± 4.4 ab	34.5 ± 8.1 b	28.0 ± 5.0 a	34.0 ± 9.8 b	<0.001 *
Dry matter (%)	20.9 ± 1.1	20.5 ± 1.2	0.281	21.1 ± 1.2	20.3 ± 1.0	0.102	20.7 ± 1.0 ab	21.5 ± 1.1 b	20.5 ± 1.4 ab	20.1 ± 0.6 a	0.003 *
Starch (%)	13.8 ± 1.0	13.3 ± 1.2	0.286	14.0 ± 1.1	13.2 ± 1.0	0.121	13.6 ± 1.0 ab	14.3 ± 1.1 b	13.4 ± 1.4 ab	13.0 ± 0.6 a	0.003 *
Sucrose (g/100 g DW)	5.3 ± 1.2	5.0 ± 1.6	0.082	5.9 ± 1.4	4.5 ± 1.2	0.001 *	4.5 ± 1.4 a	6.0 ± 1.4 b	4.3 ± 0.9 a	6.0 ± 1.1 b	<0.001 *
Glucose (g/100 g DW)	0.93 ± 0.13	0.91 ± 0.12	0.672	0.94 ± 0.15	0.89 ± 0.09	0.393	0.94 ± 0.10 ab	0.97 ± 0.11 b	0.83 ± 0.10 a	0.93 ± 0.15 ab	0.016 *
Fructose (g/100 g DW)	0.82 ± 0.07	0.83 ± 0.11	0.815	0.83 ± 0.08	0.82 ± 0.10	0.788	0.84 ± 0.10	0.81 ± 0.10	0.82 ± 0.08	0.82 ± 0.10	0.921
Vitamin C (mmol/kg DW)	7.4 ± 1.6	7.5 ± 2.0	0.958	6.8 ± 1.5	8.1 ± 1.8	0.063	9.0 ± 1.4 c	7.0 ± 1.9 ab	7.7 ± 1.6 bc	6.1 ± 0.8 a	<0.001 *
Protein content (g/100 g DW)	7.9 ± 2.1	7.5 ± 1.4	0.348	7.8 ± 1.9	7.6 ± 1.7	0.558	7.2 ± 2.0	7.2 ± 1.0	8.1 ± 1.1	8.4 ± 2.5	0.244
Ca (mg/kg DW)	858 ± 405	566 ± 229	0.014 *	696 ± 359	728 ± 362	0.672	842 ± 443 b	773 ± 422 b	750 ± 209 b	485 ± 215 a	<0.001 *
Mg (mg/kg DW)	808 ± 348	771 ± 175	0.048 *	778 ± 280	801 ± 272	0.146	814 ± 257 b	855 ± 168 b	921 ± 98 b	567 ± 370 a	<0.001 *
K (g/kg DW)	19.9 ± 2.4	16.9 ± 2.2	0.037 *	18.6 ± 3.3	18.2 ± 2.1	0.700	17.2 ± 4.0 a	17.6 ± 1.8 ab	19.1 ± 1.6 ab	19.7 ± 2.1 b	0.004 *
P (g/kg DW)	2.4 ± 0.3	1.8 ± 0.7	0.013 *	2.1 ± 0.7	2.1 ± 0.5	0.876	1.6 ± 0.9 a	2.0 ± 0.4 ab	2.3 ± 0.4 b	2.5 ± 0.4 c	<0.001 *

* $p < 0.05$; Different letters indicate homogenous groups in Tukey's HSD test ($p < 0.05$); Data are presented as mean ± standard deviation (N = 3); † Cover—Lutrasil® (Freudenberg, Weinheim, Germany), 17 g/m^2 in weight.

Table 2. Nutritional properties of potato tubers affected by location, plant cover and cultivar in the second year.

Nutritional Parameters	Location			Cover †			Cultivar				
	Split	Pula	p-Value	Yes	No	p-Value	Berber	Jerla	Red Scarlet	Vivaldi	p-Value
Yield (t/ha)	11.4 ± 4.4	20.1 ± 7.6	0.040 *	15.3 ± 8.5	16.1 ± 7.3	0.524	19.3 ± 8.5 b	12.9 ± 4.5 a	17.8 ± 6.6 b	12.9 ± 9.4 a	<0.001 *
Dry matter (%)	21.0 ± 0.7	20.7 ± 0.7	0.032 *	21.4 ± 0.4	20.3 ± 0.5	<0.001 *	21.1 ± 0.5 b	20.8 ± 0.7 b	20.4 ± 0.6 a	21.0 ± 0.8 b	<0.001 *
Starch (%)	13.8 ± 0.6	13.6 ± 0.6	0.092	14.1 ± 0.4	13.2 ± 0.5	0.001 *	14.0 ± 0.6 b	13.6 ± 0.6 ab	13.2 ± 0.5 a	13.9 ± 0.7 b	<0.001 *
Sucrose (g/100 g DW)	5.7 ± 1.5	6.1 ± 1.2	0.217	6.5 ± 1.5	5.3 ± 0.9	0.011 *	7.1 ± 1.3 b	5.8 ± 1.2 ab	5.8 ± 1.0 ab	5.0 ± 1.1 a	<0.001 *
Glucose (g/100 g DW)	0.95 ± 0.10	0.90 ± 0.08	<0.001 *	0.96 ± 0.07	0.88 ± 0.10	<0.001 *	0.88 ± 0.11 a	0.93 ± 0.09 ab	0.99 ± 0.07 b	0.89 ± 0.08 a	0.008
Fructose (g/100 g DW)	0.88 ± 0.13	0.90 ± 0.07	0.220	0.93 ± 0.09	0.85 ± 0.10	0.003 *	0.86 ± 0.11 a	0.87 ± 0.09 ab	0.96 ± 0.10 b	0.88 ± 0.08 ab	0.044
Vitamin C (mmol/kg DW)	7.0 ± 1.6	7.5 ± 1.7	0.202	6.5 ± 1.3	8.1 ± 1.5	0.009 *	7.7 ± 2.0 b	7.4 ± 1.5 ab	6.2 ± 1.1 a	7.8 ± 1.6 b	0.044 *
Protein content (g/100 g DW)	5.9 ± 1.2	8.0 ± 1.9	0.007 *	7.1 ± 2.1	6.8 ± 1.6	0.561	6.0 ± 1.7 a	8.0 ± 2.5 b	7.3 ± 1.0 ab	6.4 ± 1.4 ab	0.009 *
Ca (mg/kg DW)	1021 ± 588	952 ± 681	0.783	1100 ± 746	873 ± 479	0.383	1035 ± 784	1202 ± 727	884 ± 325	825 ± 596	0.282
Mg (mg/kg DW)	838 ± 125	955 ± 136	0.041 *	907 ± 143	886 ± 144	0.629	877 ± 116 a	888 ± 180 ab	1012 ± 124 b	810 ± 44 a	0.002 *
K (g/kg DW)	12.4 ± 4.9	17.0 ± 2.8	0.046 *	16.0 ± 3.5	13.4 ± 5.2	0.180	14.7 ± 3.9 a	13.3 ± 5.0 a	16.6 ± 5.3 b	14.0 ± 3.8 a	0.017 *
P (g/kg DW)	2.3 ± 0.4	2.7 ± 0.4	0.018 *	2.6 ± 0.4	2.4 ± 0.5	0.102	2.3 ± 0.4 a	2.6 ± 0.5 ab	2.7 ± 0.4 b	2.4 ± 0.4 ab	0.021 *

* $p < 0.05$; Different letters indicate homogenous groups in Tukey's HSD test ($p < 0.05$); Data are presented as mean ± standard deviation (N = 3); † Cover—Lutrasil® (Freudenberg, Weinheim, Germany), 17 g/m^2 in weight.

Table 3. Interaction between location, plant cover and cultivar effects on nutritional parameters in the first and second harvest years.

Year	Interaction	Nutritional Parameters											
		Ca (mg/kg DW)	**Mg (mg/kg DW)**	**K (g/100 g DW)**	**P (g/100 g DW)**	**Glucose (g/100 g DW)**	**Fructose (g/100 g DW)**	**Sucrose (g/100 g DW)**	**Vitamin C (mmol/kg DW)**	**Dry Matter (%)**	**Starch (%)**	**Protein Content (g/100 g DW)**	**Yield (t/ha)**
First	Location × Cover	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Cover × Cultivar	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns
	Location × Cultivar	***	***	*	***	ns	ns	***	*	ns	ns	ns	ns
	Location × Cover × Cultivar	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Second	Location × Cover	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Cover × Cultivar	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Location × Cultivar	*	ns	ns	ns	ns	ns	ns	ns	*	*	ns	ns
	Location × Cover × Cultivar	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

* $p < 0.05$, *** $p < 0.001$, ns—not significant.

Table 4. Nutritional properties of potato tubers affected by the interaction between location and cultivar.

Year	Location	Cultivar	Ca (mg/kg DW)	Mg (mg/kg DW)	K (g/kg DW)	P (g/kg DW)	Sucrose (g/100 g DW)	Vitamin C (mmol/kg DW)	Dry matter (%)	Starch (%)
First	Split	Adora	1184 ± 258 c	1028 ± 70 d	20.0 ± 3.5 bc	2.3 ± 0.2 bc	5.6 ± 0.8 bc	8.5 ± 1.5 bc	21.1 ± 0.5	13.9 ± 0.4
		Berber	1132 ± 205 c	1000 ± 57 d	18.3 ± 2.2 bc	2.3 ± 0.2 bc	5.6 ± 0.7 bc	6.8 ± 1.3 ab	21.6 ± 1.5	14.5 ± 1.4
		Jerla	801 ± 219 bc	977 ± 80 d	20.3 ± 0.9 bc	2.5 ± 0.4 c	4.0 ± 1.0 a	8.5 ± 1.2 bc	20.7 ± 1.3	13.6 ± 1.2
		Red Scarlet	315 ± 145 a	226 ± 11 a	20.8 ± 2.1 c	2.5 ± 0.5 c	6.2 ± 1.3 c	6.0 ± 0.5 a	20.4 ± 0.5	13.3 ± 0.4
	Pula	Adora	499 ± 290 ab	601 ± 174 b	14.3 ± 1.9 a	0.8 ± 0.7 a	3.3 ± 0.7 a	9.5 ± 1.3 c	20.4 ± 1.3	13.3 ± 1.2
		Berber	413 ± 200 ab	710 ± 93 bc	16.9 ± 0.9 ab	1.7 ± 0.2 b	6.4 ± 1.9 c	7.1 ± 2.5 ab	21.4 ± 0.5	14.1 ± 0.7
		Jerla	698 ± 203 ab	866 ± 85 cd	17.9 ± 1.1 abc	2.1 ± 0.1 bc	4.6 ± 0.7 ab	6.9 ± 1.7 ab	20.3 ± 1.6	13.2 ± 1.6
		Red Scarlet	654 ± 108 ab	908 ± 150 d	18.6 ± 1.6 bc	2.4 ± 0.2 c	5.8 ± 1.0 bc	6.3 ± 1.0 ab	19.8 ± 0.6	12.7 ± 0.6
Second	Split	Berber	651 ± 350 a	799 ± 67	12.6 ± 4.4	2.0 ± 0.4	7.0 ± 1.7	6.9 ± 1.8	21.2 ± 0.6 cd	14.1 ± 0.6 cd
		Jerla	1442 ± 866 a	770 ± 89	10.7 ± 5.3	2.4 ± 0.3	6.1 ± 0.9	7.8 ± 1.3	20.8 ± 0.7 abcd	13.6 ± 0.6 abcd
		Red Scarlet	1060 ± 353 a	981 ± 154	13.6 ± 6.2	2.4 ± 0.3	5.5 ± 1.0	6.1 ± 1.2	20.5 ± 0.5 ab	13.3 ± 0.4 ab
		Vivaldi	928 ± 450 a	801 ± 52	12.6 ± 4.3	2.4 ± 0.4	4.3 ± 0.6	7.3 ± 1.7	21.5 ± 0.7 d	14.2 ± 0.6 d
	Pula	Berber	1419 ± 936 a	955 ± 103	16.9 ± 1.5	2.5 ± 0.3	7.1 ± 0.9	8.6 ± 1.8	21.1 ± 0.5 bcd	13.9 ± 0.7 bcd
		Jerla	961 ± 523 a	1005 ± 173	16.0 ± 3.2	2.8 ± 0.6	5.6 ± 1.4	6.9 ± 1.7	20.8 ± 0.7 abc	13.7 ± 0.6 abcd
		Red Scarlet	707 ± 183 a	1043 ± 88	19.6 ± 1.4	3.0 ± 0.3	6.1 ± 1.0	6.3 ± 1.0	20.3 ± 0.6 a	13.2 ± 0.7 a
		Vivaldi	722 ± 743 a	818 ± 36	15.5 ± 3.0	2.4 ± 0.4	5.6 ± 1.2	8.3 ± 1.5	20.6 ± 0.8 abc	13.5 ± 0.6 abc

Different letters in columns indicate homogenous groups in Tukey's HSD test ($p < 0.05$); Data are presented as mean ± standard deviation (N = 3).

3.2. Carbohydrates

Location had no significant impact on potato tuber starch content in both harvest years (Tables 1 and 2). The effect of the plant cover was found to be significant in the second year, where plants with the cover yielded tubers with higher starch levels compared to plants grown without the cover (Table 2). In the first year, the difference was not statistically significant (Table 1). Similarly to dry matter, Berber had the highest starch content in the first year, closely followed by Adora, Jerla and finally Red Scarlet (Table 1). In the second year of the investigation, Berber and Vivaldi exhibited the highest starch content, followed by Jerla and Red Scarlet (Table 2).

The interaction between cultivar and location was found to be significant for the starch content in the second year (Table 3). Vivaldi achieved significantly higher starch content in Split compared to Pula (Table 4). Red Scarlet had similar starch content at both locations (Table 4). Tuber sucrose content did not differ between planting locations in both harvest years (Tables 1 and 2). The application of the plant cover had significant influence on sucrose content in both harvest years, where tubers grown with the plant cover had higher sucrose content than those grown without (Tables 1 and 2). Sucrose content also differed between cultivars in both harvest years (Tables 1 and 2). In the first year, Berber and Red Scarlet had significantly higher sucrose content compared to Jerla and Adora (Table 1) while in the second year, Berber had significantly higher sucrose content compared to the Vivaldi cultivar (Table 2). Significant interactions were observed between planting location and potato cultivar in the first year (Table 3), where the Adora cultivar showed significantly higher sucrose content in Split compared to Pula (Table 4).

Potato tuber glucose content was found to be significantly higher in tubers grown in Split in the second harvest year (Table 2). Significant interactions for sucrose content were observed between locations and cultivars in the first year (Table 3) where the sucrose content was significantly higher for Adora in Split compared to Pula (Table 4). In the first year, although higher on average in Split, there were no significant differences between planting locations (Table 1). Plants that were covered yielded tubers with significantly higher glucose levels in the second harvest year (Table 2). Significant differences in glucose content between cultivars were detected in both harvest years (Tables 1 and 2). In the first year, Berber had significantly higher glucose content compared to Jerla, and it was comparable to the other investigated cultivars (Table 1). In the second year, Red Scarlet achieved significantly higher glucose content compared to Berber (Table 2).

Fructose content in potato tubers was not influenced by planting location in both harvest years (Tables 1 and 2). Significantly higher fructose content was observed in tubers that were grown with the plant cover in the second harvest year (Table 2). In the first year, there were no significant differences in fructose content between cultivars nor the application of the plant cover (Table 1). In the second harvest year, similarly to glucose, significantly higher fructose content was detected in Red Scarlet compared to the Berber cultivar (Table 2).

3.3. Vitamin C

There were no observed differences in vitamin C content between potato tubers grown on different locations in both years (Tables 1 and 2), but significant interactions were observed between the application of the plant cover and location, as well as between location and cultivar in the first year (Table 3). In Split, Adora and Jerla exhibited significantly higher vitamin C content compared to Red Scarlet, while in Pula, Adora was most abundant in vitamin C among the investigated cultivars (Table 4). The interaction between cultivar and plant cover was highly expressed with Berber, where the use of the planting cover significantly decreased the amount of vitamin C present in its tuber compared to uncovered plants (data not shown). In the second year, significant differences were observed between tubers grown with or without plant cover, where tubers grown without the cover exhibited higher vitamin C content (Table 2). In the first year, Adora had significantly higher vitamin

C content compared to Berber and Red Scarlet cultivars (Table 1). In the second year, Berber and Vivaldi had significantly higher vitamin C content compared to Red Scarlet (Table 2).

3.4. Protein Content

There were no significant differences observed in potato tubers' protein content in the first harvest year either according to planting location, plant cover or cultivar (Table 1). Higher protein content was observed in the second year in tubers grown in Pula, while there was no statistically significant difference observed between potato tubers grown with or without plant cover (Table 2). In the second year, Jerla exhibited significantly higher protein content compared to Berber (Table 2).

3.5. Mineral Content

Potato tubers' mineral content was found to be significantly different between planting locations in both years, except for Ca in the second year (Tables 1 and 2). Significant interactions between location and potato cultivar were observed for Ca, Mg, K and P in the first year as well as for Ca in the second year (Table 3). The interaction shows that all cultivars, except Jerla, had higher Ca concentrations in Split compared to Pula in the first year, while in the second year, Tukey's post hoc test revealed no differences among cultivars and locations (Table 4). In the first year, Adora, Berber, and Jerla exhibited significantly higher Mg levels in Split compared to in Pula, while the opposite was observed for Red Scarlet (Table 4). The K and P levels were significantly higher in Split compared to in Pula only for Berber in the first year (Table 4). In the second harvest year, potato tubers grown in Split had higher Mg, K and P concentrations (Table 2). Plant cover had no influence on any of the observed tuber mineral levels in both harvest years.

In both harvest years, potato tubers' Mg, K and P content was significantly different between cultivars, while Ca content was found to be significantly different in the first harvest year (Tables 1 and 2). In the first year, the Ca and Mg contents were lowest in Red Scarlet, whic attained significantly higher Mg levels in the second year compared to Berber and Vivaldi (Tables 1 and 2). In the first year, Red Scarlet had significantly higher K content compared to Adora, while in the second year, Red Scarlet had the highest K content among the investigated cultivars (Tables 1 and 2). The P content was highest in Red Scarlet in the first year, while in the second year, Red Scarlet had significantly higher P content only compared to Berber (Tables 1 and 2).

3.6. Sensory Analysis of Oil-Fried "Early" Potatoes

In the first year, all sensory characteristics of oil-fried "early" potatoes were significantly influenced by planting location, where potato tubers grown in Split were consistently graded higher than those grown in Pula (Table 5). In the second year, none of the observed sensory characteristics were found to be significantly different between potato planting locations (Table 6).

Table 5. Sensory characteristics of potato tubers affected by location, plant cover and cultivar in the first year.

Sensory Characteristics	Location			Cover †			Cultivar				
	Split	Pula	*p*-Value	Yes	No	*p*-Value	Adora	Berber	Jerla	Red Scarlet	*p*-Value
Overall appearance	3.8 ± 0.8	3.3 ± 0.9	<0.001 *	3.5 ± 0.9	3.6 ± 0.9	0.496	3.4 ± 0.9 a	3.8 ± 1.0 b	3.5 ± 0.9 ab	3.6 ± 0.9 ab	0.050 *
Odor intensity	3.4 ± 0.8	3.1 ± 0.9	0.047 *	3.2 ± 0.8	3.3 ± 0.9	0.458	3.1 ± 1.0	3.3 ± 0.9	3.3 ± 0.7	3.2 ± 0.8	0.468
Overall taste	3.5 ± 0.9	3.0 ± 0.9	0.003 *	3.2 ± 0.9	3.3 ± 1.0	0.086	3.1 ± 1.0 a	3.6 ± 0.9 b	3.1 ± 0.8 a	3.3 ± 0.8 ab	0.003 *
Crispness	3.3 ± 0.9	2.8 ± 1.0	<0.001 *	3.1 ± 1.0	3.0 ± 1.0	0.938	3.1 ± 1.1 ab	3.4 ± 1.0 b	3.0 ± 0.8 ab	2.7 ± 0.9 a	0.002 *
Texture	3.7 ± 0.8	3.0 ± 0.9	<0.001 *	3.4 ± 0.8	3.4 ± 1.0	0.877	3.4 ± 1.0	3.6 ± 1.0	3.3 ± 0.8	3.2 ± 0.8	0.057
Overall impression	6.4 ± 1.6	5.3 ± 1.6	<0.001 *	5.8 ± 1.6	5.9 ± 1.8	0.059	5.7 ± 1.8	6.3 ± 1.9	5.7 ± 1.6	5.8 ± 1.5	0.793

* $p < 0.05$, Different letters in potato cultivars indicate homogenous groups in Tukey's HSD test ($p < 0.05$); Data are presented as mean ± standard deviation (N = 15); † Cover—Lutrasil® (Freudenberg, Weinheim, Germany), 17 g/m^2 in weight.

Table 6. Sensory characteristics of potato tubers affected by location, plant cover and cultivar in the second year.

Sensory Characteristics	Location			Cover †			Cultivar				
	Split	Pula	*p*-Value	Yes	No	*p*-Value	Berber	Jerla	Red Scarlet	Vivaldi	*p*-Value
Overall appearance	3.5 ± 0.9	3.6 ± 0.8	0.293	3.5 ± 0.9	3.6 ± 0.8	0.451	3.6 ± 0.8	3.7 ± 0.8	3.7 ± 0.9	3.3 ± 0.9	0.080
Odor intensity	3.2 ± 0.8	3.2 ± 0.8	0.779	3.1 ± 0.9	3.2 ± 0.8	0.352	3.1 ± 0.8	3.3 ± 0.8	3.2 ± 0.8	3.2 ± 0.9	0.461
Overall taste	3.3 ± 0.9	3.2 ± 0.9	0.663	3.2 ± 0.9	3.3 ± 0.9	0.220	3.3 ± 0.9	3.3 ± 0.8	3.4 ± 0.9	3.0 ± 0.8	0.161
Crispness	3.2 ± 0.9	3.2 ± 0.9	0.937	3.2 ± 0.9	3.3 ± 1.0	0.212	3.6 ± 0.8 b	3.1 ± 0.9 a	3.3 ± 0.9 ab	2.9 ± 0.9 a	<0.001 *
Texture	3.4 ± 0.9	3.4 ± 0.9	0.920	3.4 ± 0.8	3.5 ± 0.9	0.256	3.6 ± 0.8	3.4 ± 0.9	3.5 ± 0.9	3.3 ± 0.8	0.392
Overall impression	5.5 ± 1.9	5.5 ± 1.7	0.683	5.3 ± 1.8	5.7 ± 1.7	0.083	5.8 ± 1.7 b	5.6 ± 1.7 ab	5.8 ± 1.7 b	4.8 ± 1.8 a	0.011 *

* $p < 0.05$; Different letters in potato cultivars indicate homogenous groups in Tukey's HSD test ($p < 0.05$); Data are presented as mean ± standard deviation (N = 15); † Cover—Lutrasil® (Freudenberg, Weinheim, Germany), 17 g/m^2 in weight.

Plant cover had no influence on the observed sensory characteristics in both harvest years (Tables 5 and 6). A significant difference in both harvest years was observed in the crispness characteristic of oil-fried potatoes between potato cultivars. Significantly higher scores were observed for Berber compared to Jerla in the first year, and Berber compared to Jerla and Vivaldi in the second year (Tables 5 and 6). Overall impression was significantly higher for Berber and Red Scarlet compared to Vivaldi in the second year (Table 6).

3.7. PLS Analysis of Obtained Data

To further reveal differences between the obtained data, multivariate analysis was performed on potato tubers' physicochemical parameters, as well as on sensory characteristics. More precisely, a PLS model was developed for each dependent effect—potato cultivar, planting location and plant cover. The results for the first harvest year are presented in Figure 2 and for the second harvest year in Figure 3. In the first harvest year, the developed PLS model based on potato tubers' physicochemical parameters successfully differentiated between potato cultivars. The Berber cultivar was characterized by high dry matter, starch, sucrose, glucose, and Mg content combined with low protein and Vitamin C content, while Adora potato tubers represented the opposite (Figure 2a).

The obtained PLS model differed between potato tubers grown with or without plant cover. Tubers grown with the plant cover exhibited lower vitamin C concentrations and higher K, P, and protein content than potato tubers grown without the cover (Figure 2b). However, the model was not successful in differentiating between potato tubers' planting location (Figure 2c). The developed PLS model based on oil-fried potato sensory scores could not differentiate between potato cultivars (Figure 2d). Differences could be observed between potato tubers grown with and without the plant cover, where oil-fried potatoes grown with the plant cover were graded higher for overall appearance, impression, texture, and crispness over the potatoes which were grown without the cover (Figure 2e). Moreover, French fries from potatoes grown in Split were graded higher in the same sensory characteristics as those grown with the plant cover, i.e., overall appearance, impression, texture, and crispness, compared to those grown in Pula or without the plant cover (Figure 2f).

The obtained PLS model based on physicochemical parameters for the second harvest year showed clear differences between potato tubers grown with or without plant cover. Tubers grown with the plant cover had higher dry matter and starch content, higher soluble sugar content (sucrose, glucose, and fructose), higher Ca content, and lower vitamin C content than those grown without the cover. The plant cover had no impact on protein, K, P and Mg content (Figure 3c).

Differences could also be observed between potato tubers grown in Pula and Split. According to the developed PLS model, potato tubers grown in Split had higher dry matter and starch content combined with lower protein, K, P and Mg concentrations. However, planting location had no impact on soluble sugar and Ca content (Figure 3b).

There were no differences between potato cultivars in the second harvest year (Figure 3a). The developed PLS model based on oil-fried potato sensory scores could not differentiate among potato cultivars (Figure 3d), whether potatoes were grown with or without the plant cover (Figure 3f) or between planting locations (Figure 3e).

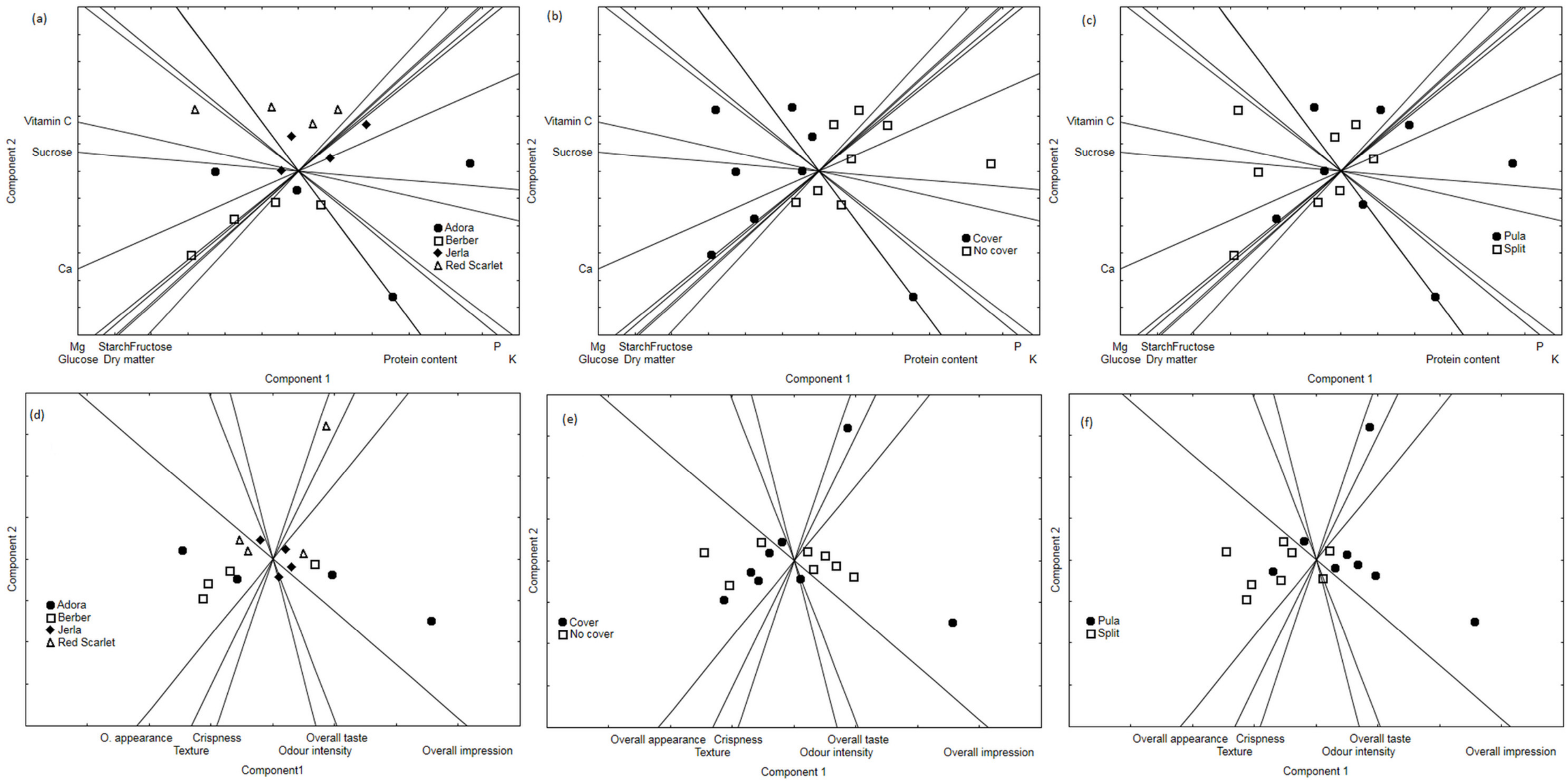

Figure 2. PLS models of the effect of (**a**) cultivar, (**b**) plant cover, (**c**) location on "early" potato physicochemical parameters and the effect of (**d**) cultivar, (**e**) plant cover, (**f**) location on oil-fried "early" potato sensory characteristics in the first harvest year.

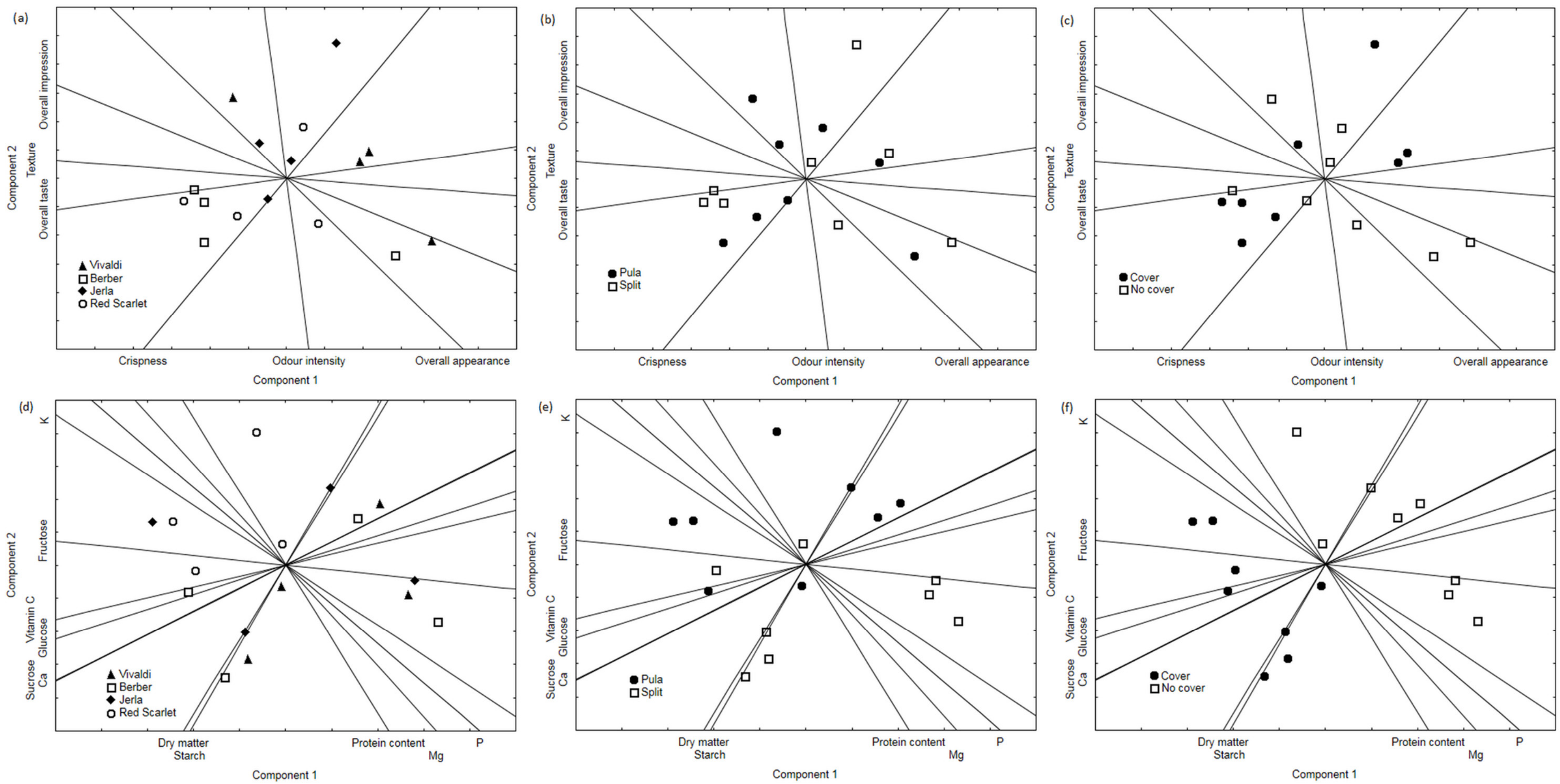

Figure 3. PLS models of the effect of (**a**) cultivar, (**b**) location, (**c**) plant cover on "early" potato physicochemical parameters and the effect of (**d**) cultivar, (**e**) location, (**f**) plant cover on oil-fried "early" potato sensory characteristics in the second harvest year.

4. Discussion

Our results showed that the planting location had a significant influence on potato yield, dry matter, glucose, and protein content in the second harvest year. The climate in Split is on average 2 °C warmer, which can stimulate the "earliness" of potato cultivars and therefore favor quicker dry matter accumulation in the tubers, as was observed previously [24]. Temperature influences dry matter accumulation directly by affecting the daily growth rate [25]. The total dry matter production is determined by the length of the growth cycle, which is divided into four phases critical for dry matter accumulation [25]. When the plant is subjected to temperate conditions, the tuberization and subsequent growth rate increases with temperatures from 15 °C up to the optimal 22 °C [25]. The latter temperature range induced earlier transition to crop senescence [25] which could explain the higher potato dry matter in Split compared to Pula in the second year. Our results are similar those of the study published by Lombardo et al. [24], where the authors reported that among three planting locations in Sicily (Italy), the highest dry matter content was observed in "early" tubers grown at the location with the highest minimum temperature. The same authors published another study, where they found that the dry matter accumulation was higher in tubers at the warmer planting location (the minimum temperature was higher by +2.6 °C on average), but only in the case of the conventional farming system [26].

In our experiment, starch content was not significantly different between locations, except in the second year and only for Vivaldi, which had higher starch content in Split compared to Pula. Fructose content did not differ between the investigated planting locations in both years, while glucose was significantly higher in Split but only in the second year. Sucrose content was significantly higher only for Adora in the first year in Split compared to Pula. Chung et al. [27] observed significant differences in potato starch and glucose content between two planting locations in Canada, where they attributed the discrepancies to environmental conditions such as total rainfall, temperature, and soil type. Simkova et al. [28] investigated the effect of the planting location on potato starch content, where the authors observed significant differences among planting locations with different above-sea altitudes. In our case, the absence of a more pronounced planting location effect could be attributed to the similarity of Pula and Split, where both are located closely to the Mediterranean coast and with similar climatic conditions. Contrary to Lombardo et al. [24] and Lombardo et al. [26], where significant differences were observed in vitamin C content between different planting locations, our research showed that the planting location did not influence vitamin C content. Protein content was found to be significantly higher in Pula compared to Split only in the first year. Lombardo et al. [26] did not observe differences in potato protein content between planting locations.

The effect of planting location was more pronounced in potato mineral content, where significant differences were observed in both harvest years, which could be influenced by differences in soil types. According to the literature, potato tubers' mineral content is influenced by soil mineral composition [29], by either conventional or organic production [30], or cultivar [30,31]. The same conclusions are presented in the PLS models, where distinctive locations can be observed in the second harvest year but not in the first. Lombardo et al. [24] and Wekesa et al. [29] reported that the tuber mineral content was significantly influenced by the planting location, which is in line with our findings, especially in the second year. In the first year, significant interactions in the tuber mineral content were observed for all investigated minerals, where significant differences were observed only for the Adora cultivar, where higher K and P content was found in Split compared to Pula.

In our study, the yield was not significantly affected by the application of the plant cover, which is opposite to the findings of Jabłońska-Ceglarek and Wadas [32], where the application of a non-woven polypropylene cover increased the average yield by 23.34% 60 days after planting. Probably, the effect of plant cover is less pronounced in less severe climates (higher early spring temperatures), as were present in our study.

Our results show that in the first year there were no differences in dry matter content between covered and non-covered plants, but in the second year, the use of the plant cover stimulated the accumulation of dry matter in potato tubers. The study by Jabłońska-Ceglarek and Wadas [32] showed that the plant cover did not influence tuber dry matter and starch content until 75 days after planting, suggesting that it is dependent on the physiological age of the tuber. So, it seems that the chemical composition of the tuber is dependent on the environmental conditions during potato vegetation, the potato cultivation method as well as on the crop maturity.

The plant covering investigated in this experiment had a similar effect on the tuber's nutritional parameters as the planting location in Split in the second year. Nutritional parameters which correlate with potato tuber physiological maturity—dry matter and carbohydrate content, including starch, sucrose, glucose, and fructose—were significantly higher in the second harvest year, while the vitamin C content was significantly lower in tubers grown under the plant cover. This effect can be explained by earlier crop transition to later developmental phases, as well as plant senescence, which stimulates earlier dry matter accumulation and tuber maturity [25] at higher temperatures under the plant cover. At the same time, Cho et al. [33] demonstrated that as the maturity level of potato tubers increases, the vitamin C content decreases, which could explain the observed decrease in vitamin C content in tubers grown under the plant cover. Additionally, Njoku et al. [34] showed a drop in vitamin C content in citrus fruits grown at warmer planting locations. Cantore et al. [35] suggested that the use of the non-woven covers raise air and soil temperature around the plant by 0.8 to 1.8 °C, thus increasing net assimilation and water use efficiency, plant weight and yield, which could explain the effect of earlier tuber initiation and growth under the cover. Additionally, Wadas and Kosterna [36] further corroborated the faster growing rate after plant emergence of potato cultivars under the plant cover compared to bare soil. Jabłońska-Ceglarek and Wadas [32] also observed a decrease in tuber vitamin C content in plants grown under the cover compared to no crop cover. In a study by Michalik [37], the use of non-woven covers contributed to dry matter accumulation and yield in some sweet pepper cultivars, but plants grown without a protective cover contained higher L-ascorbic acid content. Additionally, the study by Luthra et al. [38] found that processing potatoes had lower tuber yield in comparison to table cultivars, but had high ascorbic acid and low sucrose content. A reduction in ascorbic acid content and elevated sucrose content in tomato fruit was observed when mulching with black PE film was applied [39], while some authors suggest that soil covering with plastic film promotes plant productivity and reduces the fruit quality (acidity, pH, carotenoids, ascorbic acid, and potassium), except for total soluble solids of some tomato cultivars [40]. Other research also suggests that using both perforated foil or non-woven polypropylene plant covers elevates soil temperature by 1 to 2 °C, forcing plant emergence, shortening the tuber setting period and accelerating plant growth [36,41].

Our results showed that the plant cover did not influence the tubers' mineral content in both years. The results obtained by Wadas et al. [42] show differences between the application of different potato plant covers in the tubers' P and Mg content, where higher content of the minerals was found in tubers grown under the plant cover.

The choice of potato cultivar had a significant influence on all investigated parameters, except for fructose and protein content in the first year and Ca content in the second year. The strong effect of genotype has been confirmed by many researchers. Lombardo et al. [24] investigated the effect of eight different cultivars on "early" potato dry matter, vitamin C, and mineral content, and found significant differences among the investigated cultivars. Simkova et al. [28] investigated the differences in starch and other nutritional parameters among 16 different potato cultivars and detected significant differences.

The obtained values for dry matter, starch and protein content in our study are in line with the values obtained in "early" potato cultivars by Lombardo et al. [26]. The results obtained for sucrose are lower, while the glucose and fructose content is higher compared to the results from the same study [26]. Additionally, the obtained vitamin C content in our investigated cultivars is higher compared to the values reported in the literature [24,26]. Our results showed that the most abundant mineral in potato tubers is K, followed by P.

The obtained values for K, P, Ca, and Mg are in line with the results published by Wekesa et al. [29], as well as the USDA nutritional database [43].

The planting location in Split in the first year had a positive effect on the observed sensory characteristics of oil-fried early potatoes, while in the second harvest year, the differences were not significant. Agblor and Scanlon [44] observed differences in fry texture and color between two planting locations, where better texture properties were determined from fried potatoes made from tubers with higher Ca content. In our study, higher Ca content was observed in tubers grown in Split compared to Pula in the first year, while no significant differences were observed in the second year between planting locations. Two key factors were important in obtaining deep-fried potato products of good quality—high dry matter content and low reducing sugar content [20]. A subtle positive effect on sensory characteristics was observed with the use of plant cover, where differences could be observed through the developed PLS model in the first year. The effect of the plant cover was not significant on the fried potato sensory characteristics in both harvest years, which implies that the potato "earliness" induced by the plant cover did not cause any negative effects on the perceived sensory attributes of "early" fried potatoes. The effect of cultivar was significant on several sensory attributes in our study, including overall appearance, overall taste, and crispness in the first year, and crispness and overall impression in the second year. Among the investigated cultivars, Berber was among the highest rated fried potatoes in every sensory attribute, with significant differences between cultivars.

The application of a plant cover significantly increased the potato tubers' dry matter, starch, and sugar content in the second year. Sensory analysis of the oil-fried "early" potatoes revealed no differences between potatoes grown with or without the plant cover. We also observed significantly higher dry matter content in potatoes grown at the Split location in the second year, while no differences in the sensory scores between oil-fried potatoes grown at the investigated locations were observed. By employing a plant cover or by choosing a warmer planting location, the desired potato maturity level could be reached in less time, and one could more effectively exploit the "early" potato market.

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References

1. FAOSTAT. Food and Agriculture Organization Corporate Statistical Database. Available online: https://www.fao.org/faostat/en/#data (accessed on 22 February 2022).
2. King, J.C.; Slavin, J.L. White Potatoes, Human Health, and Dietary Guidance. *Adv. Nutr. Int. Rev. J.* **2013**, *4*, 393S–401S. [CrossRef] [PubMed]
3. Kreutzmann, S.; Bassompierre, M.; Thybo, A.K.; Buch, L.; Engelsen, S.B. Exploratory Study of Potato Cultivar Differences in Sensory and Hedonistic Applicability Tests. *Potato Res.* **2011**, *54*, 13–28. [CrossRef]
4. UNECE. *Standard FFV-52 Concerning the Marketing and Commercial Quality Control of Early and Ware Potatoes*; UNECE: Geneva, Switzerland, 2017.
5. Buono, V.; Paradiso, A.; Serio, F.; Gonnella, M.; De Gara, L.; Santamaria, P. Tuber Quality and Nutritional Components of "Early" Potato Subjected to Chemical Haulm Desiccation. *J. Food Compos. Anal.* **2009**, *22*, 556–562. [CrossRef]
6. Wijesinha-Bettoni, R.; Mouillé, B. The Contribution of Potatoes to Global Food Security, Nutrition and Healthy Diets. *Am. J. Potato Res.* **2019**, *96*, 139–149. [CrossRef]

7. Burlingame, B.; Mouillé, B.; Charrondière, R. Nutrients, Bioactive Non-Nutrients and Anti-Nutrients in Potatoes. *J. Food Compos. Anal.* **2009**, *22*, 494–502. [CrossRef]
8. Navarre, D.A.; Shakya, R.; Hellmann, H. Chapter 6—Vitamins, Phytonutrients, and Minerals in Potato. In *Advances in Potato Chemistry and Technology*; Academic Press: Cambridge, MA, USA, 2016; pp. 117–166, ISBN 9780128000021.
9. FAO. *International Year of the Potato—2008*; FAO: Rome, Italy, 2008.
10. Jansky, S.H. Potato Flavor. *Am. J. Potato Res.* **2010**, *87*, 209–217. [CrossRef]
11. Caracciolo, F.; Cembalo, L. Traceability and Demand Sensitiveness: Evidences From Italian Fresh Potatoes Consumption. *Int. J. Food Syst. Dyn.* **2010**, *1*, 352–365. [CrossRef]
12. Kim, Y.-U.; Seo, B.-S.; Choi, D.-H.; Ban, H.-Y.; Lee, B.-W. Impact of High Temperatures on the Marketable Tuber Yield and Related Traits of Potato. *Eur. J. Agron.* **2017**, *89*, 46–52. [CrossRef]
13. Ban, D.; Vrtačić, M.; Goreta Ban, S.; Dumičić, G.; Oplanić, M.; Horvat, J.; Žnidarčič, D. Effect of Variety, Direct Covering and Date of Harvest on the Early Potato Growth and Yield. In Proceedings of the 46th Croatian and 6th International Symposium on Agriculture, Opatija, Croatia, 14–18 February 2011; Pospišil, M., Ed.; University of Zagreb, Faculty of Agriculture: Zagreb, Croatia, 2011; pp. 496–500.
14. Stark, J.C.; Novy, R.G.; Whitworth, J.L.; Knowles, N.R.; Pavek, M.J.; Thornton, M.; Spear, R.; Brown, C.R.; Charlton, B.A.; Sathuvalli, V.; et al. Mountain Gem Russet: A Potato Variety with High Early and Full Season Yield Potential and Excellent Fresh Market and Early Processing Characteristics. *Am. J. Potato Res.* **2016**, *93*, 158–171. [CrossRef]
15. Hamouz, K.; Lachman, J.; Dvořák, P.; Trnková, E. Influence of Non-Woven Fleece on the Yield Formation of Early Potatoes. *Plant Soil Environ.* **2011**, *52*, 289–294. [CrossRef]
16. Hirai, G. The Effect of Non-Woven Fabric Floating Row Covers on the Emergence, Growth, and Bulb Yield of Direct-Seeded Onions (*Allium Cepa* L.) in a Subarctic Area. *Hortic. J.* **2019**, *88*, 67–75. [CrossRef]
17. Kazimierczak, R.; Srednicka-Tober, D.; Hallmann, E.; Kopczynska, K.; Zarzynska, K. The Impact of Organic vs. Conventional Agricultural Practices on Selected Quality Features of Eight Potato Cultivars. *Agronomy* **2019**, *9*, 799. [CrossRef]
18. McKenzie, M.; Corrigan, V. Chapter 12—Potato Flavor. In *Advances in Potato Chemistry and Technology*; Academic Press: Cambridge, MA, USA, 2016; pp. 339–368, ISBN 9780128000021.
19. Pedreschi, F.; Mariotti, M.S.; Cortés, P. Chapter 15—Fried and Dehydrated Potato Products. In *Advances in Potato Chemistry and Technology*; Academic Press: Cambridge, MA, USA, 2016; pp. 459–474, ISBN 9780128000021.
20. Pedreschi, F. Frying of Potatoes: Physical, Chemical, and Microstructural Changes. *Dry. Technol.* **2012**, *30*, 707–725. [CrossRef]
21. Štampar, F.; Usenik, V.; Dolenc-Šturm, K. Evaluating of Some Quality Parameters of Different Apricot Cultivars Using Hplc Method. *Acta Aliment.* **1999**, *28*, 297–309. [CrossRef]
22. Vasanthan, T.; Bergthaller, W.; Driedger, D.; Yeung, J.; Sporns, P. Starch from Alberta Potatoes: Wet-Isolation and Some Physicochemical Properties. *Food Res. Int.* **1999**, *32*, 355–365. [CrossRef]
23. Tausz, M.; Wonisch, A.; Grill, D.; Morales, D.; Soledad Jiménez, M. Measuring Antioxidants in Tree Species in the Natural Environment: From Sampling to Data Evaluation. *J. Exp. Bot.* **2003**, *54*, 1505–1510. [CrossRef]
24. Lombardo, S.; Pandino, G.; Mauromicale, G. The Influence of Growing Environment on the Antioxidant and Mineral Content of "Early" Crop Potato. *J. Food Compos. Anal.* **2013**, *32*, 28–35. [CrossRef]
25. Kooman, P.L.; Haverkort, A.J. Modelling Development and Growth of the Potato Crop Influenced by Temperature and Daylength: LINTUL-POTATO. In *Potato Ecology and Modelling of Crops under Conditions Limiting Growth*; Springer: Heidelberg, Germany, 1995; pp. 41–59. [CrossRef]
26. Lombardo, S.; Pandino, G.; Mauromicale, G. The Effect on Tuber Quality of an Organic versus a Conventional Cultivation System in the Early Crop Potato. *J. Food Compos. Anal.* **2017**, *62*, 189–196. [CrossRef]
27. Chung, H.J.; Li, X.Q.; Kalinga, D.; Lim, S.T.; Yada, R.; Liu, Q. Physicochemical Properties of Dry Matter and Isolated Starch from Potatoes Grown in Different Locations in Canada. *Food Res. Int.* **2014**, *57*, 89–94. [CrossRef]
28. Simkova, D.; Lachman, J.; Hamouz, K.; Vokal, B. Effect of Cultivar, Location and Year on Total Starch, Amylose, Phosphorus Content and Starch Grain Size of High Starch Potato Cultivars for Food and Industrial Processing. *Food Chem.* **2013**, *141*, 3872–3880. [CrossRef]
29. Wekesa, M.N.; Okoth, M.W.; Abong', G.O.; Muthoni, J.; Kabira, J.N. Effect of Soil Characteristics on Potato Tuber Minerals Composition of Selected Kenyan Varieties. *J. Agric. Sci.* **2014**, *6*, 163. [CrossRef]
30. Lombardo, S.; Pandino, G.; Mauromicale, G. The Mineral Profile in Organically and Conventionally Grown "Early" Crop Potato Tubers. *Sci. Hortic.* **2014**, *167*, 169–173. [CrossRef]
31. Tamasi, G.; Cambi, M.; Gaggelli, N.; Autino, A.; Cresti, M.; Cini, R. The Content of Selected Minerals and Vitamin C for Potatoes (*Solanum Tuberosum* L.) from the High Tiber Valley Area, Southeast Tuscany. *J. Food Compos. Anal.* **2015**, *41*, 157–164. [CrossRef]
32. Jabłońska-Ceglarek, R.; Wadas, W. Effect of Nonwoven Polypropylene Covers on Early Tuber Yield of Potato Crops. *Plant Soil Environ.* **2005**, *51*, 226–231. [CrossRef]
33. Cho, K.S.; Jeong, H.J.; Cho, J.H.; Park, Y.E.; Hong, S.Y.; Won, H.S.; Kim, H.J. Vitamin C Content of Potato Clones from Korean Breeding Lines and Compositional Changes during Growth and after Storage. *Hortic. Environ. Biotechnol.* **2013**, *54*, 70–75. [CrossRef]
34. Njoku, P.C.; Ayuk, A.A.; Okoye, C.V. Temperature Effects on Vitamin C Content in Citrus Fruits. *Pak. J. Nutr.* **2011**, *10*, 1168–1169. [CrossRef]

35. Cantore, V.; Pace, B.; Calabrese, N.; Boari, F.; Schiattone, M.I. Effects of Non-Woven Fabric and Fertilizer on Air and Soil Temperature, Leaf Gas Exchange, Yield and Quality of Wild Rocket Grown in Organic Farming. *Acta Hortic.* **2013**, *1005*, 479–486. [CrossRef]
36. Wadas, W.; Kosterna, E. Effect of Perforated Foil and Polypropylene Fibre Covers on Development of Early Potato Cultivars. *Plant Soil Environ.* **2007**, *53*, 136–141. [CrossRef]
37. Michalik, L. The Effect of Non-Woven PP Fabric Covers on the Yielding and the Fruit Quality of Field-Grown Sweet Peppers. *Acta Sci. Pol.-Hortorum Cultus* **2010**, *9*, 25–32.
38. Luthra, S.; Gupta, V.; Kaundal, B.; Tiwari, J. Genetic Analysis of Tuber Yield, Processing and Nutritional Traits in Potato (*Solanum Tuberosum*). *Indian J. Agric. Sci.* **2018**, *88*, 1214–1221.
39. Horvat, J.; Ban, D.; Goreta Ban, S.; Oplanić, M.; Žnidarčič, D. Fertigation and Mulching Effect Bioactive and Nutritive Compounds of Tomato Fruit (*Lycopersicon Esculentum* Mill.). In Proceedings of the 45th Croatian & 5th International Symposium on Agriculture, Opatija, Croatia, 15–19 February 2010; Marić, S., Lončarić, Z., Eds.; Poljoprivredi fakultet Sveučilišta Josipa Jurja Strossmayera u Osijeku: Opatija, Croatia, 2010; pp. 634–638.
40. Caliman, F.; da Silva, D.; Stringheta, P.; Fontes, P.; Moreira, G.; Mattedi, A.; Naher, L.; Ismail, A. Relation between Plant Yield and Fruit Quality Characteristics of Tomato. *Biosci. J.* **2008**, *24*, 46–52.
41. Wadas, W. Using Non-Woven Polypropylene Covers in Potato Production: A Review. *J. Cent. Eur. Agric.* **2016**, *17*, 734–748. [CrossRef]
42. Wadas, W.; Jabloriska-Ceglarek, R.; Kurowska, A. Effect of Using Covers in Early Crop Potato Culture on the Content of Phosphprus and Magnesium in Tubers. *J. Elem.* **2008**, *13*, 275–280.
43. USDA. *National Nutrient Database for Standard Reference*; USDA: Washington, DC, USA, 2018.
44. Agblor, A.; Scanlon, M.G. Effect of Storage Period, Cultivar and Two Growing Locations on the Processing Quality of French Fried Potatoes. *Am. J. Potato Res.* **2002**, *79*, 167–172. [CrossRef]