SUPPLEMENTARY DATA
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Supplementary data

Supplementary table 1. Genes contributing to the sensory and quality parameters of wines were extracted from these enriched pathways, furthermore, hub genes with similar function, of which belong to enriched pathways, were extracted from the WGCNA clustered modules.

Genus	Hubgene/ Enriched	Gene name	Gene ID	Pathway	Function	Function in wine aroma	Reference
Alternaria	Enriched (E)	Phenylpyruvate aminotransferase	CC77DRAFT_1066078	Tyrosine/Phenylalanine metabolism	Contributing to phenylalanine biosynthesis.	Phenylalanine is a precursor for rose, honey and flower tones (2-phenylacetate).	Styger *et al.*, 2011
	Hubgene (H)	Citrate sythase	CC77DRAFT_250650	Krebs cycle	Formation of diacetyl via the metabolism of citrate.	Diacetyl gives the 'buttery' attribute of wine.	Bartowsky *et al.*, 2004
	Enriched (E)	Isocitrate dehydrogenase	CC77DRAFT_1056855	Krebs cycle	Catalyzes the oxidative decarboxylation of isocitrate, producing alpha-ketoglutarate.	Isocitric acid as a powerful antioxidant helps protect wine aromatic compounds against oxidation.	Kamzolova *et al.*, 2021

Enriched (E)	Glycerol kinase	CC77DRAFT_76448	Glycolysis, gluconeogenesis, and triglyceride metabolism	Converts glycerol to glycerol-3-phosphate.	Glycerol is one of several polyols present in wine a non-volatile sugar alcohol with a slightly sweet taste and a viscous nature, it is considered to confer a degree of roundness and smoothness on the palate.	Rankine *et al.*, 1971; Hinreimer, *et al.*, 1955; Hickinbotham *et al.*, 1948
Enriched (E)	L-lactate dehydrogenase	CC77DRAFT_285449	Malolactic fermentation	Malolactic fermentation-Malolactic fermentation (MLF) is responsible for the decarboxylation of l-malic-acid into lactic-acid.	It reduces the acidity of wine, improves flavor complexity and microbiological stability.	Vicente *et al.*, 2022
Enriched (E)	Long-chain-fatty-acid-CoA ligase	CC77DRAFT_1033357	Fatty acid metabolism	Long chain fatty acyl-CoA synthetase catalyzes the formation of fatty acyl-CoA by a two-step process proceeding through an adenylated intermediate.	Medium and long chain fatty acids, higher alcohols, acetate esters and ethyl esters are the main components that contribute to wine fermentative aromas, providing fruity and floral notes.	Swiegers *et al.*, 2005; Verstrepen *et al.*, 2003

	Enriched (E)	Mevalonate kinase	CC77DRAFT _1019990	Isoprenoid and sterol metabolism	Contributes biosynthesis of geranyl diphosphate, farnesyl diphosphate and diterpenes geranylgeranyl diphosphate, which play role in terpene metabolism.	Terpenes are one of the most important groups of volatile compounds contributing to the aroma profile of wine grapes.	Marais, 1983
	Enriched (E)	Fatty acid synthase beta subunit	CC77DRAFT _928877	Fatty acid metabolism	De-novo synthesis of fatty acids.	Medium and long chain fatty acids, contribute to wine aromas, providing fruity and floral notes.	Swiegers *et al.*, 2005
	Enriched (E)	S-formylglutathione hydrolase	CC77DRAFT _1003962	Methane metabolism	Oxidating formaldehyde into formate, reducing the concentration of this compound.	Formate derivate compounds such as isopentyl formate are associated with an apple like aroma in wine.	Kelebek *et al.*, 2011
	Enriched (E)	Cynnamyl alcohol dehydrogenase	CC77DRAFT _404246	Phenylpropanoid metabolism	Catalyzes the formation of cynnamaldehyde from cinnamyl alcohol.	Cynnamaldehyde contributes to the formation of sweet cherry type aromas.	Burdock, *et al.*, 2016
Aureobasidium	Enriched (E)	Acetolactate sythase	M438DRAFT _264767	Valine, Leucine and Isoleucine metabolism	Involved in the synthesis of acetolactate.	Acetolactate is a precursor of vicinal diketones causing butter like aromas.	Bruner, *et al.*, 2022

Enriched (E)	Saccharopine dehydrogenase	M438DRAFT_353266	Lysine biosynthesis	Transforms L-saccharopine to 2-oxoglutarate.	2-oxoglutarate is one of the main carbonyl compounds in wine.	Herzan, *et al.*, 2020
Enriched (E)	Galactose oxidase	M438DRAFT_276942	Galactose metabolism	Catalyzes the oxidation of alcohols to aldehydes	The oxidation flavor in wine is due to multiple compounds including a range of aldehydes.	Culleré, *et al.*, 2007
Hubgene (H)	Feruloyl esterase	M438DRAFT_347279	Feruloyl metabolism	Involved in the release of hydroxycinnamic acids from their esterified forms, hydroxycinnamic acids can be transformed into volatile phenols.	Volatile phenols are important contributors to the aroma of plant derived foods	Schieber, *et al.*, 2020
Hubgene (H)	Carboxylic ester hydrolase	M438DRAFT_363842	Glycerophospholipid metabolism	Contributes to ester degradation.	Ester degradation gave rise to the formation of their corresponding carboxylic acid reducing the amount of wine odorants	Pérez-Jiménez, *et al.*, 2019
Hubgene (H)	Glycosyltransferase	M438DRAFT_316845	Terpenoid metabolism	Monoterpenyl glycosyltransferases contribute to the production of monoterpenyl glycosides.	The importance of monoterpenes on varietal flavor of wines has been reviewed.	Strauss *et al.*, 1986

Hubgene (H) and Enriched (E)	Pyruvate decarboxylase	M438DRAFT_346971	Pyruvate metabolism	Catalyzes the decarboxylation of pyruvic acid to acetaldehyde	Acetaldehyde is one of the most important sensory carbonyl compounds in wine and constitutes approximately 90% of the total aldehyde content in wine.	Liu *et al.*, 2000
Hubgene (H) and Enriched (E)	Pyruvate dehydrogenase	M438DRAFT_348965	Pyruvate metabolism	The acetate produced by the PDH bypass accumulates during alcoholic fermentation.	In excessive quantities, volatile acids are seen as a spoilage characteristic conferring the wine an acrid taste and the unpleasant vinegar aroma.	Boulton *et al.*, 2013
Hubgene (H) and Enriched (E)	Isocitrate lyase	M438DRAFT_343020	Krebs cycle	Catalyzes the cleavage of isocitrate to succinate and glyoxylate.	Isocitric acid as a powerful antioxidant helps protect wine aromatic compounds against oxidation	Kamzolova *et al.*, 2021
Hubgene (H)	Malic enzyme	B5807_05369	Krebs cycle	Conversion of L-malic to L-lactic acid	Malolactic fermentation can affect wine flavor by modifying the concentrations of aroma impact compounds such as diacetyl, esters, higher alcohols, and volatile acids.	Capozzi *et al.*, 2015

Hubgene (H) and Enriched (E)	Glycoside hydrolase	M438DRAFT_317847	Glycolysis	Forms glycoconjugates.	Accumulated non-volatile and flavorless glycoconjugates make up a reserve of aroma precursors.	Sarry *et al.*, 2004
Hubgene (H) and Enriched (E)	Aromatic amino acid transferase	M438DRAFT_343791	Amino acid metabolism	Catalyze the transamination of aromatic amino acids to corresponding alpha-keto acids	Microbial catabolism of amino acids produces flavor compounds of importance for wine, however amino acids play a relevant role in wine quality and can allow for classifying wines according to the variety.	Ardö *et al.*, 2006
Hubgene (H)	Anthranilate synthase	M438DRAFT_335458	Anthranilate and Tryptophan metabolism	Synthesizes methyl anthrnilate.	Methyl anthranilate is a molecule with high aromatic value, the note of orange blossom.	Lin *et al.*, 2019

Hubgene (H) and Enriched (E)	Glutamate cystein lygase	M438DRAFT_342907	Glutamate metabolism	Glutamate cystein ligase is a rate limiting enzyme in gluthatione biosynthesis.	Glutathione, a strong antioxidant naturally present in grape berries and produced by yeasts during fermentation, can be added by winemakers to control oxidative deterioration of wine, and prevents loss of flavor and aroma	Binati *et al.*, 2021
Hubgene (H)	Glutathione hydrolase	M438DRAFT_280042	Glutamate metabolism	Formation of cysteinglycine which is a precursor for 3-mercaptohexan-1-ol.	3-Mercaptohexan-1-ol is a wine odorant gives wine a 'fruity' aroma.	Capone *et al.*, 2012; Murat *et al.*, 2001
Enriched (E)	Kynureninase	M438DRAFT_265743	Tryptophan metabolism	Catalyzes the cleavage of L-kynurenine to anthranilic acid.	Kynurenine gives "untypical aging off-flavor" in wines.	Hoenicke *et al.*, 2002
Enriched (E)	3-isopropylmalate dehydrogenase	M438DRAFT_313770	Leucine metabolism	Transforms (2R,3S)-3-isopropylmalate to 4-methyl-2-oxopentanoate which is an intermediate in leucine biosynthesis.	Leucine contributes to a fruity flavor in wine and other alcoholic beverages.	Shimizu *et al.*, 2016

Enriched (E)	Gamma-glutamylcyclotransferase	M438DRAFT_323211	Glutathione metabolism	γ-glutamyl transferases/transpeptidases are involved in the catabolism of many compounds that are conjugated to glutathione.	GHS have a variety of roles. Furthermore, many distinctive flavor and aroma compounds in Sauvignon blanc wines originate from odorless C5- and C6-GSH conjugates or their GGT catabolized derivatives. These precursors are then processed into their volatile forms by yeast during fermentation.	Philips *et al.*, 2019
Enriched (E)	Prephenate dehydratase	M438DRAFT_326681	Nitrogen metabolism/Amino acid metabolism	Prephenate dehydratase converts prephenate to phenylpyruvate which is subsequently converted to 2-Phenylethanol.	2-phenylethanol gives honey, rose or lilac aroma in wines and fermented foods.	Synos *et al.*, 2015
Hubgene (H) and Enriched (E)	Aldehyde dehydrogenase	M438DRAFT_282832	Amino acid metabolism, Carbohydrate metabolism, Alcohol metabolism	Catalyzes the oxidation of aldehydes to carboxylic acids.	Organic acids content in must and wine influence in the balance of the flavor as well as in the chemical stability, pH, and thus in the quality of wine.	Ali *et al.*, 2011

Enriched (E)	Aspartate aminotransferase	M438DRAFT _279163	Aspartate metabolism, Tyrosine metabolism	Involved in the synthesis of tyrosine, which is an aromatic amino acid which can be degraded to form floral, and chemical flavors.	Tyrosine is an aromatic amino acid which can be degraded to form floral, and chemical flavors.	Ardö, 2006
Enriched (E)	Hydroxyacylglutathione hydrolase	M438DRAFT _273852	Pyruvate metabolism	Catalyzes the hydrolysis of S-D-lactoyl-glutathione to from glutathione and D-lactic-acid.	Glutathione inhibited the decline of several volatiles such as isoamyl acetate, ethyl hexanoate, ethyl octanoate, ethyl decanoate, and linalool in wine during storage.	Papadopoulou *et al.*, 2008
Enriched (E)	Citrate sythase	M438DRAFT _294441	Krebs cycle	Formation of diacetyl via the metabolism of citrate.	Diacetyl gives the 'buttery' attribute of wine.	Bartowsky *et al.*, 2004
Enriched (E)	L-lactate dehydrogenase	M438DRAFT _292234	Malolactic fermentation	See above		
Enriched (E)	Mevalonate kinase	M438DRAFT _265955	Mevalonate metabolism- Lipids	See above		

Enriched (E)	Thiol ester dehydrase-isomerase	M438DRAFT_310991	Fatty acid metabolism	Involved in the synthesis of esters.	Esters constitute a broad family of volatile compounds impacting the organoleptic properties of wine.	Marullo *et al.*, 2021
Enriched (E)	ERG20 farnesyl diphosphate synthase	M438DRAFT_269366	Ergosterol metabolism	Involved in the synthesis of rotundone.	Rotundone contributes to giving wine a peppery aroma.	Siebert *et al.*, 2008
Enriched (E)	Maleylacetate reductase	M438DRAFT_268034	Gamma-hexachlorocyclohexane-, benzoate- and 1,4-dichlorobenzene metabolism	Maleylacetate is then converted to 3-oxoadipate by maleylacetate reductase, after which it is converted to 3-oxoadipate-SCoA and further to acetyl-CoA and succinate that enters the TCA280.	The enzyme is involved in the degradation pathway of aromatic compounds.	Chauhan *et al.*, 2009

	Hubgene (H) and Enriched (E)	Geranyl diphosphate sythase	M438DRAFT_273287	Mevalonate metabolism (Cholesterol)	Catalyzes terpenoid biosynthesis.	Terpenoids are one of the most important compounds regarding wine aroma representing the uniqueness of the wine, and are indicative of a specific grape variety and wine region.	Mele *et al.*, 2021
	Enriched (E)	Pantothenate kinase	M438DRAFT_366935	Coenzyme A biosynthetic pathway	Pantothenate kinase overexpression increases intracellular CoA and acetyl-CoA levels and influences ester or higher alcohol synthesis.	Higher alcohols have considerable impact on the aroma and flavor of fermented products.	De-La-Fuente-Blanco *et al.*, 2016
Epicoccum	Enriched (E)	Pentafunctional arom polypeptide	B5807_03777	Amino acid metabolism	Involved in aromatic amino acid biosynthesis, which can be degraded to form floral, and chemical flavors.	Aromatic amino acids can be degraded to form floral, and chemical flavors.	Ardö, 2006

Hubgene (H) and Enriched (E)	Phosphoglucomutase	B5807_00578	Glycolysis and gluconeogenisis	Catalyzes a key step in hexose metabolism, which can form precursors of important volatiles.	Many of the wine flavors formed during fermentation are metabolites of the hexose metabolism pathway	Reiter *et al.*, 2021
Enriched (E)	Acetolactate sythase	B5807_00488	Malolactic metabolism; Citric acid metabolism	see above		
Enriched (E)	Lactoylglutathione lyase	B5807_09934	Amino sugar metabolism	Lactoylglutathione lyase or glyoxalase I is involved in the detoxification of methylglyoxal together with aldo-keto reductase.	Dicarbonyl compounds, like methylglyoxal, are often associated with amino acids in the formation of odorous products present in wine, for instance, leucine and methylglyoxal give rise to 3-methylbutanal responsible for a moderate amylic aroma.	Howell *et al.*, 2005
Enriched (E)	Aldehyde dehydrogenase	B5807_0481	Amino acid metabolism, Carbohydrate metabolism, Alcohol metabolism	See above		

Enriched (E)	Malate dehydrogenase	B5807_02946	Krebs cycle	Malate dehydrogenase catalyzes the reversible conversion of oxaloacetate to l-malate with the participation of NAD(H) in malolactic fermentation.	Malolactic fermentation can affect wine flavor by modifying the concentrations of aroma impact compounds such as diacetyl, esters, higher alcohols, and volatile acids.	Capozzi *et al.*, 2015
Enriched (E)	Malic enzyme	B5807_05369	Krebs cycle	See above		
Enriched (E)	Glycerol kinase	B5807_01031	Glycolysis, gluconeogenesis, and triglyceride metabolism	See above		
Enriched (E)	Fatty acid synthase alpha subunit	B5807_00377	Fatty acid metabolism	De-novo synthesis of fatty acids;	Medium and long chain fatty acids are the main components that contribute to wine fermentative aromas, providing fruity and floral notes.	Swiegers *et al.*, 2005; Verstrepen *et al.*, 2003
Enriched (E)	S-formylglutathione hydrolase	B5807_08147	Methane metabolism	See above		

Hubgene (H) and Enriched (E)	Citrate sythase	B5807_06716	Krebs cycle	See above	
Enriched (E)	6-phosphogluconolactonase	B5807_08165	Pentose phosphate pathway	6-Phosphogluconolactone is an intermediate in the pentose phosphate pathway.	Play role in fermentation producing higher alcohol as a by-product. Huang *et al.*, 2021

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