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Effects of Fruit Bagging Treatment with Different Types of Bags on the Contents of Phenolics and Monoterpenes in Muscat-Flavored Table Grapes

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Abstract: The effects of fruit bagging treatments with seven different types of bags on the physicochemical characteristics of three table grape cultivars: RuiduZaohong (RDZH), RuiduHongyu (RDHY), and RuiduHongmei (RDHM) were investigated. Headspace-solid-phase micro-extraction combined with gas chromatography mass spectrometry (HS-SPME-GC-MS) was used to determine the compositions of monoterpenes in the fruit. The results showed that the total soluble solids in RDZH and RDHY fruits treated with the transparent, mesh, yellow, white, and blue bags were significantly higher than the control. The sugar–acid ratio of RDZH was optimized under the transparent bag and yellow bag treatments, and both significantly increased the sugar-acid ratio of RDHY and RDHM. Additionally, mesh bag, transparent bag, and white bag improved the contents of phenolics to a certain extent. The most abundant volatiles were linalool, geraniol, β-myrcene, β-*cis*-ocimene, and β-*trans*-ocimene, of which linalool was the main aroma component. The least squares discriminant analysis results showed that linalool, 4-terpineol, and terpinolen could be used to distinguish the main contribution of different bagging treatments for RDZH. *Trans*-isogeraniol, α-terpineol, and terpinolen could be used for RDHY. *Trans*-isogeraniol, β-myrcene, and terpinolen could be used for RDHM. In conclusion, transparent and white bags promoted the accumulation of phenolics and monoterpenes while pink and blue bags showed inhibitory effects.

Keywords: grapes; bagging technique; monoterpene; muscat flavor

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1. Introduction

Fruit bagging technology is a key cultivation measure to produce high-quality pollution-free fruits that can also improve their commerciality. Bagging can improve fruit coloring, enhance fruit appearance, effectively prevent fruit surface pollution, and reduce pesticide residues, which is one of the important technical measures used in the fruit industry nowadays [1–4]. At present, it has been widely used in fruit tree production on apple, pear, grape, and peach species [5–8]. Fruit bags of different materials and colors have different light transmittances, which can change the microenvironment for fruit growth and development, ultimately affecting fruit quality [9–11].

As a key indicator of the quality of grape fruits, aroma directly affects the popularity among consumers. Particularly, muscat-flavored grapes are especially appreciated around the world, due to their sweet floral or fruity notes. Muscat aroma-producing substances are mainly monoterpene volatiles, including linalool, geraniol, nerol, myrcene, ocimene,

rose oxide, terpineol, citronellol and their oxides [12–14]. Monoterpene biosynthesis is initiated by the production of dimethylallyl diphosphate (DMAPP) and plant isopentenyl diphosphate (IPP) in two pathways, the plastidial methylerythritol phosphate (MEP) and primarily cytosolic mevalonic acid (MVA) pathways, with the former regarded as the main biosynthesis route for monoterpenes in the grape mesocarp and exocarp [15–18]. Studies on the impact of cultivation techniques on the aroma of grape fruits have focused on different climatic types, harvesting times, vine training systems, pruning manners, and trellis systems [19–22]. Moreover, non-muscat varieties and non-aromatic varieties have always been used as study materials. For instance, Ji et al. [23] compared the effects of different paper bag colors, namely, red bags, green bags, blue bags, white bags, and unbagged (CK), on the quality of Kyoho fruit. It was found that the bagging treatment did not affect total soluble solids (TSS) or titratable acids (TA). However, it was found that red, green, and blue bags significantly reduced the contents of terpenes and aldehydes, where green bags had the most significant negative effect. Jiang [24] evaluated the effects of different paper bag colors, namely, black bags, white bags, yellow bags, brown bags and unbagged (CK), on fruit quality and aroma components in Marselan. It was found that bagging reduced the total amount of aroma components, where black bag led to the most negative effect, followed by brown and yellow bag, and white bag corresponded to the least negative effect. However, few studies have reported the effects of bagging techniques on the fruit volatile components in muscat-flavored grapes. The present study evaluated the effects of seven different types of fruit bags on the basic physicochemical parameters, contents of phenolics, and compositions of monoterpenes of three table grape cultivars with muscat flavor to provide a theoretical basis for the application of grape bagging technology to effectively control fruit quality during production.

2. Materials and Methods

2.1. Test Site

The trial was conducted in 2016 in the demonstration vineyard in Machanying Town, Pinggu District, Beijing, China (40°13′ N, 117°12′ E). The test site was a typical alluvial plain, grapes soil-bury over-wintering zone, with an average annual temperature of 11.7 °C, an annual rainfall of 397 mm, and a growing degree day index of 2207 (base = 10 °C). The field capacity was 25.4%, bulk density was 1.37 g/cm^3, the content of organic substances was 21.07 g/kg, pH was 7.8, total nitrogen was 0.86 g/kg, total phosphorus was 0.87 g/kg, total potassium was 24.1 g/kg, and the content of soluble salts was 1.03 g/kg.

2.2. Materials and Sampling

The grape cultivars used in the experiment were *Vitis* interspecific hybrids, including RuiduZaohong (RDZH), RuiduHongyu (RDHY), and RuiduHongmei (RDHM). All three cultivars were selected by the Institute of Forestry and Pomology, Beijing Academy of Agriculture and Forestry Sciences. The grape skin of RDZH was light red with a light muscat aroma. The grape skin of RDHY was purple-red with a strong muscat aroma. The grape skin of RDHM was reddish-purple with a strong muscat aroma. Planted in 2010, the trellising system was a hedge V-system, trained to one side horizontal cordon with an inclined trunk [21,25], and the spacing in the rows and between the rows was 2 × 3 m. Vineyard management practices, such as irrigation, fertilization, disease, and pest control, were followed according to the local standards.

Three rows of grapevines (30 vines per row) were conducted for each cultivar. Twenty moderate-growth vines from each cultivar were selected to control their yield at the same level. The clusters were bagged in early July (30 days after fruit setting) with seven different types of fruit bags (provided by Hangzhou Nongfeng Plastic Film & Packaging Co., Ltd., Hangzhou, China): white polypropylene micro-perforation bags, pink polypropylene micro-perforation bags, yellow polypropylene micro-perforation bags, blue polypropylene micro-perforation bags, transparent polypropylene micro-perforation bags, nylon mesh bags, and white paper bags, which are commonly used in production (Figure 1).

Fifteen clusters were randomly selected from each single vine for bagging treatment, each type of bag was used on two clusters, and the remaining one cluster used a type of bag randomly. The same conduction was repeated on twenty vines for each cultivar. The reason the paper bag was chosen for control treatment instead of an unbagged treatment is to protect the grape clusters from birds. RDHY is an early-ripening cultivar with a bright red color, which could easily be eaten up by birds without the protection of the bag. Due to the different ripening stages of the three cultivars, fruits were considered to reach maturity when the seeds turned brown. The fruits were sampled from different fruiting positions throughout the whole vine at the end of August and the beginning of September. Ten clusters of each treatment were collected randomly and brought back to the laboratory to identify basic physicochemical parameters. The remainder of the fruits were quick-frozen in liquid nitrogen and stored at −80 °C. In the present study, abbreviations are used in the charts and figures for different kinds of fruit bagging treatments: white polypropylene micro-perforation bags = white bag, pink polypropylene micro-perforation bags = pink bag, yellow polypropylene micro-perforation bags = yellow bag, blue polypropylene micro-perforation bags = blue bag, transparent polypropylene micro-perforation bags = transparent bag, nylon mesh bags = mesh bag, and white paper bags = paper bag (control).

Figure 1. Fruit bagging treatment with different types of bags. (**A**): white polypropylene micro-perforation bags; (**B**): pink polypropylene micro-perforation bags; (**C**): yellow polypropylene micro-perforation bags; (**D**): blue polypropylene micro-perforation bags; (**E**): transparent polypropylene micro-perforation bags; (**F**): nylon mesh bags; and (**G**): white paper bags.

2.3. Measurements and Methods

2.3.1. Determination of Basic Physical and Chemical Indicators

The mass of each treated cluster was weighed by an electronic scale JM-A20002 (Cixi Red diamond Equipment Co., Ltd., Ningbo, China). The TSS was determined by a portable Brix meter PAL-1 (Atago Co., Ltd., Tokyo, Japan), and TA was determined by titration with 0.1 mol/L NaOH. The sugar-acid ratio was obtained by dividing the TSS by the TA. The remaining fruit samples were rapidly frozen in liquid nitrogen and stored in an ultra-low temperature refrigerator (−80 °C).

2.3.2. Measurement of Phenolic Contents in Grape Fruits

The total anthocyanins [26], proanthocyanidin [27], and flavonoid [28] contents were determined by ultraviolet and visible spectrophotometer P330 (Implen, Westlake Village,

CA, USA) with three replicates. The maximum absorption wavelength of the anthocyanins extract was measured with a spectrophotometer, and the corresponding compound was malvidin. Therefore, dimethyl-delphinidin-diglucoside-chloride was used as a standard, and the standards for proanthocyanidin and flavonoid were, respectively, proanthocyanidin and catechin.

2.3.3. Extraction of Monoterpenes

Extraction of monoterpenes followed previously published method with modifications [29]. The grape fruits stored in the ultra-low temperature refrigerator at −80 °C were taken for examination, where 50 g was weighed for the monoterpene extraction analysis. The grape fruits were rapidly frozen in liquid nitrogen to remove impurities, such as pedicels or seeds. Then, 0.5 g of D-glucono-delta-lactone was added to inhibit the activity of glycoside hydrolase. Next, the grape fruits were ground by a stainless grinder A11 (IKA Works, Guangzhou, China) and then mixed with 2 g of cross-linked polyvinylpyrrolidone (PVPP) under liquid nitrogen to prevent the oxidation of the sample. The flesh was macerated for 2 h at room temperature, followed by centrifugation (8000 r/min) for 10 min to collect the clear juice. Afterwards, the supernatant was transferred to a 50 mL centrifuge tube. Thereafter, the free volatiles were extracted under the following headspace-solid-phase micro-extraction (HS-SPME) conditions: 5 mL of juice was mixed with 10 µL of 4-methyl-2-pentanol (internal standard) and 1 g of NaCl in a 20 mL Teflon silicone screw-top vial. The vial was equilibrated at 40 °C for 30 min with stirring at 500 r/min. Afterward, an activated SPME tip (Supelco, Bellefonte, PA, USA) was inserted into the headspace of the vial, and the volatile components were adsorbed at 40 °C for 30 min. Additionally, the SPME tip was inserted into the GC inlet for at 250 °C for 8 min to release the volatiles. Three replicates per treatment.

2.3.4. Detection of Monoterpenes and the Qualitative and Quantitative Analysis

Gas chromatography and mass spectrometry (GC-MS) model: Agilent 7890B GC and Agilent 5977A MS (Agilent Technologies, Santa Clara, CA, USA). The capillary column was HP-INNOWAX (60 m × 0.25 mm × 0.25 µm, J&W Scientific, Folsom, CA, USA). The GC-MS conditions referred to the method published by Wu et al. [30]: high-purity helium was used as the carrier gas (He, >99.999%) at a flow rate of 1 mL/min; the inlet temperature was 250 °C, the sample was under spitless injection, and the resolution time was 8 min; and the ramp-up procedure was conducted at 50 °C for 1 min, then ramped up to 220 °C at 3 °C/min, and kept for 5 min. The mass spectrometry ionization method was electronic ionization, the ion source temperature was 230 °C, the ionization energy was 70 eV, the quadrupole temperature was 150 °C, the mass spectrometry interface temperature was 280 °C, and the mass scan range was 30–350 m/z

The detection conditions of GC-MS and the qualitative and quantitative analysis of aroma substances were referred to in previous studies [31]. The mass spectra were retrieved from the NIST 11 library using full-ion scanning spectra. The retention indices were calculated based on the chromatographic retention times and the mass spectra of existing standards. For compounds with standards, the corresponding standard curves were used for quantification, whereas for compounds without standards, the NIST 05 library of standards with similar chemical structures, functional groups, and numbers of carbon atoms were used for quantification.

2.4. Data Processing and Statistical Analysis

The data were compiled and plotted using Microsoft Excel 2007 software (Microsoft Corporation, Redmond, WA, USA). A statistical analysis of the data was performed using the analysis software Sigma Plot 12.0 (Systat Software Inc., San Jose, CA, USA), using Student–Newman–Keuls multiple comparisons for significance ANOVA with the lowest significant level of $p < 0.05$. Furthermore, the cluster analysis and least square discriminant analysis were performed using MetaboAnalyst 4.0 (Xia Lab @ McGill, Quebec, QC, Canada).

3. Results and Analysis

3.1. Effects of Fruit Bagging Treatment with Different Types of Bags on the Basic Quality Indicators of the Three Table Grape Cultivars

As shown in Table 1, there was no significant effect from the different types of fruit bags on the cluster weight or TA of RDZH. However, there was a significant effect on TSS: the content was the lowest with the paper bag and pink bag treatments, while the content in the other five treatments was significantly higher than the paper bag, with the white bag and blue bag treatments showing the highest content. The effect on the sugar–acid ratio was highest under the mesh bag treatment, followed by the pink bag, blue bag, and paper bag treatments, and lowest in the yellow bag and transparent bag treatments. Studies have shown that when the sugar-acid ratio of the table grape is between 20 and 40, the sugar–acid ratio is directly proportional to the consumer preference, the sugar–acid ratio is inversely proportional to consumer preference when it exceeds 40, and the difference was perceptible when the difference between the sugar–acid ratios of two samples was not less than 5 [32,33]. The sugar–acid ratios of RDZH under different treatments were all above 40. Therefore, the lower the value, the better the balance of the sweet and sour taste of the fruit. The sugar–acid ratios under the yellow bag and transparent bag treatments were the lowest. However, the difference between them and most of the other treatments was less than five, and only more than five from the mesh bag treatment, so the fruit taste of the mesh bag treatment was over-sweet.

Table 1. Effects of fruit bagging treatment with different types of bags on the basic quality indicators of the three table grape cultivars.

Cultivar	Bag Type	Cluster Weight/g	Total Soluble Solids/° Brix	Titratable Acidity/(%)	TSS/TA
RDZH	White bag	595 ± 74 a	15.6 ± 0.1 a	0.312 ± 0.002 a	49.8 ± 0.3 b
	Pink bag	558 ± 73 a	14.0 ± 0.1 c	0.271 ± 0.002 a	51.6 ± 0.4 b
	Yellow bag	614 ± 97 a	14.8 ± 0.1 ab	0.322 ± 0.013 a	46.0 ± 1.5 c
	Blue bag	643 ± 80 a	15.1 ± 0.1 a	0.299 ± 0.001 a	50.5 ± 0.3 b
	Transparent bag	600 ± 26 a	14.3 ± 0.0 b	0.307 ± 0.001 a	46.4 ± 0.2 c
	Mesh bag	514 ± 85 a	14.8 ± 0.0 ab	0.270 ± 0.003 a	54.8 ± 0.3 a
	Paper bag	692 ± 104 a	13.8 ± 0.0 c	0.270 ± 0.001 a	51.3 ± 0.2 b
RDHY	White bag	354 ± 55 a	20.7 ± 0.0 d	0.395 ± 0.0.02 a	52.3 ± 0.2 b
	Pink bag	404 ± 59 a	21.3 ± 0.1 c	0.386 ± 0.006 b	55.5 ± 0.3 b
	Yellow bag	375 ± 21 a	21.8 ± 0.1 b	0.360 ± 0.001 d	60.5 ± 0.4 a
	Blue bag	381 ± 42 a	19.2 ± 0.1 e	0.360 ± 0.004 d	53.2 ± 0.6 b
	Transparent bag	375 ± 21 a	23.0 ± 0.1 a	0.377 ± 0.002 c	60.9 ± 0.2 a
	Mesh bag	380 ± 37 a	21.0 ± 0.2 c	0.381 ± 0.001 bc	55.1 ± 0.3 b
	Paper bag	387 ± 55 a	18.7 ± 0.1 f	0.357 ± 0.003 d	52.4 ± 0.5 b
RDHM	White bag	666 ± 59 a	16.9 ± 0.6 a	0.562 ± 0.002 b	29.5 ± 1.6 bc
	Pink bag	667 ± 142 a	15.5 ± 0.2 b	0.505 ± 0.009 bc	31.0 ± 0.3 b
	Yellow bag	592 ± 14 a	15.9 ± 0.6 ab	0.447 ± 0.001 e	35.8 ± 1.5 a
	Blue bag	597 ± 90 a	15.9 ± 0.8 ab	0.496 ± 0.001 c	30.1 ± 1.9 bc
	Transparent bag	601 ± 52 a	15.5 ± 0.2 b	0.466 ± 0.006 d	33.6 ± 0.3 a
	Mesh bag	644 ± 107 a	17.3 ± 0.3 a	0.634 ± 0.005 a	27.4 ± 0.6 c
	Paper bag	706 ± 97 a	16.0 ± 0.7 ab	0.508 ± 0.001 bc	31.6 ± 1.7 b
p-values	Cultivar	<0.001	<0.001	<0.001	<0.001
	Treatment	0.547	<0.001	<0.001	<0.001
	Cultivar × Treatment	0.591	<0.001	<0.001	<0.001

Note: Data are average ± SE. Different letters stand for the significant difference (p value < 0.05). The same applies below.

There was no significant effect from the different types of fruit bag treatments on the cluster weight of RDHY. The TSS of the RDHY bagging treatments were significantly higher than that of the paper bag treatment. In descending order, they were transparent bags, yellow bags, pink and mesh bags, white bags, and blue bags. The TA results showed that all treatments were higher than the paper bag treatment, with white bags being the highest, followed by the pink, mesh, transparent, yellow, and blue bags. The sugar–acid ratio of RDHY was high, above 52 for all treatments, with that under transparent and

yellow bags treatments being the highest, which were above 60, followed by pink and mesh bags, and finally bluebags, paper bags, and white bags. Therefore, the fruit taste under the transparent and yellow bag treatments was over-sweet, while the fruit sugar–acid ratio under the blue, paper, and white bag treatments were relatively balanced.

There was no significant difference in cluster weight between the treatments of RDHM. The TSS under the mesh and white bag treatments were higher than that of the paper bag, whereas the TSS under the pink and transparent bag treatments were lower than that under the paper bag treatment. The TA results showed that the mesh bag treatment was the highest, followed by the white, paper and pink bags, then by the blue bag, transparent bag, and finally the yellow bag as the lowest. The results of the sugar–acid ratio were that the yellow and transparent bags were the highest, followed by paper, pink, blue and white bags, while the mesh was the lowest. The sugar–acid ratio of RDHM was below 40 for all treatments, so it was believed that the higher the value, the better the balance of taste, i.e., the yellow and transparent bags were better than the others, while the mesh, white, and bluebags were worse (sour taste).

3.2. Effects of Fruit Bagging Treatment with Different Types of Bags on Phenolic Contents in the Three Table Grape Cultivars

Fruit bagging treatment with different types of bags had a significant effect on the contents of phenolics in fruits (Figure 2). The results of the total anthocyanins were relatively consistent with the color of fruit peels of the cultivar: RDHM had reddish-purple peels with the highest total anthocyanin content; RDHY had red peels with the second highest total anthocyanin content; and RDZH had light red peels with the lowest total anthocyanin content. The differences among the seven different types of fruit bags were as follows: RDZH had the highest content under the mesh bag treatment, the lowest under the white bag treatment, and the other treatments were in between; RDHY had the highest in the yellow bag treatment, the lowest in the pink bag treatment, and the other treatments were in between; and the total anthocyanin content of RDHM was higher than that of paper bags in all bag treatments, with transparent bags and mesh bags reaching significant levels.

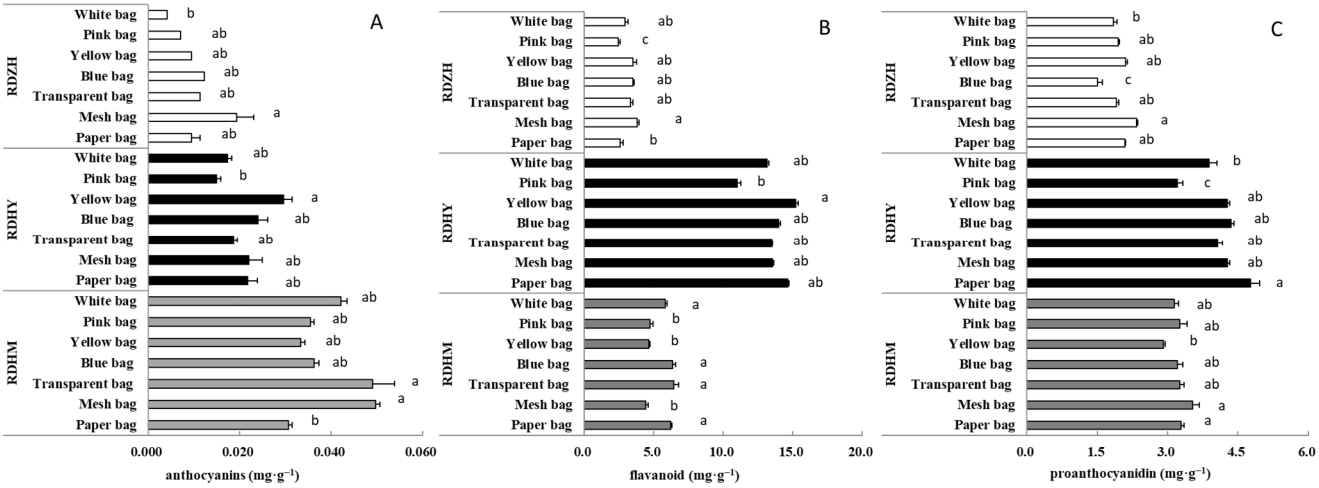


Figure 2. Effects of fruit bagging treatment with different types of bags on the total contents of anthocyanins (**A**), flavonoids (**B**), and proanthocyanidins (**C**) in the three table grape cultivars. Different letters besides the bars with the same color stand for the significant difference (p value < 0.05).

Differences in flavonoid content between the cultivars were also found. The flavonoid content was significantly higher in RDHY than that in RDZH and RDHM, while that in RDHM was slightly higher than in RDZH. The flavonoid contents under different types of fruit bag treatments were found to be the following. RDZH under the mesh bag treatment was significantly higher than that under the paper bag treatment, RDZH under the pink bag treatment was significantly lower than that under the paper bag treatment, and the

flavonoid content under the remaining four treatments was between those under the mesh and paper bag treatments. For RDHY, yellow bags were significantly higher than pink bags, and the remaining five treatments were between them with no significant difference. For RDHM, the white, blue, transparent, and paper bags were at the same level, which was significantly higher than the pink, yellow, and mesh bags.

The differences in proanthocyanidin content among the cultivars were as follows: RDHY showed the highest result, followed by RDHM, while RDZH was the lowest. The results of proanthocyanidin in different types of fruit bags were found to be the following. For RDZH, the mesh bag treatment significantly increased the content of proanthocyanidin, the blue bag treatment significantly decreased the content of proanthocyanidin, while the rest of the treatments and the paper bag treatment were at the same level. The white and pink bag treatments for RDHY and the yellow bag treatment for RDHM significantly reduced the proanthocyanidin content.

3.3. Effects of Fruit Bagging Treatment with Different Types of Bags on the Compositions and Contents of Monoterpenes in the Three Table Grape Cultivars

3.3.1. Compositions and Contents of Monoterpenes in the Three Table Grape Cultivars

The 26 monoterpenes differed in the three table grape cultivars (Table 2). Citronellal (M15) and *trans*-isogeraniol (M24) were not detected in RDZH, citronellal (M15) was not detected in RDHY, while the remaining 24 compounds were detected. The six compounds with the highest monoterpene content in the RDZH and RDHY fruits were linalool (M16), geraniol (M25), geranic acid (M26), β-*cis*-ocimene (M6), β-myrcene (M1), and β-*trans*-ocimene (M4). The six compounds with the highest monoterpene content in the RDHM fruits were linalool (M16), geraniol (M25), β-myrcene (M1), β-*cis*-ocimene (M6), β-*trans*-ocimene (M4), and α-terpinol (M19). The contents of neral (M18) and geranial (M20) were similar in the three cultivars. The contents of *cis*-rose oxide (M8) and *trans*-rose oxide (M9) were the highest in RDHY, and the contents in RDZH and RDHM were similar. The contents of *cis*-furan linalool oxide (M12), *trans*-furan linalool oxide (M13), and nerol (M22) were the highest in RDHY, followed by RDHM, and the lowest in RDZH. The contents of nerol oxide (M14), β-citronellol (M21), and geranic acid (M26) were also the highest in RDHY, followed by RDZH, and the lowest in RDHM. The geraniol (M25) content was the highest in RDHM, followed by RDZH, and then RDHY. The contents of the remaining 15 monoterpenes were the highest in RDHM, followed by RDHY, and RDZH had the lowest content. Total monoterpenes also showed the same pattern of RDHM > RDHY > RDZH (Figure 3).

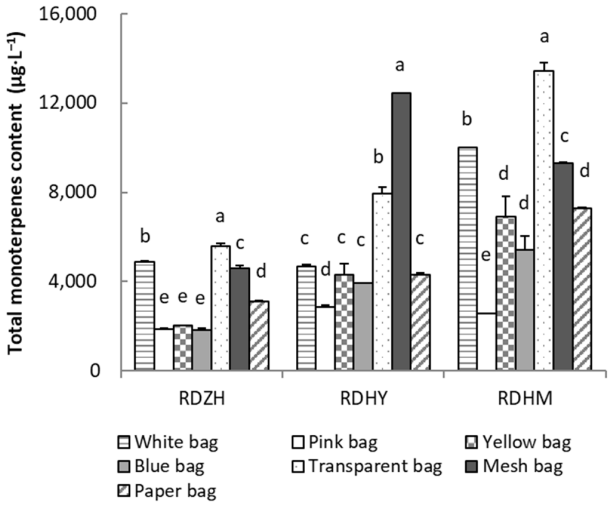


Figure 3. Effects of fruit bagging treatment with different types of bags on the total contents of monoterpenes in the three table grape cultivars. Different letters on the bars of certain cultivar stand for the significant difference (p value < 0.05).

Table 2. Effects of fruit bagging treatment with different types of bags on monoterpene contents in three table grape cultivars (μg·L^{-1}).

Code	Compound	Cultivar	Type of Bags							Cultivar *p* Value	Treatment *p* Value	Treatment × Cultivar *p* Value
			White Bag	Pink Bag	Yellow Bag	Blue Bag	Transparent Bag	Mesh Bag	Paper Bag			
M1	β-Myrcene	RDZH	289.51 ± 0.28 b	76.89 ± 3.10 e	84.73 ± 0.84 e	81.21 ± 3.51 e	356.47 ± 11.65 a	219.73 ± 1.30 c	169.38 ± 1.93 d	<0.001	<0.001	<0.001
		RDHY	234.83 ± 8.28 a	100.46 ± 4.86 b	160.64 ± 22.52 ab	163.84 ± 3.95 a	502.35 ± 21.37 a	815.37 ± 8.74 a	162.01 ± 4.84 ab			
		RDHM	1232.81 ± 3.35 b	225.14 ± 2.41 g	558.30 ± 22.70 e	457.62 ± 18.14 f	1538.13 ± 51.74 a	998.11 ± 1.79 c	828.12 ± 51.22 d			
M2	Limonene	RDZH	25.72 ± 0.74 a	5.37 ± 0.02 d	5.74 ± 0.15 c	4.98 ± 0.10 e	22.94 ± 0.93 a	21.58 ± 0.55 a	9.10 ± 0.09 b	<0.001	<0.001	<0.001
		RDHY	14.47 ± 0.07 c	6.93 ± 0.17 d	14.28 ± 2.38 c	12.28 ± 0.45 c	33.21 ± 0.82 b	50.62 ± 1.35 a	11.84 ± 0.06 c			
		RDHM	61.36 ± 0.79 a	22.15 ± 0.01 c	52.30 ± 2.05 ab	28.21 ± 0.37 b	138.64 ± 5.32 a	42.97 ± 8.24 ab	61.91 ± 1.11 a			
M3	Phellandrene	RDZH	4.38 ± 0.04 b	1.81 ± 0.03 c	1.98 ± 0.07 bc	1.93 ± 0.06 bc	5.14 ± 0.14 a	3.29 ± 0.24 b	2.93 ± 0.03 bc	<0.001	<0.001	<0.001
		RDHY	3.45 ± 0.05 c	2.08 ± 0.27 d	3.24 ± 0.32 c	3.22 ± 0.00 c	5.63 ± 0.15 b	10.44 ± 0.15 a	3.16 ± 0.01 c			
		RDHM	9.92 ± 0.07 b	3.57 ± 0.03 f	6.99 ± 0.28 d	5.49 ± 0.11 e	15.38 ± 0.56 a	8.99 ± 0.11 c	8.54 ± 0.30 c			
M4	β-*trans*-Ocimene	RDZH	114.96 ± 1.71 a	29.84 ± 1.09 d	31.25 ± 1.39 d	27.56 ± 1.54 d	124.59 ± 4.50 a	103.83 ± 2.19 b	53.45 ± 0.26 c	<0.001	<0.001	<0.001
		RDHY	70.66 ± 0.14 b	34.95 ± 0.72 c	60.21 ± 10.42 bc	58.69 ± 0.95 bc	171.69 ± 5.13 b	266.60 ± 4.90 a	59.39 ± 0.90 bc			
		RDHM	289.22 ± 0.70 b	77.17 ± 0.06 d	198.41 ± 12.47 b	147.79 ± 16.54 c	518.90 ± 15.56 a	247.31 ± 1.34 b	248.07 ± 8.29 b			
M5	γ-Terpinen	RDZH	4.91 ± 0.02 a	2.09 ± 0.02 b	2.08 ± 0.04 b	2.00 ± 0.02 b	4.65 ± 0.10 a	4.78 ± 0.25 a	2.64 ± 0.01 b	<0.001	<0.001	<0.001
		RDHY	3.49 ± 0.03 c	1.84 ± 0.26 d	3.33 ± 0.35 c	3.02 ± 0.06 c	6.49 ± 0.09 b	11.94 ± 1.11 a	2.94 ± 0.03 c			
		RDHM	9.21 ± 0.04 b	3.85 ± 0.00 d	7.87 ± 0.32 b	5.50 ± 0.50 c	18.91 ± 0.87 a	8.44 ± 0.19 b	8.94 ± 0.24 b			
M6	β-*cis*-Ocimene	RDZH	304.88 ± 1.67 a	73.78 ± 2.79 c	76.99 ± 2.09 c	66.65 ± 2.89 c	316.65 ± 12.28 a	269.59 ± 7.22 a	132.39 ± 0.95 b	<0.001	<0.001	<0.001
		RDHY	178.49 ± 0.86 b	86.59 ± 1.22 c	156.88 ± 26.79 b	147.94 ± 3.83 b	444.09 ± 11.32 b	691.05 ± 8.78 a	147.80 ± 2.01 b			
		RDHM	736.44 ± 4.87 b	195.07 ± 0.18 d	517.19 ± 32.10 b	367.11 ± 40.19 c	1380.25 ± 41.72 a	638.25 ± 1.87 b	635.52 ± 19.41 b			
M7	Terpinolen	RDZH	31.97 ± 0.56 a	5.96 ± 0.05 d	5.80 ± 0.20 d	4.93 ± 0.01 d	26.19 ± 1.53 c	28.47 ± 0.95 b	8.20 ± 0.17 d	<0.001	<0.001	<0.001
		RDHY	15.56 ± 0.09 c	5.18 ± 0.20 d	14.71 ± 2.55 c	12.28 ± 0.88 c	35.92 ± 0.71 b	58.75 ± 1.99 a	11.08 ± 0.17 c			
		RDHM	61.68 ± 0.85 b	25.54 ± 0.00 d	69.51 ± 4.02 b	34.09 ± 3.96 c	189.01 ± 9.36 a	63.64 ± 0.49 b	73.30 ± 1.39 b			
M8	*cis*-Rose oxide	RDZH	3.65 ± 0.01 a	3.42 ± 0.00 b	3.39 ± 0.00 b	3.39 ± 0.00 b	3.64 ± 0.01 a	3.68 ± 0.00 a	3.46 ± 0.00 a	<0.001	<0.001	<0.001
		RDHY	3.96 ± 0.00 c	3.61 ± 0.01 e	3.67 ± 0.08 e	3.84 ± 0.01 e	4.73 ± 0.01 b	5.32 ± 0.06 a	3.89 ± 0.01 d			
		RDHM	3.47 ± 0.03 a	3.27 ± 0.00 c	3.31 ± 0.00 b	3.29 ± 0.01 c	3.40 ± 0.01 a	3.40 ± 0.00 a	3.33 ± 0.00 a			
M9	*trans*-Rose oxide	RDZH	3.34 ± 0.01 a	3.29 ± 0.00 a	3.28 ± 0.00 b	3.27 ± 0.00 b	3.34 ± 0.00 a	3.36 ± 0.00 a	3.27 ± 0.00 b	<0.001	<0.001	<0.001
		RDHY	3.45 ± 0.00 c	3.33 ± 0.01 f	3.35 ± 0.02 f	3.40 ± 0.00 e	3.61 ± 0.00 b	3.76 ± 0.02 a	3.42 ± 0.00 d			
		RDHM	3.26 ± 0.00 a	3.26 ± 0.00 a	3.26 ± 0.00 a	3.26 ± 0.00 a	3.26 ± 0.00 a	3.26 ± 0.00 a	3.26 ± 0.00 a			
M10	Allo-ocimene	RDZH	96.53 ± 0.27 a	23.66 ± 1.13 c	24.34 ± 0.98 c	21.04 ± 1.01 c	99.30 ± 3.72 a	83.22 ± 2.08 a	41.36 ± 0.37 b	<0.001	<0.001	<0.001
		RDHY	56.56 ± 0.48 c	26.47 ± 0.76 d	47.93 ± 8.45 c	45.63 ± 1.22 c	137.47 ± 3.73 b	211.96 ± 3.62 a	45.21 ± 1.02 c			
		RDHM	250.94 ± 2.28 b	71.04 ± 0.05 e	194.90 ± 16.88 c	130.80 ± 14.13 d	486.07 ± 15.13 a	217.58 ± 1.49 c	228.47 ± 7.20 c			
M11	(E,Z)-Allo-ocimene	RDZH	16.95 ± 0.09 b	4.43 ± 0.21 e	5.25 ± 0.04 e	4.52 ± 0.25 e	19.84 ± 0.91 a	14.40 ± 0.09 c	8.71 ± 0.17 d	<0.001	<0.001	<0.001
		RDHY	10.90 ± 0.29 c	5.93 ± 0.14 e	9.65 ± 1.58 d	8.81 ± 0.09 d	24.99 ± 0.57 b	36.96 ± 0.77 a	7.70 ± 0.15 d			
		RDHM	41.19 ± 0.69 b	15.85 ± 0.57 d	37.17 ± 2.97 b	26.03 ± 2.74 c	86.13 ± 3.32 a	36.64 ± 0.08 b	39.39 ± 1.14 b			
M12	*cis*-Furan linalool oxide	RDZH	15.89 ± 0.06 d	6.03 ± 0.06 e	5.75 ± 0.05 e	5.78 ± 0.05 e	21.98 ± 0.68 a	18.36 ± 0.37 b	16.79 ± 0.36 c	<0.001	<0.001	<0.001
		RDHY	25.54 ± 0.15 c	19.46 ± 0.41 d	26.82 ± 3.07 c	25.77 ± 0.17 c	82.06 ± 2.45 b	93.47 ± 0.03 a	27.80 ± 0.44 c			
		RDHM	39.33 ± 0.19 a	7.88 ± 0.03 c	15.15 ± 0.66 bc	15.93 ± 1.52 bc	31.91 ± 0.86 b	20.24 ± 0.14 b	15.50 ± 0.04 bc			
M13	*trans*-Furan linalool oxide	RDZH	11.30 ± 0.17 b	4.66 ± 0.03 d	4.31 ± 0.02 f	4.47 ± 0.03 e	16.92 ± 0.21 a	10.39 ± 0.09 c	11.61 ± 0.14 b	<0.001	<0.001	<0.001
		RDHY	11.30 ± 0.25 bc	8.26 ± 0.08 d	11.11 ± 0.92 bc	9.65 ± 0.19 c	33.56 ± 0.99 b	46.16 ± 0.37 a	12.22 ± 0.02 bc			
		RDHM	19.35 ± 0.38 a	4.41 ± 0.00 d	6.81 ± 0.24 d	7.46 ± 0.57 cd	15.99 ± 0.29 b	11.10 ± 0.06 c	7.38 ± 0.05 cd			
M14	Nerol oxide	RDZH	50.06 ± 0.15 a	18.61 ± 0.21 ab	14.33 ± 0.28 b	15.32 ± 0.42 b	45.23 ± 1.65 a	53.26 ± 2.29 a	18.47 ± 0.11 b	<0.001	<0.001	<0.001
		RDHY	31.09 ± 0.21 b	12.97 ± 0.01 c	32.39 ± 4.50 b	28.36 ± 0.86 b	67.52 ± 3.15 b	91.02 ± 2.61 a	21.90 ± 0.12 b			
		RDHM	41.78 ± 0.39 b	18.90 ± 0.01 be	32.37 ± 1.99 c	23.35 ± 1.61 d	67.55 ± 3.25 a	34.74 ± 0.31 c	32.22 ± 0.55 c			
M15	Citronellal	RDZH	nd	nd	nd	nd	nd	nd	nd	\	\	\
		RDHY	nd	nd	nd	nd	nd	nd	nd			
		RDHM	tr	tr	tr	tr	tr	86.25 ± 0.72	tr			
M16	Linalool	RDZH	1762.30 ± 1.90 b	216.97 ± 1.07 g	474.2 ± 1.10 e	377.73 ± 9.25 f	2393.30 ± 34.43 a	1682.54 ± 30.35 c	1205.12 ± 1.11 d	<0.001	<0.001	<0.001
		RDHY	1298.49 ± 1.77 c	1074.63 ± 3.15 c	1415.71 ± 206.33 c	1455.78 ± 7.22 c	4130.05 ± 117.28 b	6503.62 ± 23.10 a	1587.67 ± 35.39 c			
		RDHM	6119.10 ± 11.03 b	916.68 ± 3.07 c	2880.75 ± 477.51 bc	3001.95 ± 417.51 bc	6235.79 ± 95.99 a	4446.00 ± 15.01 bc	3308.75 ± 94.21 bc			

Table 2. *Cont.*

Code	Compound	Cultivar	Type of Bags							Cultivar *p* Value	Treatment *p* Value	Treatment × Cultivar *p* Value
			White Bag	Pink Bag	Yellow Bag	Blue Bag	Transparent Bag	Mesh Bag	Paper Bag			
M17	4-Terpineol	RDZH	1.77 ± 0.00 a	tr	tr	tr	1.73 ± 0.01 a	1.78 ± 0.02 a	tr	<0.001	<0.001	<0.001
		RDHY	1.70 ± 0.01 c	1.50 ± 0.01 e	1.70 ± 0.05 c	1.56 ± 0.01 d	2.22 ± 0.04 b	2.97 ± 0.01 a	1.62 ± 0.01 c			
		RDHM	2.49 ± 0.01 a	1.67 ± 0.01 c	2.49 ± 0.20 a	1.87 ± 0.07 b	4.15 ± 0.18 a	2.35 ± 0.02 a	2.35 ± 0.04 a			
M18	Neral	RDZH	3.02 ± 0.07 b	2.94 ± 0.03 b	3.34 ± 0.12 a	2.94 ± 0.04 b	2.92 ± 0.03 b	3.19 ± 0.10 ab	2.88 ± 0.05 b	<0.001	0.002	0.115
		RDHY	2.85 ± 0.02 a	2.81 ± 0.08 a	2.80 ± 0.05 a	2.78 ± 0.05 a	2.78 ± 0.05 a	2.82 ± 0.08 a	2.84 ± 0.08 a			
		RDHM	2.87 ± 0.07 a	2.91 ± 0.10 a	3.14 ± 0.15 a	2.86 ± 0.07 a	3.03 ± 0.11 a	3.04 ± 0.03 a	2.88 ± 0.03 a			
M19	α-Terpineol	RDZH	78.80 ± 0.47 a	15.24 ± 0.29 b	14.97 ± 0.47 b	14.84 ± 0.08 b	64.10 ± 3.54 a	67.72 ± 3.09 a	21.49 ± 1.32 ab	<0.001	<0.001	<0.001
		RDHY	41.00 ± 0.89 c	17.17 ± 0.80 f	50.68 ± 6.14 c	35.07 ± 0.99 d	106.46 ± 5.58 b	189.84 ± 0.47 a	31.45 ± 0.15 e			
		RDHM	156.97 ± 0.02 b	68.73 ± 0.01 d	212.25 ± 35.57 b	97.82 ± 9.03 c	480.07 ± 26.69 a	182.72 ± 1.31 b	199.46 ± 1.20 b			
M20	Geranial	RDZH	3.90 ± 0.03 c	3.69 ± 0.02 e	4.91 ± 0.04 a	3.72 ± 0.00 e	3.78 ± 0.02 d	4.47 ± 0.04 b	3.51 ± 0.01 f	<0.001	<0.001	<0.001
		RDHY	3.33 ± 0.02 a	3.05 ± 0.02 b	3.01 ± 0.03 b	2.97 ± 0.02 b	2.97 ± 0.01 b	3.04 ± 0.01 b	3.07 ± 0.01 b			
		RDHM	3.36 ± 0.02 b	3.42 ± 0.01 ab	4.56 ± 0.28 a	3.45 ± 0.08 ab	4.22 ± 0.03 a	4.44 ± 0.09 a	3.74 ± 0.00 a			
M21	β-Citronellol	RDZH	30.38 ± 0.06 b	12.90 ± 0.10 e	10.64 ± 0.04 f	11.32 ± 0.42 f	35.68 ± 0.43 a	28.60 ± 0.68 c	20.54 ± 0.37 d	<0.001	<0.001	<0.001
		RDHY	75.53 ± 1.19 ab	57.75 ± 1.23 b	56.67 ± 6.43 b	65.77 ± 0.81 b	74.25 ± 3.74 ab	105.02 ± 1.84 a	76.98 ± 1.52 ab			
		RDHM	10.22 ± 0.36 a	3.81 ± 0.04 c	8.97 ± 1.26 a	5.23 ± 0.60 b	14.33 ± 0.41 a	15.10 ± 0.09 a	9.04 ± 0.00 a			
M22	Nerol	RDZH	85.60 ± 0.46 b	43.90 ± 0.16 d	37.79 ± 0.17 d	37.72 ± 1.82 d	96.57 ± 2.43 a	93.31 ± 2.43 ab	48.96 ± 1.09 c	<0.001	<0.001	<0.001
		RDHY	100.32 ± 1.42 a	72.64 ± 2.06 b	81.21 ± 8.18 b	86.08 ± 0.92 b	62.70 ± 2.76 c	102.40 ± 0.90 a	83.52 ± 2.03 b			
		RDHM	66.07 ± 0.54 c	46.30 ± 0.31 e	117.83 ± 16.91 b	54.95 ± 4.61 d	167.17 ± 7.33 a	138.46 ± 0.56 b	90.92 ± 0.45 b			
M23	*cis*-Isogeraniol	RDZH	0.52 ± 0.00 ab	0.53 ± 0.00 ab	0.50 ± 0.03 ab	0.46 ± 0.00 b	0.42 ± 0.01 c	0.64 ± 0.06 a	0.41 ± 0.00 c	<0.001	<0.001	<0.001
		RDHY	1.02 ± 0.00 c	0.70 ± 0.07 d	0.90 ± 0.05 d	1.14 ± 0.03 b	0.84 ± 0.09 d	1.23 ± 0.05 b	1.46 ± 0.09 a			
		RDHM	0.49 ± 0.01 a	0.53 ± 0.02 a	0.83 ± 0.22 a	0.44 ± 0.01 b	0.91 ± 0.02 a	1.13 ± 0.01 a	0.79 ± 0.02 a			
M24	*trans*-Isogeraniol	RDZH	nd	nd	nd	nd	nd	nd	nd	<0.001	<0.001	<0.001
		RDHY	tr	tr	0.55 ± 0.02 b	tr	0.58 ± 0.02 b	0.82 ± 0.05 a	tr			
		RDHM	tr	tr	tr	tr	0.95 ± 0.01 a	0.71 ± 0.00 b	tr			
M25	Geraniol	RDZH	1479.47 ± 11.82 a	960.55 ± 2.19 b	1020.42 ± 3.25 b	918.98 ± 57.23 b	1428.81 ± 35.10 a	1356.98 ± 33.83 a	1005.08 ± 27.40 b	<0.001	<0.001	<0.001
		RDHY	1152.08 ± 22.92 a	457.63 ± 14.53 b	576.93 ± 60.73 b	497.57 ± 5.74 b	461.10 ± 23.04 b	751.39 ± 12.20 a	579.61 ± 16.96 b			
		RDHM	787.40 ± 6.12 b	799.42 ± 9.01 b	1818.86 ± 269.13 a	948.40 ± 98.76 b	1938.07 ± 65.03 a	1927.52 ± 4.34 a	1371.84 ± 8.79 a			
M26	Geranic acid	RDZH	485.05 ± 1.76 a	361.99 ± 20.49	184.12 ± 7.55 d	229.83 ± 7.17 c	474.83 ± 27.11 a	520.57 ± 28.02 a	317.48 ± 1.66 b	<0.001	<0.001	<0.001
		RDHY	1352.11 ± 53.42 b	a839.78 ± 81.15 c	1586.83 ± 110.41 b	1265.26 ± 13.28 b	1537.73 ± 86.14 b	2365.66 ± 64.53 a	1405.63 ± 17.42 b			
		RDHM	45.46 ± 1.35 b	68.84 ± 7.05 b	147.77 ± 30.49 a	47.65 ± 8.64 b	105.64 ± 0.36 a	157.80 ± 2.19 a	115.27 ± 0.31 a			

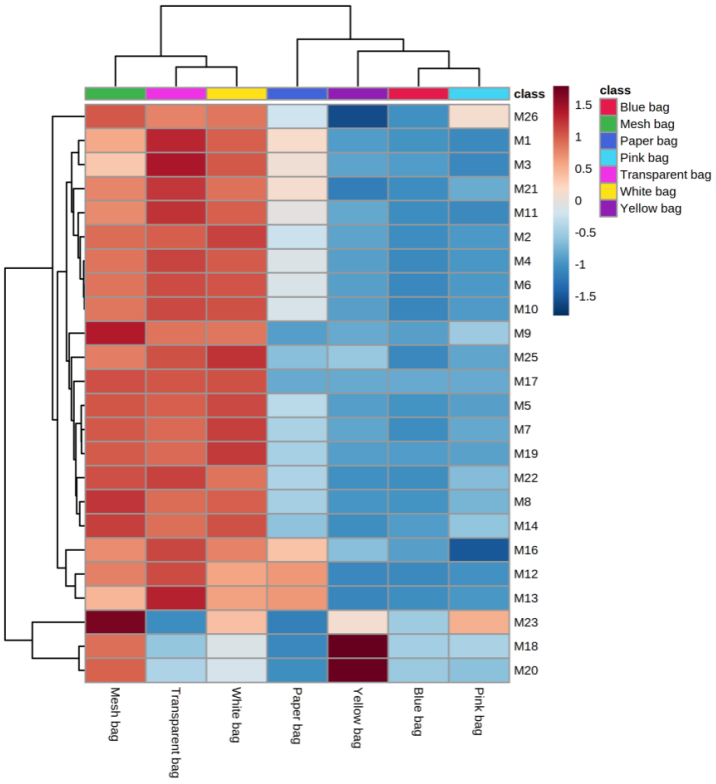
Note: "tr" represents trace amount; "nd" represents not detected.

3.3.2. Effects of Fruit Bagging Treatment with Different Types of Bags on the Compositions and Contents of Monoterpenes in the Three Table Grape Cultivars

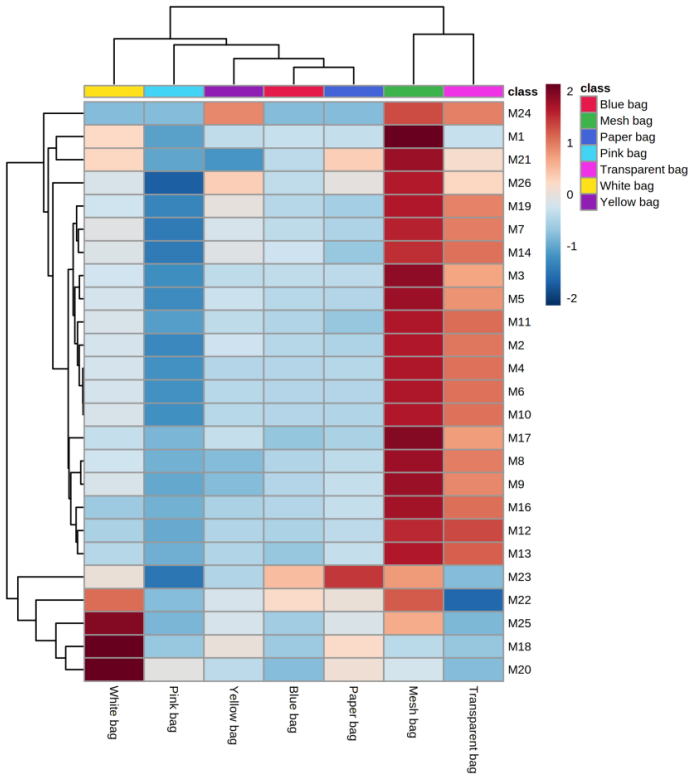
The total monoterpenes in different types of fruit bags varied significantly (Figure 3). For RDZH, transparent bags had the highest total monoterpenes (5569.0 $\mu g \cdot L^{-1}$), which was significantly higher than white bags (4904.8 $\mu g \cdot L^{-1}$); white bags were significantly higher than mesh bags (4597.7 $\mu g \cdot L^{-1}$); and all three were significantly higher than paper bags (3107.2 $\mu g \cdot L^{-1}$). The pink, yellow, and blue bags were significantly lower than paper bags. The total amount of monoterpenes was 12,422.2 $\mu g \cdot L^{-1}$ for the RDHY mesh bag treatment and 7934.9 $\mu g \cdot L^{-1}$ for the transparent bag treatment, both of which were significantly higher than the paper bag treatment (4294.1 $\mu g \cdot L^{-1}$), while the white, yellow, blue, and paper bag treatments were at the same level, and pink bags were significantly lower than paper bags. Furthermore, RDHM and RDZH showed similar patterns, where the total amount of monoterpenes in the transparent bag treatment was the highest (13,448.0 $\mu g \cdot L^{-1}$) and significantly higher than the white bag treatment (9994.3 $\mu g \cdot L^{-1}$), the white bag treatment was significantly higher than the mesh bag treatment (9300.2 $\mu g \cdot L^{-1}$), and all three were significantly higher than the paper bag treatment (7299 $\mu g \cdot L^{-1}$). The yellow, blue, and paper bag treatments were at the same level, and the pink bag treatment was the lowest.

The cluster analysis results showed that the seven treatments on RDZH were mainly clustered into three categories (Figure 4A). The first category consisted of mesh bags, white bags, and transparent bags, which promoted the accumulation of monoterpenes in RDZH fruits. The second category was paper bags, which were the experimental control. The third category included yellow, pink, and blue bags, which inhibited the accumulation of monoterpenes in RDZH fruits. The 26 monoterpenes of RDZH were mainly clustered into four categories. The first category contained neral (M18) and geranial (M20), which were high in the yellow and mesh bag treatments and low in the other treatments. The second category contained only *cis*-isogeraniol (M23), which was high in the mesh, white, pink, and yellow bag treatments, but low in the blue, transparent, and paper bag treatments. The third category included 22 compounds, such as β-myrcene (M1), phellandrene (M3), and β-citronellol (M21), which were high in the mesh, white, and transparent bag treatments and low in the yellow, pink, and blue bag treatments. The fourth category contained only geranic acid (M26), which was high in the mesh, white, transparent, and pink bag treatments and low in the paper, blue, and yellow bag treatments.

The seven treatments on RDHY were mainly clustered into three groups (Figure 4B). The first group included white bags, which contained high levels of nerol (M22), geraniol (M25), neral (M18), and geranial (M20), while the other compounds were at intermediate levels. The second category comprised the pink, yellow, blue, and paper bags. Most of the monoterpenes were inhibited by the second category of treatments. The third category included transparent and mesh bags, which promoted the accumulation of the most monoterpenes. Twenty-six kinds of monoterpenes were mainly clustered into four groups. The first group contained nerol (M22), geraniol (M25), neral (M18), and geranial (M20), which were the most abundant in the white bag treatment and the least abundant in the transparent bag treatment. The second group contained only *cis*-isogeraniol (M23), which was high in the paper and mesh bag treatments, and low in the pink and transparent bag treatments. The third group contained 20 compounds, including β-citronellol (M21), geranic acid (M26), and α-terpineol (M19), among others. The content of this group of compounds was high in the mesh and transparent bags and low in the pink bag. The fourth group contained only *trans*-isogeraniol (M24), which was high in the mesh, yellow, and transparent bags, but low in the other four treatments.

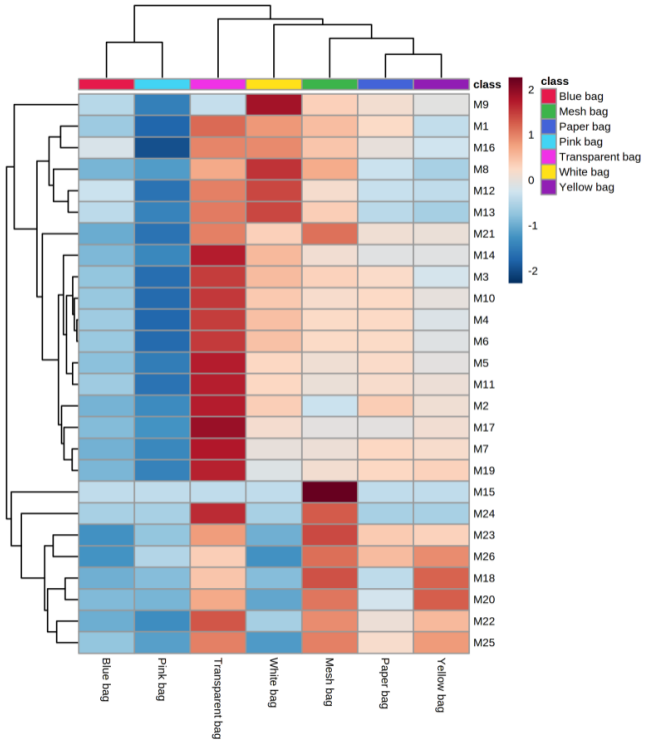


(**A**)



(**B**)

Figure 4. *Cont.*



(**C**)

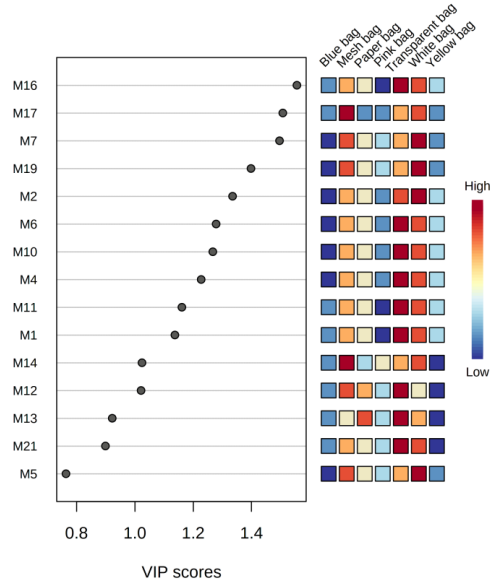
Figure 4. Hierarchical cluster analysis of the effects of fruit bagging treatment with different types of bags on the monoterpene content of three table grape cultivars ((**A**): RDZH; (**B**): RDHY; and (**C**): RDHM).

The seven treatments on RDHM were mainly clustered into three categories (Figure 4C). The first category included pink and blue bags, which significantly inhibited the accumulation of all 26 monoterpenes. The second category consisted of transparent bags, which promoted the accumulation of 24 monoterpenes. The third category consisted of white, mesh, yellow, and paper bags, which promoted the accumulation of some compounds and inhibited the accumulation of others. Among them, the white bag treatment promoted the accumulation of *trans*-rose oxide (M9), *cis*-rose oxide (M8), *cis*-furan linalool oxide (M12), and *trans*-furan linalool oxide (M13), whereas the accumulation of geranic acid (M26), geraniol (M25), *cis*-isogeraniol (M23), geranial (M20), and neral (M18) were inhibited. The mesh bag treatment promoted the accumulation of citronellal (M15), *trans*-isogeraniol (M24), *cis*-isogeraniol (M23), neral (M18), β-citronellol (M21), geranic acid (M26), and geranial (M20), though it exhibited no obvious inhibitory effect on other compounds. The yellow bag treatment promoted the accumulation of neral (M18), geranial (M20), geranic acid (M26), and geraniol (M25), while the effect on other compounds was not significant. The 26 monoterpenes were mainly clustered into four categories. The first category contained *trans*-isogeraniol (M24), *cis*-isogeraniol (M23), geranic acid (M26), neral (M18), geranial (M20), nerol (M22), and geraniol (M25). This type of compound presented high content in the mesh, transparent, and yellow bags, and low content in the pink, blue, and white bags. The second category contained only citronellal (M15), which was only high in mesh bags, and low in other treatments, including transparent bags. The third group contained 17 compounds, including β-myrcene (M1), linalool (M16), and *cis*-rose oxide (M8). The compounds in this group, except *cis*-rose oxide (M8), *cis*-furan linalool oxide (M12), and *trans*-furan linalool oxide (M13), were high in white bags. Furthermore, β-citronellol (M21) was high in mesh bags, where most compounds had the highest content in transparent bags and the lowest in the pink and blue bags. The fourth category contained only *trans*-rose

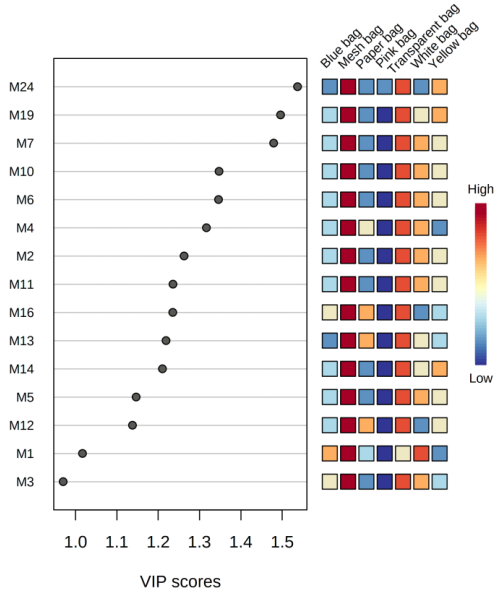
oxide (M9); this type of compound had the highest content under the white bag treatment, and the lowest content under the blue, transparent, and pink bag treatments.

3.3.3. Least Square Discriminant Analysis of Monoterpenes

The least square discriminant analysis was performed on the content data of monoterpenes. From the results (Figure 5), the variable important in projection (VIP) value was greater than 1.0, which was considered the main contributing differential compound. It can be seen that the five compounds with larger RDZH VIP values are linalool (M16), 4-terpineol (M17), terpinolen (M7), α-terpineol (M19), and limonene (M2). The five compounds with larger RDHY VIP values are *trans*-isogeraniol (M24), α-terpineol (M19), terpinolen (M7), allo-ocimene (M10), and β-*cis*-ocimene (M6). Lastly, the five compounds with higher RDHM VIP values are *trans*-isogeraniol (M24), β-myrcene (M1), terpinolen (M7), β-*cis*-ocimene (M6), and α-terpineol (M19).

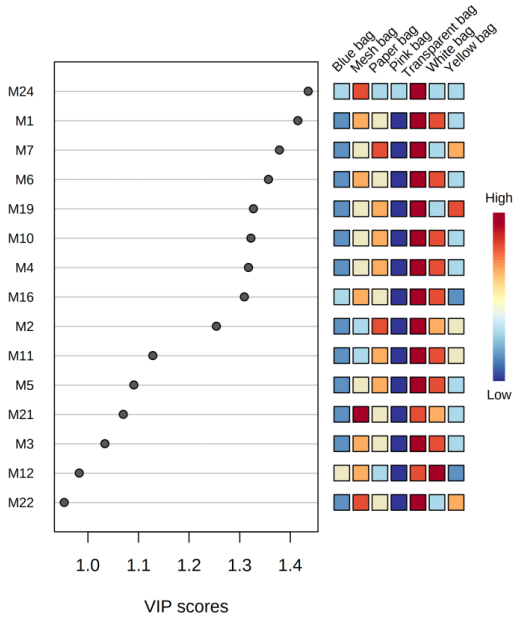


(**A**)



(**B**)

Figure 5. *Cont.*



(**C**)

Figure 5. Main compounds based on VIP value under fruit bagging treatment with different types of bags in three table grape cultivars ((**A**): RDZH; (**B**): RDHY; and (**C**): RDHM).

4. Discussion

Bagging technology influences the activity of various enzymes, the respiration intensity, the transport of assimilated substances, and the accumulation of volatile components during fruit development by regulating the microenvironment inside the bag, which include factors such as temperature, humidity, light quality, and light intensity [34–36].

The results of previous studies exploring the effects of bagging treatments on fruit quality were not consistent. For example, Sharma et al. [37] used non-bagging as a control and found that yellow non-woven bags significantly increased soluble solids, vitamin C, and total phenols in apples. Shang et al. [38] used non-bagging as a control and found that the yellow and red filter coating reduced the total sugar and proanthocyanidin content of cultivated grapes. Cheng et al. [39] found that blue and red filtered films increased soluble solids and total sugars in Red Globe grape fruits, with the white filtered film as the control. No significant differences were found between the orange treatment, green treatment, light-proof treatment, or the control. The blue filter film also increased phenylalanine lyase (PAL) activity and promoted the synthesis of anthocyanins. This study found that the TSS of RDZH and RDHY fruits treated with the transparent bag, mesh bag, yellow bag, white bag, and blue bag were significantly higher than the control, and that there was no significant effect on the TSS of RDHM fruits. The sugar–acid ratio of RDZH under the transparent and yellow bag treatments was the best, and both significantly increased the sugar–acid ratio of RDHY and RDHM. However, the high sugar–acid ratio led to excessive sweetness, while the sugar–acid ratio of RDHY was high overall (above 52 in all treatments). The sugar–acid ratio of RDHM under the transparent and yellow bag treatments was above 60; hence, it was not conducive to the balance of taste. On the contrary, the sugar–acid ratio of RDHM was generally low (below 40 in all treatments). Therefore, the sweetness and sour taste of the fruits under the transparent and yellow bag treatments was better. The mesh bag treatment increased the total anthocyanins, flavonoid, and proanthocyanidin contents of RDZH fruits, while the white, pink, and blue bag treatments, respectively, reduced the total anthocyanins, flavonoid, and proanthocyanidin contents. The RDHY yellow bag treatment increased the total anthocyanins and flavonoid content, while the pink bag showed a significant negative effect. The transparent and mesh bags significantly increased the total anthocyanins of RDHM, while the pink and blue bags had an inhibitory effect.

The flavor of the grape fruits mainly consisted of sweetness, sourness, and aroma. The basic taste came from the sweetness and sourness. The aroma was also one of the important sensory evaluation indicators of fruit flavor, and the composition of flavor varied depending on the composition and content of aroma substances [40]. Monoterpenes are important isoprene derivatives in grape fruits, which are typical aroma components of muscat-aroma grapes. In this study, five of the six compounds with the highest contents in RDZH, RDHY, and RDHM were found to be consistent, namely, linalool, geraniol, β-myrcene, β-*cis*-ocimenes, and β-*trans*-ocimenes, which were in general agreement with the results of Wang et al. [41]. The linalool content was the highest in all the treatments in this study. It was higher than the aroma threshold [42], which was the main aroma component in all three cultivars, giving grapes floral and citrus aromas [43]. It was also the main substance responsible for the difference in aroma among the cultivars. Additionally, the difference in linalool between different treatments was highly significant (216.97–2393.30 $\mu g \cdot L^{-1}$ for RDZH, 1074.63–6503.62 $\mu g \cdot L^{-1}$ for RDHY, and 916.68–6235.79 $\mu g \cdot L^{-1}$ for RDHM), indicating that its contribution to the grape aroma was the greatest, which was consistent with the results of least squares discriminant analysis. The results of previous studies indicated that the muscat aroma in grape fruits was associated with rose oxide, which was present in all rose-aroma grape cultivars, though it did not mean that rose oxide was absent in non-rose-aroma grapes [13]. In this study, rose oxide was detected in all treatments and was above its aroma threshold [44]. Since geranial was a *cis*-isomer of neral, both were clustered into the same class in the cluster analysis of the twenty-six compounds of the three cultivars, which were mainly found in the mesh bags and the yellow bags. Based on the total free monoterpene content in the fruit, grape cultivars were classified as muscat-aroma (total free monoterpene content >6 $mg \cdot L^{-1}$), non-muscat-aroma (total 1–4 $mg \cdot L^{-1}$), and non-aroma (total less than 1 $mg \cdot L^{-1}$) [12]. The monoterpene compositions and contents of different treatments showed that the transparent, white, and mesh bag treatments promoted monoterpene accumulation in RDZH, where none of them reached 6 $mg \cdot L^{-1}$, which was a non-muscat-aroma type. However, the pink, yellow, and blue bag treatments had significant inhibitory effects. The mesh and transparent bag treatments significantly promoted monoterpene accumulation in RDHY (where the mesh bag was nearly two times higher than the paper bag, and the transparent bag was nearly double the paper bag), and the total amount of free monoterpene of this cultivar was greater than 6 $mg \cdot L^{-1}$ under these two treatments, reaching muscat-aroma level, and the pink bag had a significant inhibitory effect.

In summary, in an open field, a simple rain-shelter cultivation mode fruit bagging technique can effectively prevent fruit surface contamination, reduce pesticide residues, and protect against bird pecking. Compared with traditional white paper bags, transparent polypropylene micro-perforation bags, followed by white polypropylene micro-perforation bags, were the most effective in terms of fruit sweet-sour taste, phenolics, and monoterpene accumulation. The yellow polypropylene micro-perforation bag increased the total anthocyanins and flavonoid content of RDHY, but it had inhibitory effects on certain indicators of other cultivars. The negative effect of pink polypropylene micro-perforation bag was the most significant, followed by blue polypropylene micro-perforation bag. It was worthwhile to conduct in-depth research in different orchards across several years combined with the microenvironment (temperature, humidity, light transmittance) inside the bag, the respiration rate of grape fruit and certain key enzymes during fruit development to have a further understanding on the mechanisms of bagging treatment on grapes.

5. Conclusions

Different types of fruit bags provide specific microenvironments for the development of grape fruits, which, in turn, have different effects on fruit quality. In terms of the sweet–sour taste, for the accumulation of phenolics and monoterpenes in muscat-aroma table grapes, transparent polypropylene micro-perforation bags and white polypropylene micro-perforation bags were more effective than conventional white paper bags in promoting

the accumulation of phenolics (such as total anthocyanins) and monoterpenes (such as linalool) based on improving fruit ripeness. The negative effects of the pink polypropylene micro-perforation bags and blue polypropylene micro-perforation bags were significant.

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References

1. He, L.; Xu, X.Q.; Wang, Y.; Vanderweide, J.; Sun, R.Z.; Cheng, G.; Pan, Q.H. Differential influence of timing and duration of bunch bagging on volatile organic compounds in Cabernet Sauvignon berries (*Vitis vinifera* L.). *Aust. J. Grape Wine Res.* **2021**, *28*, 75–85. [CrossRef]
2. Wang, S.-M.; Gao, H.-J.; Zhang, X.-B. Research progress on the effects of bagging treatment on pear fruit. *China Fruits* **2002**, *75*, 49–52.
3. Wu, W.; Lie, D.; He, S.-L. Review on the effects of bagging treatment on fruit quality. *South China Fruits* **2006**, *35*, 82–86.
4. Zhang, J.; Niu, J.; Duan, Y.; Zhang, M.; Liu, J.; Li, P.; Ma, F. Photoprotection mechanism in the cv. Fuji, Raku Raku apple peel at different levels of photo oxidative sunburn. *Physiol. Plant.* **2015**, *154*, 54–65. [CrossRef] [PubMed]
5. Chen, C.; Zhang, D.; Wang, Y.; Li, P.; Ma, F. Effects of fruit bagging on the contents of phenolic compounds in the peel and flesh of 'Golden Delicious', 'Red Delicious', and 'Royal Gala' apples. *Sci. Hortic.* **2012**, *142*, 68–73. [CrossRef]
6. Wang, Y.-J.; Yang, C.-X.; Liu, C.-Y.; Xu, M.; Li, S.-H.; Yang, L.; Wang, Y.-N. Effects of bagging on volatiles and polyphenols in "Wanmi" peaches during endocarp hardening and final fruit rapid growth stages. *J. Food Sci.* **2010**, *75*, 455–460. [CrossRef]
7. Wang, Y.-T.; Li, X.; Li, Y.; Li, L.-L.; Zhang, S.-L. Effects of bagging on browning spot incidence and content of different forms of calcium in 'Huangguan' pear fruits. *Acta Hortic. Sin.* **2011**, *38*, 1507–1514.
8. Wang, J.-Y.; Feng, J.; Hou, X.-D.; Tao, J.-M. Effects of bagging treatments with different materials on aroma components and their biosynthetic gene expression in 'Shine Muscat' grape berry. *J. Fruit Sci.* **2017**, *34*, 1–11.
9. Feng, F.; Li, M.; Ma, F.; Cheng, L. The effects of bagging and debagging on external fruit quality, metabolites, and the expression of anthocyanin biosynthetic genes in 'Jonagold' apple (Malus domestica Borkh.). *Sci. Hortic.* **2014**, *165*, 123–131. [CrossRef]
10. Sun, R.-Z.; Guo, C.; Qiang, L.; Zhu, Y.-R.; Xue, Z.; Yu, W.; He, Y.-N.; Li, S.-Y.; Lei, H.; Wu, C.; et al. Comparative physiological, metabolomic, and transcriptomic analyses reveal developmental stage-dependent effects of cluster bagging on phenolic metabolism in Cabernet Sauvignon grape berries. *BMC Plant Biol.* **2019**, *19*, 59. [CrossRef]
11. Zhang, J.-G.; Wang, H.-Y.; Wang, M.; Sun, J.-S.; Liu, Y.-F.; Schrader, L. Effect of bagging on microenvironments of apple fruits. *Acta Ecol. Sin.* **2005**, *25*, 1082–1087.
12. Mateo, J.J.; Jimenez, M. Monoterpenes in grape juice and wines. *J. Chromatogr. A* **2000**, *881*, 557–567. [CrossRef]
13. Ruiz-Garcia, L.; Hellin, P.; Flores, P.; Fenoll, J. Prediction of Muscat aroma in table grape by analysis of rose oxide. *Food Chem.* **2014**, *154*, 151–157. [CrossRef] [PubMed]
14. Yang, C.; Wang, Y.; Wu, B.; Fang, J.; Li, S. Volatile compounds evolution of three table grapes with different flavour during and after maturation. *Food Chem.* **2011**, *128*, 823–830. [CrossRef]
15. Gunata, Y.Z.; Bayonove, C.L.; Baumes, R.L.; Cordonnier, R.E. The aroma of grapes—localization and evolution of free and bound fractions of some grape aroma components Cv muscat during 1st development and maturation. *J. Sci. Food Agric.* **1985**, *36*, 857–862. [CrossRef]
16. Luan, F.; Wüst, M. Differential incorporation of 1-deoxy-D-xylulose into (3S)-linalool and geraniol in grape berry exocarp and mesocarp. *Phytochemistry* **2002**, *60*, 451–459. [CrossRef]
17. Park, S.K.; Morrison, J.C.; Adams, D.O.; Noble, A.C. Distribution of free and glycosidically bound monoterpenes in the skin and mesocarp of Muscat of Alexandria grapes during development. *J. Agric. Food Chem.* **1991**, *39*, 514–518. [CrossRef]
18. Yue, X.F.; Ma, X.; Tang, Y.L.; Wang, Y.; Wu, B.W.; Jiao, X.L.; Zhang, Z.W.; Ju, Y.L. Effect of cluster zone leaf removal on monoterpene profiles of sauvignon blanc grapes and wines. *Food Res. Int.* **2020**, *131*, 109028. [CrossRef]

19. Falcao, L.D.; Revel, G.D.; Perello, M.C.; Moutsiou, A.; Zanus, M.C.; Bordignon-Luiz, M.T. A survey of seasonal temperatures and vineyard altitude influences on 2-methoxy-3-isobutylpyrazine, C13-norisoprenoids, and the sensory profile of Brazilian Cabernet Sauvignon wines. *J. Agric. Food Chem.* **2007**, *55*, 3605–3612. [CrossRef]
20. Kalua, C.M.; Boss, P.K. Evolution of volatile compounds during the development of Cabernet Sauvignon grapes (*Vitis vinifera* L.). *J. Agric. Food Chem.* **2009**, *57*, 3818–3830. [CrossRef]
21. Wang, X.-Y.; Zhang, G.-J.; Sun, L.; Zhao, Y.; Yan, A.-L.; Wang, H.-L.; Ren, J.-C.; Xu, H.-Y. Effects of two trellis systems on viticultural characteristics and fruit quality of three table grape cultivars. *Sci. Agric. Sin.* **2019**, *52*, 1150–1163.
22. Zhang, J. Effects of Different Dwarf Training Patterns on Volatile Flavor Compound of Cabernet Gernischt. Master's Thesis, Ningxia University, Yinchuan, China, 2018.
23. Ji, X.-H.; Wang, B.-L.; Wang, X.-D.; Shi, X.-B.; Liu, P.-P.; Liu, F.-Z.; Wang, H.-B. Effects of different color paper bags on aroma development of Kyoho grape berries. *J. Integr. Agric.* **2019**, *18*, 70–82. [CrossRef]
24. Jiang, X.-F. Effects of Different Bags on Fruit Quality and Aroma Components in Grape cv. 'Maserlan'. Master's Thesis, Gansu Agricultural University, Lanzhou, China, 2018.
25. Zhang, G.-J.; Wang, X.-Y.; Sun, L.; Yan, A.-L.; Wang, H.-L.; Ren, J.-C.; Xu, H.-Y. Grapevine vigor control theory and coping strategy for grape growing under mainland monsoon type climate. *Sino Overseas Grapevine Wine* **2016**, *3*, 30–33.
26. Yang, F.-C.; Wu, J.; Cheng, J.-H.; Xu, K.; Chen, J.-W. Studies on extraction and physical-chemical properties of anthocyanin from red globe grape peel. *J. Fruit Sci.* **2007**, *24*, 287–292.
27. Ramchandani, A.G.; Chettiyar, R.S.; Pakhale, S. Evaluation of antioxidant and anti-initiating activities of crude polyphenolic extracts from seedless and seeded Indian grapes. *Food Chem.* **2010**, *119*, 298–305. [CrossRef]
28. Dai, H.; Qin, C.; Ding, L. Effects of salicylic acid on the contents of total flavonoids and resveratrol and related enzyme activities in 'Cabernet Sauvignon'. *J. China Agric. Univ.* **2016**, *21*, 37–42.
29. Wu, Y.-W.; Pan, Q.-H.; Qu, W.-J.; Duan, C.-Q. Comparison of volatile profiles of nine litchi (Litchi chinensis Sonn.) cultivars from Southern China. *J. Agric. Food Chem.* **2009**, *57*, 9676–9681. [CrossRef]
30. Wu, Y.-W.; Zhu, B.-Q.; Tu, C.; Duan, C.-Q.; Pan, Q.-H. Generation of volatile compounds in litchi wine during winemaking and short-term bottle storage. *J. Agric. Food Chem.* **2011**, *59*, 4923–4931. [CrossRef]
31. Sun, L.; Zhu, B.-Q.; Zhang, X.-Y.; Zhang, G.-J.; Yan, A.-L.; Wang, H.-L.; Wang, X.-Y.; Xu, H.-Y. The accumulation profiles of terpene metabolites in three Muscat table grape cultivars through HS-SPME-GCMS. *Sci. Data* **2020**, *7*, 5. [CrossRef]
32. Crisosto, C.H.; Crisosto, G.M. Understanding American and Chinese consumer acceptance of 'Red Globe' table grapes. *Postharvest Biol. Technol.* **2002**, *24*, 155162. [CrossRef]
33. Jayasena, V.; Cameron, I. Brix/acid ratio as a predictor of consumer acceptability of Crimson Seedless table grapes. *J. Food Qual.* **2008**, *31*, 736–750. [CrossRef]
34. Kong, J.-J.; Cao, P.; Wu, X.; Yuan, Y.-Z.; Yu, P.-J.; Tao, S.-T.; Zhang, S.-L. Effects of light quality on fruit quality and absorption of mineral elements in 'DangshanSuli' pear fruit development. *Acta Hortic. Sin.* **2018**, *45*, 1173–1184.
35. Verreynne, J.S.; Rabe, E.; Theron, K.I. Effect of bearing position on fruit quality of mandarin types. *S. Afr. J. Plant Soil* **2004**, *21*, 1–7. [CrossRef]
36. Wang, H.-B.; Zhang, K.-K.; Ji, X.-H.; Wang, X.-D.; Shi, X.-B.; Wang, B.-L.; Zheng, X.-C.; Liu, F.-Z. Effects of different color paper bags on volatile constituents of Kyoho grape berries. *Chin. J. Appl. Ecol.* **2017**, *28*, 1274–1280.
37. Sharma, R.R.; Pal, R.K.; Asrey, R.; Sagar, V.R.; Dhiman, M.R.; Rana, M.R. Pre-harvest fruit bagging influences fruit color and quality of apple cv. Delicious. *Agric. Sci.* **2013**, *4*, 443–448. [CrossRef]
38. Shang, J.-B.; Tian, S.-F.; Ji, X.; Wang, D.; Liu, H.; Zhang, N. Effects of fruit bagging on the quality of grapes under protected cultivation. *Nor. Hortic.* **2014**, *1*, 42–45.
39. Cheng, J.-H.; Wei, L.-Z.; Lei, M.; Zheng, T.; Wu, J. Influences of different light filter film bags on berry quality in 'Red Globe'. *J. Fruit Sci.* **2015**, *32*, 87–93.
40. Song, J.; Forney, C.F. Flavour volatile production and regulation in fruit. *Can. J. Plant Sci.* **2008**, *88*, 537–550. [CrossRef]
41. Wang, H.-L.; Wang, X.-Y.; Yan, A.-L.; Sun, L.; Zhang, G.-J.; Ren, J.-C.; Xu, H.-Y. The accumulation of monoterpenes and the expression of its biosynthesis related genes in 'AishenMeigui' grape berries cultivated in different trellis systems during Ripening Stage. *Sci. Agric. Sin.* **2019**, *52*, 1136–1149.
42. Wen, Y.-Q.; Zhong, G.-Y.; Gao, Y.; Lan, Y.-B.; Duan, C.-Q.; Pan, Q.-H. Using the combined analysis of transcripts and metabolites to propose key genes for differential terpene accumulation across two regions. *BMC Plant Biol.* **2015**, *8*, 1226. [CrossRef]
43. Pino, J.A.; Mesa, J. Contribution of volatile compounds to mango (*Mangifera indica* L.) aroma. *Flavour Fragr. J.* **2006**, *21*, 207–213. [CrossRef]
44. Fenoll, J.; Manso, A.; Hellin, P.; Ruiz, L.; Flores, P. Changes in the aromatic composition of the Vitis vinifera grape Muscat Hamburg during ripening. *Food Chem.* **2009**, *114*, 420–428. [CrossRef]