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Original Research Paper

Prospective of new grape (*Vitis vinifera* L.) hybrids in the raisin industry

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ABSTRACT

India is one of the world's leading producers of raisins. However, only a few grape varieties are used to sustain raisin production in India. Therefore, using bunch and berry characteristics, biochemical content, and sensory evaluation, seven possible grape hybrids were assessed for suitability for raisin/monukka purpose. The hybrid 'H19.24' showed promising results concerning raisin/monukka recovery (24.70%), organoleptic test and biochemical content (proline: 20.7 µmoles/g, anthocyanin: 2.08 mg/g, color intensity: 3.09, phenol: 2.01 mg/g, tannin: 3.62 mg/g, and protein: 35.3 mg/g). Its better acceptability and durability in the commercial market are indicated by its exceptional hedonic score for each sensory evaluation's components. Along with the high protein content (34.0 mg/g), H111.24 also earned higher scores for pulp content (7.14), sweetness (7.06), flavour (6.50), taste (6.93), and overall acceptability (7.07). These two hybrids will boost the Indian raisin industry in both domestic and foreign markets by being added to the small varietal collection of raisin grapes.

Keywords: Berry traits, biochemical traits, grape hybrid, raisin recovery, sensory evaluation

INTRODUCTION

Grape (*Vitis vinifera* L.) cultivation is one of the promising and financially rewarding agricultural enterprises in India. The cultivation of grapes holds significance as a key commercial fruit crop in India, thriving across diverse climatic conditions. World's table grape production was recorded three per cent higher in 2022 compared to 2021, reaching 31.5 million tonnes. However, dried grapes accomplished production of 1.4 million tonnes which was 7 per cent higher than the previous year. In India, grapes are mainly consumed as fresh and about 28 per cent of total production is converted into raisins (Sharma et al., 2020).

Health consciousness has led to an escalation in demand for nutritious food. Among dried food products, black raisins stand out for their high phenolic compound content and strong antioxidant activity (Karakaya & Tas, 2001). Raisins hold a special significance due to their significant potential to enhance the human immune system, as they contain distinct phytochemical composition and natural attributes that make them a valuable source of essential minerals (Simsek et al., 2004; Fang et al., 2010). Similar to other fruits, raisins are a concentrated source of carbohydrates, with approximately half of their available carbohydrate content consisting of fructose (Gary & Arianna, 2010; Matthews et al., 1987; Yeonsoo et al., 2008). It contributes significantly to daily fiber intake and is abundant in antioxidants, providing excellent protection against cardiovascular disease, supporting cancer recovery, and aiding in the relief of constipation (Bin & Clifford, 2008; Fang et al., 2010). The demand for raisins has been steadily increasing due to their extensive use in medicinal preparations, bakery and dairy products in addition to being eaten as snacks.

Dried grapes are highly concentrated in Asia and the America. In the country, Maharashtra is the leading state for fresh and raisin grape production. Sangli, Solapur and Nashik districts of Maharashtra are well known for raisin production (Pawar et al. 2024, Sharma et al., 2020).

The Indian fresh grape sector encounters challenges in marketing, both domestically and internationally, due to a lack of new varieties, oscillating regulations, paucity of grading-packaging knowledge, labour unavailability during important viticulture operations, lack of updated market information, etc. (Karangami et al., 2021). Fresh grapes are sensitive for spoilage because of high moisture, which elevates the microbial load and hence cannot be stored for a longer time.

Also, there is the possibility of a glut in the market which subsequently reduces the price. Furthermore, realizing the utmost advantages of grape cultivation necessitates the establishment of processing industries dedicated to producing value-added products such as high-quality raisins/monukka. Therefore, processing fresh grapes to dried raisins/monukka is a good option for better price realization due to longer storage, making its availability throughout the year.

The Indian, raisin industry predominantly relies on limited grape varieties like Thompson Seedless and its clones such as Tas-A-Ganesh and Sonaka, as well as Sharad Seedless and its clonal selections like Krishna Seedless, Sarita Seedless, Nanasaheb Purple, etc. (Sharma et al., 2018). The quality of raisins is significantly influenced by the grape variety, growing conditions, sugar content at harvest and processing method, which impact the sensory parameters and thus the consumer acceptability (Sharma et al., 2018). Drying greatly influences the raisin's texture and nutrients (Yang et al., 2009).

Recognizing the significance and high demand for coloured monukka/raisins, seven potential munakka/raisin purpose hybrids were selected based on preliminary observations on berry morphological and sensory parameters. This study aimed to evaluate the performance of potential new hybrids for munakka/raisin purpose based on bunch and berry parameters, raisin recovery, biochemical properties and sensory evaluation in comparison to commercial variety 'Sharad Seedless'. The study will expand the options for the availability of more monukka/raisin purpose-coloured grape varieties to support the Indian raisin industry.

MATERIALS AND METHODS

The study was conducted under the tropical region at ICAR-National Research Centre for Grapes, Pune with latitude 18°32′N and longitude 73°51′E during 2022 to 2024. Seven-year-old grape vines grafted on Dogridge rootstock, planted at the distance of 9 × 5 ft^2 and trained on Y trellises were carefully selected for the investigation. The study was conducted in a randomized block design comprising 6 vines each in the three replications. Throughout the study duration, all standard recommended viticultural practices were diligently followed. The potential seeded (H84.24, H81.24, H111.24, H68.24, H01.23, H58.24) and rudimentary seeded (H19.24) coloured hybrids used for evaluation for munakka/raisin purpose in comparison to the commercial variety 'Sharad Seedless'.

Bunch and berry traits

Average bunch weight (g) was recorded from the ten randomly selected bunches from each replication. Twenty-five berries were collected from different portions of bunches to record the weight of the berries (g). To determine the total soluble solids (TSS) and titratable acidity (TA) of berries, the juice was extracted from crushed berries (approximately 25 berries randomly collected from different vines within the same replication) and centrifuged for 5 minutes at 5000 rpm. The obtained data were recorded using a digital hand refractometer for measuring TSS (model ERMA of Japan) and the titrable acidity by titration against 0.1 N NaoH using phenolphthalein indicator as estimated by Ranganna (1986).

Raisin making and recovery

For the raisin making, one kilogram of fresh grapes was immersed in an emulsion containing 2.5% potassium carbonate and 1.5% ethyl oleate for 2 minutes. The grapes were then placed inside the raisin shed until reaching a moisture level of 14-16 per cent. Raisin recovery was calculated using the following formula.

Raisin recovery (%) = (weight of raisins/weight of fresh grapes) ×100

Raisin biochemical traits

Samples were prepared by crushing the raisins using a mortar and pestle to determine the biochemical composition of the raisins. Following the crushing, 0.5 grams of the raisin samples were placed into centrifuge tubes, to which 20 mL of 80% methanol was added. The tubes were then shaken and centrifuged at 5000 rpm for 5 minutes, after which the supernatant was collected for analysis. The total amount of carbohydrates was calculated using the Anthrone method with D-glucose as the standard and reducing sugar was estimated using the Dinitrosalicylic Acid (DNSA) method (Sadasivam & Manickam, 1996). The protein content was calculated using the methodology recommended by Lowry et al. (1951). Gallic acid was used as a standard in the Folin-Ciocalteu method to determine the phenols (Singleton & Rossi, 1965). pH differential method was used for measuring total anthocyanin content (Lee et al., 2005), while tannins in raisins were estimated through the Folin-Denis method, with absorbance measured at 700 sm and reported in mg/g using tannic acid as a reference. The colour intensity was determined following the method of Zoecklein et al. (1995) using a spectrophotometer (UV-Visible Spectrophotometer, Evolution 201, USA).

Sensory evaluation

Raisin sensory evaluation was performed using an organoleptic test. Raisins were served to a panel of twenty-five semi-trend members representing various age groups. The 9-point Hedonic scale was employed to generate the sensory data including parameters such as pulp content, texture, flavour, sweetness, taste and overall acceptability. The test was administered using a scale from "dislike extremely" to "like extremely".

Statistical analysis

The data was analyzed using OPSTAT version (http://opstat.pythonanywhere.com/). The mean comparison was executed using analysis of variance and the Fisher's least significance difference.

RESULTS AND DISCUSSION

Bunch and berry traits

The genotypes under investigation showed notable differences in bunch weight, berry weight, pH, acidity, weight of 100 raisins, and raisin recovery (Table 1). Bunch and berry weight are the crucial parameters determining the yield potential of the genotype. The average bunch weight extended from 195.7 g to 378.7 g. H111.24 had the highest bunch weight (378.7 g), followed by H01.23 (342.7 g), and H58.24 had the lowest (195.7 g). With an average of 170.0 g for the 25-berry weight, H111.24 had the highest value, demonstrating a larger berry size. On the other hand, Sharad Seedless, H01.23, and H19.23 had relatively smaller berries, with an average of 25 berry weights of 87.0 g, 85.0 g, and 83.0 g, respectively. The primary cause of these variances is the genotype's unique genetic composition, which varies depending on the soil and climate in the area (Wrinkle, 1962).

In addition to the berries physical characteristics, the total soluble solid (TSS) and acidity content of the berries during harvest have a direct impact on the raisins' market acceptability and eating quality (Somkuwar et al., 2020). The genotypes varied from 20.0 to 22.8°B for the TSS with non-significant variation (Table 1). Since the majority of the genotypes (H84.24, H111.24, H19.24, H68.24 and H01.23) had harvest TSS above 22°B, their high TSS content made them suitable for both fresh consumption and the production of munakka and raisins. The results align with the findings of Christensen et al. (1995), who

Table 1 : Performance of grape genotypes in relation to raisin making qualities

Genotype	Bunch weight (g)	25 Berry weight (g)	Total soluble solids (°B)	Titrable acidity (g/L)	Juice pH	100 raisin weight (g)	Raisin recovery (%)
H84.24	320.0^{ab}	130.0^{c}	22.8^{a}	6.38^{b}	3.81^{b}	163.0^{a}	23.6^{b}
H81.24	326.7^{ab}	124.0^{c}	21.5^{a}	6.45^{b}	3.64^{c}	122.0^{c}	20.6^{d}
H111.24	378.7^{a}	170.0^{a}	22.8^{a}	5.10^{f}	3.89^{a}	124.0^{c}	19.7^{e}
H19.24	302.3^{b}	83.0^{e}	22.4^{a}	6.15^{c}	3.40^{f}	78.0^{e}	24.7^{a}
H68.24	315.0^{b}	115.0^{d}	22.5^{a}	6.45^{b}	3.57^{d}	127.0^{c}	23.3^{bc}
H01.23	342.7^{ab}	85.0^{e}	22.2^{a}	6.75^{a}	3.84^{b}	87.0^{d}	22.6^{c}
H58.24	195.7^{c}	140.0^{b}	22.4^{a}	5.63^{d}	3.89^{a}	153.0^{b}	23.6^{b}
Sharad Seedless (Check)	332.0^{ab}	87.0^{e}	20.0^{a}	5.40^{e}	3.52^{e}	70.0^{f}	23.0^{bc}
SEm±	18.7	10.9	0.33	0.21	0.07	12.1	0.59
LSD at 5%	62.8	6.47	NS	0.12	0.04	7.19	0.82
CV (%)	37.0	25.5	10.5	13.3	10.9	29.0	6.7

Means with at least one letter common in a row are not statistically significant using Fisher's least significant difference found that the ideal TSS value for Thompson Seedless grapes before their drying into raisins was 19°B. There were notable variations across the genotypes in titrable acidity, which influences grape flavour and shelf life. The lower the acidity, the sweeter the raisins. H111.24 showed the lowest acidity (5.10 g/L), followed by the Sharad Seedless (5.40 g/L). The titrable acidity ranged from 5.10 to 6.75 g/L. Together, tartaric and malic acids make up more than 90 per cent of the overall acidity in grape juice, making them the main acids. However, the concentration of these acids can vary significantly depending on the grape variety (Hidalgo, 2002). The pH of the juice ranged from 3.40 to 3.89, with significant variation among the genotypes. H19.24 had the lowest juice pH (3.40), whereas H111.24 and H58.24 had the highest juice pH (3.89), suggesting a reduced acidity level. Warmer climates have a higher sugar-acid ratio than cooler ones, which is reflected in decreased acidity levels (Barnuud et al., 2014; Somkuwar et al., 2020). As a result, sweeter raisins are produced, which improves consumer acceptance.

For different uses, different sizes of munakka or raisins are preferred. In the domestic market, smaller raisins are more widely accepted for enhancing the nutritional content of products like in bakeries or homemade products. Sharad Seedless and H19.24 yielded smaller raisins, with an average weight of 70.0 and 78.0 g per 100 raisins, respectively. The weight of the raisins in H84.24 (163.0 g) and H58.24 (153.0 g) was nearly twice. In addition to the quality traits of the raisins, raisin recovery is of concern for extending the profitability range. Better raisin recovery was observed in the H19.24 (24.7%) and H84.24 (23.6%) when compared to the Sharad Seedless. This indicates that these genotypes have a high potential for producing monukka/raisins. Fresh berry weight and soluble solids content are directly related to raisin weight and recovery (Christensen, 2000; Somkuwar et al., 2019; Winkler, 1962).

Raisin biochemical traits

Significant differences were displayed among the genotypes for all the biochemical traits studied in the monukka/raisin made (Table 2). Reducing sugars ranged from 637.9 mg/g (H68.24) to 713.2 mg/g (H84.24), while total carbohydrates varied between 256.8 mg/g (Sharad Seedless) to 329.7 mg/g (H84.24). Grapes' flavour character is greatly influenced by their phenol level, which varied significantly between genotypes (CV: 26.8%). The highest phenol level was found in H01.23 (2.94 mg/g), followed by Sharad Seedless (2.88 mg/g); H84.24 (1.38 mg/g) had the lowest phenol value. The grapes lose water during the drying process, which results in a notable concentration of phenolic chemicals. However, enzymatic and air oxidation can also result in the loss of these phenolic compounds during the grape-to-raisin

Table 2 : Biochemical constituents of raisins prepared from identified grape hybrids/genotypes

Genotype	Reducing sugar (mg/g)	Total carbohydrates (mg/g)	Phenol (mg/g)	Tannins (mg/g)	Protein (mg/g)	Proline (µmoles/g)	Anthocyanin (mg/g)	Colour intensity
H84.24	713.2[a]	329.7[a]	1.38[e]	2.48[f]	21.0[f]	17.9[d]	0.41[f]	1.46[e]
H81.24	681.3[bc]	285.3[b]	1.87[c]	3.26[d]	26.4[d]	17.4[d]	0.24[h]	1.21[f]
H111.24	685.9[bc]	278.8[b]	1.74[d]	2.99[e]	34.0[b]	20.4[ab]	0.95[e]	3.06[a]
H19.24	687.3[b]	285.9[b]	2.01[b]	3.62[c]	35.3[ab]	20.7[a]	2.08[a]	3.09[a]
H68.24	637.9[e]	284.0[b]	2.08[b]	3.87[b]	22.9[e]	18.9[c]	0.29[g]	1.05[g]
H01.23	657.2[de]	264.1[c]	2.94[a]	4.70[a]	36.3[a]	20.1[ab]	1.36[c]	2.27[d]
H58.24	653.5[de]	290.6[b]	1.72[d]	2.93[e]	31.2[c]	20.9[a]	1.14[d]	2.54[c]
Sharad Seedless	665.0[cd]	256.8[c]	2.88[a]	3.57[c]	34.5[b]	19.5[bc]	1.52[b]	2.95[b]
SEm±	8.43	7.67	0.20	0.24	2.11	0.46	0.23	0.30
LSD at 5%	22.2	12.4	0.13	0.15	1.26	0.96	0.02	0.09
CV (%)	3.54	7.63	26.8	19.8	19.8	6.71	65.7	38.6

The means with the same letters or having a common letter(s) are not significantly different conversion process (Breksa et al., 2010). Following the pattern of phenol content, tannin content was highest in H01.23 (4.70 mg/g) and lowest in H84.24 (2.48 mg/g). The range of protein content extended from 21.0 mg/g (H84.24) to 36.3 mg/g (H01.23). Proline, an amino acid associated with flavour enhancement in grapes, varied between 17.4 µmoles/g (H81.24) to 20.9 µmoles/g (H58.24). However, the proline range (CV: 6.7%) was not significantly wider. A wide range of anthocyanin content was found (CV: 65.7%) in comparison to other biochemical parameters. This substance gives grapes their red, purple, and blue colour and adds antioxidant qualities that differ greatly between genotypes. While H81.24 had the lowest anthocyanin content (0.24 mg/g), H19.24 had the highest anthocyanion concentration (2.08 mg/g), making it valuable for its colour and possible health advantages. Black raisins' anthocyanin pigments and phenolic chemicals are mostly responsible for their antioxidant qualities (Cevallos-Casals et al., 2006). Williamson & Carughi (2010) reviewed the health advantages of raisins and found that the main phenolic constituents were flavonols, quercetin, kaempferol, caftaric acid, and coutaric acid. These genotypes have rich colouration, which is suitable for value-added products. H68.24 had the lowest colour intensity (1.05), whereas H19.24 (3.09) and H111.24 (3.06) had the highest colour intensity.

Significant biochemical a range across the grape genotypes is highlighted in the study, with each exhibiting distinct advantage. H19.24 stands out for its high anthocyanin content, colour intensity, proline and protein content. These findings provide valuable insights for the selection of genotypes based on their intended use, whether for fresh consumption, processing or as a source of bioactive compounds. Compared to raisins from white grapes such as Thompson Seedless, Manjari Naveen, and Manjari Kishmish, black-seeded grapes have a higher level of phenols in their seeds and skin (Somkuwar et al., 2020). The findings also support those of Shao et al. (2016), who showed that different raisins differ greatly in terms of phenolic chemicals and their concentrations.

Sensory evaluation

Along with the nutritional content, the food product's appearance, texture, taste, and odour are important characteristics that greatly influence the consumer's choice. The evaluation of raisin quality includes elements that have a major influence on the marketability of raisins, such as appearance, texture, flavour and cleanliness. An essential stage in assessing

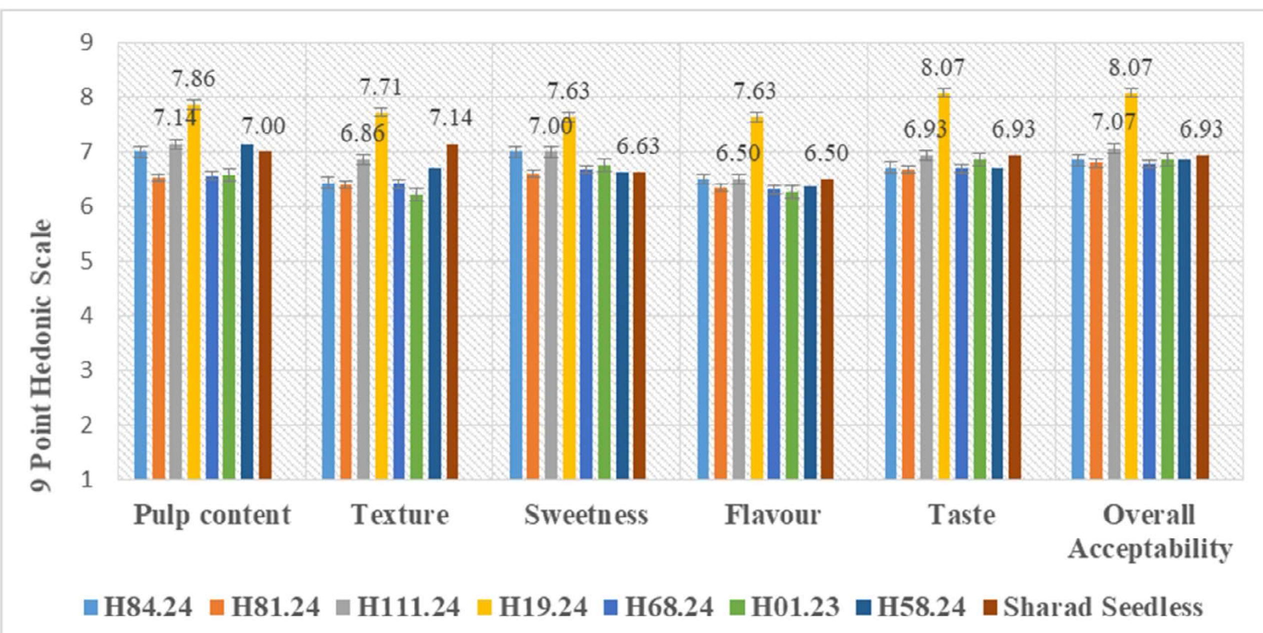

Fig. 1 : Sensory evaluation of raisins made from different grape genotypes in comparison to Sharad Seedless

the product's acceptability and quality is performing an organoleptic test. The customer favoured genotype H19.24 because it consistently performed better than other genotypes, especially in terms of pulp content (7.86), texture (7.71), sweetness (7.63), flavour (7.63), taste (8.07) and overall acceptability (8.07) (Fig. 1). Positive findings were also shown by H111.24, particularly in pulp content (7.14), texture (6.86), sweetness (7.00) and overall acceptance (7.07). Sharad Seedless demonstrated consistent and balanced scores across all attributes, indicating its general acceptability for raisin production. Similar variations in the organoleptic quality of raisins made from several grape varieties were noted by Somkuwar et al. (2020). The variability in organoleptic scores is associated with the quality of grapes and the drying conditions.

CONCLUSION

Due to their high demand in numerous kinds of food industries, dried grape production has emerged to be a global industry. Raisins' availability, affordability, nutritional value, and ease of use make them a great addition to the human diet. Only a few raisin grape varieties are utilized in the Indian raisin market. As a result, some hybrids were identified and evaluated for raisins purpose. When compared to Sharad Seedless, two of these hybrids (H19.24 and H111.24) were incredibly valuable. H19.24 undoubtedly represents the excellent raisin variety based on the thorough examination of quality parameters, biochemical composition and sensory evaluation. In addition to its excellent sensory qualities, it offers good raisin recovery. It has demonstrated a high degree of advantageous biochemical content, including protein, tannin, and phenol, making it a promising option for producing raisins of superior quality. Moreover, based on the noteworthy biochemical composition, which includes a high protein content and good sensory scores, H111.24 also shows great potential for monukka purposes. As a result, these two hybrids assure the Indian raisin industry's continued relevance in both domestic and foreign markets.

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