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## RESEARCH ARTICLE

# Tokaji Natural Sweet Wines and the Resilience of a Cultural Wine Landscape: An Exploratory Mixed-Methods Consumer Study in Hungary

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**Abstract** – Tokaji natural sweet wines are climate-sensitive cultural-heritage products. Their production depends on *Botrytis cinerea*, autumn humidity, dry ripening periods and grape varieties authorized by the Tokaj PDO, while their market future depends on consumer learning, gastronomy, wine tourism and regional sustainability. This exploratory mixed-methods study reframes consumer acceptance of Tokaji sweet wines as a socio-ecological resilience problem. A structured narrative review of peer-reviewed and official sources was combined with an anonymous cross-sectional online survey of Hungarian adult wine consumers not working in viticulture or winemaking (N=100; 30 July 2024–26 August 2024). Respondents were classified as current Tokaji sweet-wine consumers/buyers (n=37), rejecters (n=43) and potential consumers (n=20). Likert-scale variables were analysed by descriptive statistics, Kruskal-Wallis tests, Holm-adjusted Mann-Whitney comparisons and Spearman rank correlations. Flavour was the most important wine-choice factor in all groups (mean 4.73–4.80/5) but did not differ significantly between groups (H=0.12, p=0.944). Group differences were strongest for sweet-wine beliefs: rejecters agreed more with the statement "I do not like the flavour of sweet wine" (mean 3.21) than current consumers (mean 1.41), while current consumers attached higher symbolic and gift value to Tokaji sweet specialities. Because the sample was small, urban, highly educated and non-representative, the results should be interpreted as pilot evidence. The paper proposes a regenerative wine-tourism and consumer-education model linking product knowledge, food pairing, heritage interpretation and climate-adaptive viticulture to the resilience of the Tokaj cultural landscape.

**Keywords** – Tokaji Aszú; natural sweet wine; consumer preference; regenerative wine tourism; cultural landscape resilience; climate adaptation

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## INTRODUCTION

Wine regions are not only production spaces but also socio-ecological systems in which climate, soils, grape varieties, local knowledge, cultural heritage, market demand and tourism interact. In such systems, consumer demand is more than a marketing outcome: it can affect whether labour-intensive traditional products remain economically viable and whether the cultural landscape that supports them continues to be maintained.

The international wine sector has entered a period of structural pressure. The OIV state-of-the-sector report for 2025 estimated the world vineyard area at about 7.0 million ha, reported a third consecutive low global production level of 227 million hl, and estimated world wine consumption at 208 million hl, down 2.7% from 2024 (OIV, 2026). These trends have been associated with climate volatility, soft demand and changing consumer behaviour. For traditional European regions, such market changes coincide with

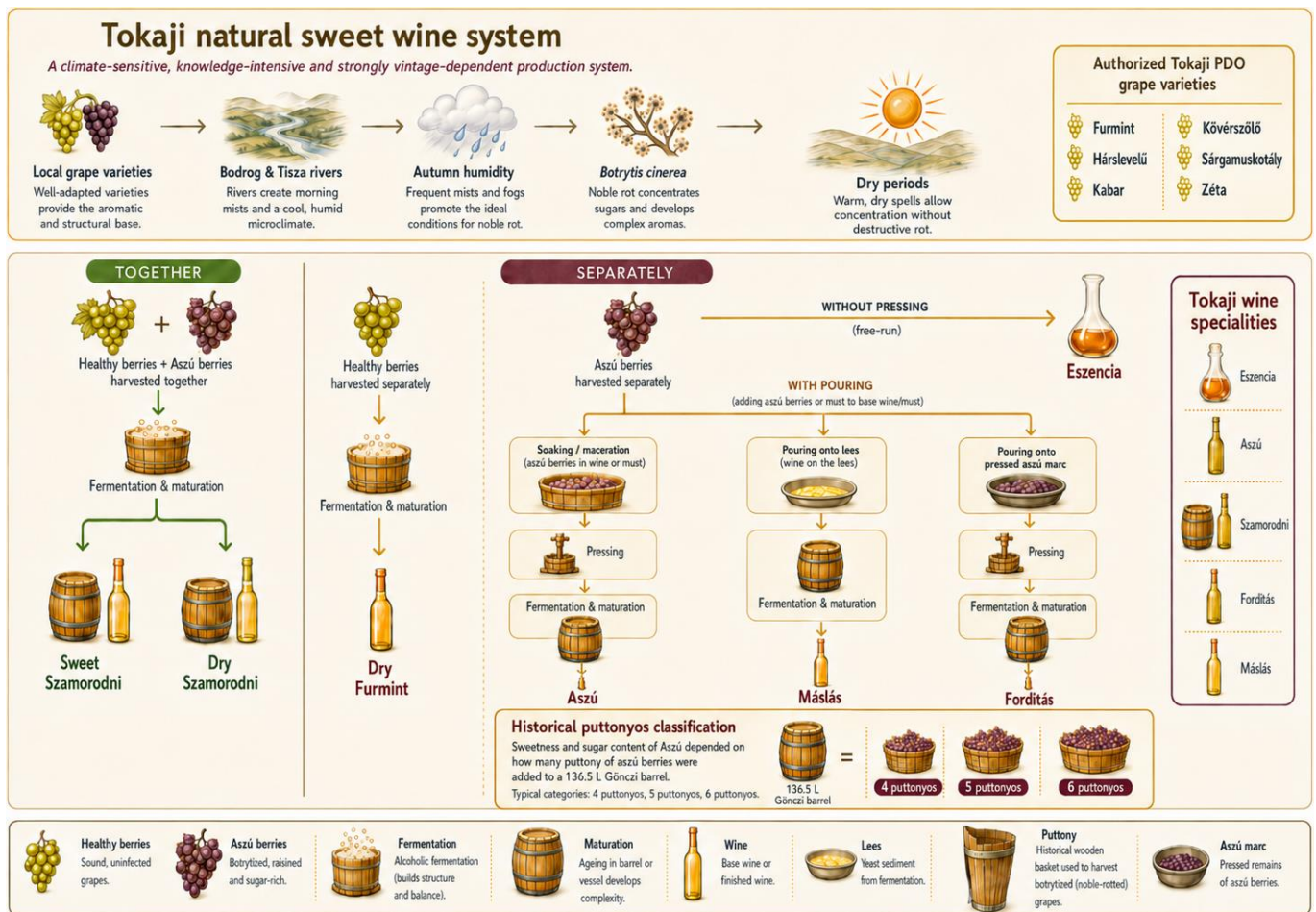
climate risks that affect yield, fruit composition and wine style (Schultz, 2000; Fraga et al., 2016; Koufos et al., 2020).

The Tokaj Wine Region Historic Cultural Landscape, inscribed on the UNESCO World Heritage List in 2002, is an especially relevant case because its international value is linked to the continuity of a wine-growing tradition, settlements, cellars, strict production regulation and a specific environmental setting. UNESCO describes the region as a cultural landscape shaped by volcanic slopes, wetlands and climatic conditions that support noble rot, and explicitly identifies climate change as a potential threat to its integrity (UNESCO World Heritage Centre, 2026).

Tokaji natural sweet wines depend on the interaction between local grape varieties, the microclimate influenced by the Bodrog and Tisza rivers, autumn humidity, *Botrytis cinerea* infection and dry periods that allow concentration without destructive rot. The official Tokaj PDO product specification defines the authorized varieties as Furmint,

Hárslevelű, Kabar, Kövérszőlő, Sárgamuskotály and Zeta, and classifies Eszencia, Aszú, Szamorodni, Fordítás and Máslás as Tokaji wine specialities (Tokaji Borvidék Hegyközségi Tanácsa, 2025). This production system is

therefore climate-sensitive, knowledge-intensive and strongly vintage-dependent (Fig. 1).



Source: Concept based on Tokaji PDO production pathways; varieties and wine specialities summarized from Tokaji Borvidék Hegyközségi Tanácsa (2025).

Figure 1. The complex Tokaj natural sweet wine system in the context of its climate sensitivity.

The market challenge is that natural sweet wines are frequently perceived through a simplified sweetness category, although their sensory profile is a complex combination of sweetness, acidity, aroma, texture, alcohol, maturity and botrytized character. This distinction matters because taste refers primarily to basic taste qualities, while flavour is a broader multisensory perception that also includes aroma, mouthfeel and expectations (Iatridi et al., 2019; Spinelli et al., 2024).

The present study responds to the reviewers recommendation to move beyond a descriptive wine-marketing paper and frame the consumer survey within cultural-landscape resilience, regenerative rural tourism and ecological cycles. The central premise is that the future of Tokaji natural sweet wines depends on two connected adaptation pathways: climate-adaptive and regenerative vineyard/winery management on the production side, and informed consumer learning through gastronomy, heritage interpretation and wine tourism on the demand side.

*Aim, novelty and research questions*

This article is an original exploratory mixed-methods study. It combines a structured narrative review of scientific and official sources with a cross-sectional online consumer

survey. The empirical component is not representative of the Hungarian population; its role is to generate pilot evidence and hypotheses for further research.

The novelty of this study is threefold. First, it treats Tokaji natural sweet wines as components of a climate-sensitive cultural landscape rather than only as commercial products. Second, it reanalyses the original survey with statistical notation and methods more appropriate for ordinal Likert-scale data. Third, it proposes a regenerative wine-tourism and consumer-education model that connects market acceptance with landscape maintenance, ecosystem services and circular resource use.

The study addresses four research questions:

1. Which factors are most important when respondents choose wine, and do these factors differ among consumers/buyers, rejecters and potential consumers of Tokaji natural sweet wines?
2. Which self-reported beliefs and barriers distinguish sweet-wine consumers, rejecters and potential consumers?
3. How should the survey findings be interpreted in relation to consumer learning, gastronomy and wine tourism?

#### 4. How can consumer education be linked to the ecological and cultural-landscape resilience of the Tokaj wine region?

##### *Tokaji natural sweet wines as a climate-sensitive product system*

For the purposes of this study, Tokaji natural sweet wines include Tokaji late-harvest wines, sweet Szamorodni, Tokaji Aszú, Fordítás, Máslás and Eszencia. These products

are not identical in production method, residual sugar, ageing or cultural function; however, all are perceived by many consumers under the broad category of sweet wine. Table 1 summarizes the product categories used in the survey and aligns them with official Tokaj PDO terminology.

Table 1. Tokaji natural sweet wine categories used in the study and their alignment with the official Tokaj PDO product specification (after Tokaj Wine Region Wine Community Council, 2025).

Survey category	Official PDO status	Official and technological notes	Relevance to the study
Tokaji Eszencia	Tokaji wine speciality	Minimum residual sugar in the current specification: 450 g/l. Very rare; obtained from the free-run juice of aszú berries.	Extreme heritage and prestige product; should be discussed as cultural history and not as a health product.
Tokaji Aszú	Tokaji wine speciality	Minimum residual sugar: 120 g/l. Made with separately harvested botrytized/aszú berries macerated with must, fermenting must, wine or new wine from the same vintage; minimum wooden-barrel ageing is specified by the PDO.	Flagship product and the main symbol of Tokaj internationally.
Tokaji sweet Szamorodni	Tokaji wine speciality	Minimum residual sugar: 45 g/l for the sweet type. Made from whole bunches containing healthy and botrytized berries.	Important bridge between Aszú and more accessible sweet styles.
Tokaji late-harvest wine	PDO wine category	Minimum residual sugar: 45 g/l. May be varietal or blended.	Accessible entry category for sweet-wine learning.
Tokaji Fordítás	Tokaji wine speciality	Produced by reusing aszú marc with must, fermenting must, wine or new wine; barrel ageing is regulated.	A traditional example of extracting value from high-quality marc; relevant to circular-winery interpretation.
Tokaji Máslás	Tokaji wine speciality	Produced by pouring must, fermenting must, wine or new wine onto the lees of Aszú or Szamorodni; barrel ageing is regulated.	A rare category that can illustrate traditional resource efficiency and wine education.

##### *Ecocycles perspective and conceptual framework*

The traditional health claims of Tokaj Aszú are not fully proven by modern medical science. Historically, it was sold in pharmacies as an official medicine (*Vinum Tokajense Passum*) to treat ailments ranging from anaemia to exhaustion. However, modern scientific research does validate that the wine possesses powerful chemical properties—specifically anti-inflammatory, antioxidant, and vascular benefits—even though it cannot legally or safely be classified as a medical cure (Markovics et al., 2023). This article does not claim health benefits for alcoholic beverages and adopts the public-health position that wine consumption, if any, should be moderate, legal and responsible (WHO, 2024).

The core of the regenerative-sustainability perspective in this context is to connect consumer behaviour with ecological cycles, ecosystem services, natural resource management, cultural heritage and sustainable development. Regenerative rural tourism and multifunctional organic agriculture provide a suitable conceptual bridge. In the Azienda Agricola model, grape growing, wine, local products, tourism, cultural heritage, direct sales, renewable energy, waste management and ecosystem-service protection form an integrated system rather than isolated activities (Nemethy et al., 2016).

The source materials on regenerative rural tourism emphasize a transition from doing less harm to creating net-

positive outcomes for ecosystems, local communities and rural economies. They also warn against greenwashing and stress the importance of ecological carrying capacity, community involvement and measurable sustainability practices (Kreidlmayer and Oláh, 2025a, 2025b). The bioenergetics source material similarly frames agriculture, forestry, wastewater treatment, compostable organic waste, renewable energy and waste-to-energy systems as parts of anthropogenic ecological cycles (Nemethy, 2018; Nemethy and Dinya, 2012).

Applied to Tokaj, these models suggest that consumer education can support resilience only if it is connected to real landscape and winery practices: soil protection, water management, biodiversity, responsible tourism flows, valorisation of grape pomace and lees, renewable-energy use, local food systems and transparent communication. Figure 2 presents the conceptual model used to interpret the survey.

## MATERIALS AND METHODS

### *Study design*

The study combines two components: (1) a structured narrative review of literature and official documents, and (2) primary analysis of an anonymous online consumer survey. The review component defines the product, ecological and cultural-landscape context. The survey component explores consumer perceptions of Tokaji natural sweet wines among

Hungarian adult wine consumers. This is an exploratory pilot design; it cannot estimate national prevalence or causality.

#### Literature and source selection

The literature review was conducted as a structured narrative review rather than a systematic meta-analysis. Sources were selected from peer-reviewed wine, tourism, consumer-behaviour, viticulture and sustainability literature; official sources from OIV, UNESCO, WHO and the Tokaj PDO product specification; and author-supplied source materials on regenerative tourism, multifunctional

organic agriculture and ecological cycles. Searches were updated in May 2026.

Priority was given to peer-reviewed articles and official institutional sources. Trade, media and commercial sources were not used to support scientific claims; where market context was needed, official OIV data were preferred. Search terms combined wine, consumer and sustainability concepts, for example: Tokaj Aszú consumer preference; sweet wine sensory liking; Botrytis climate change viticulture; regenerative wine tourism; multifunctional agriculture wine tourism; cultural landscape resilience; circular winery; and wine tourism ecosystem services.

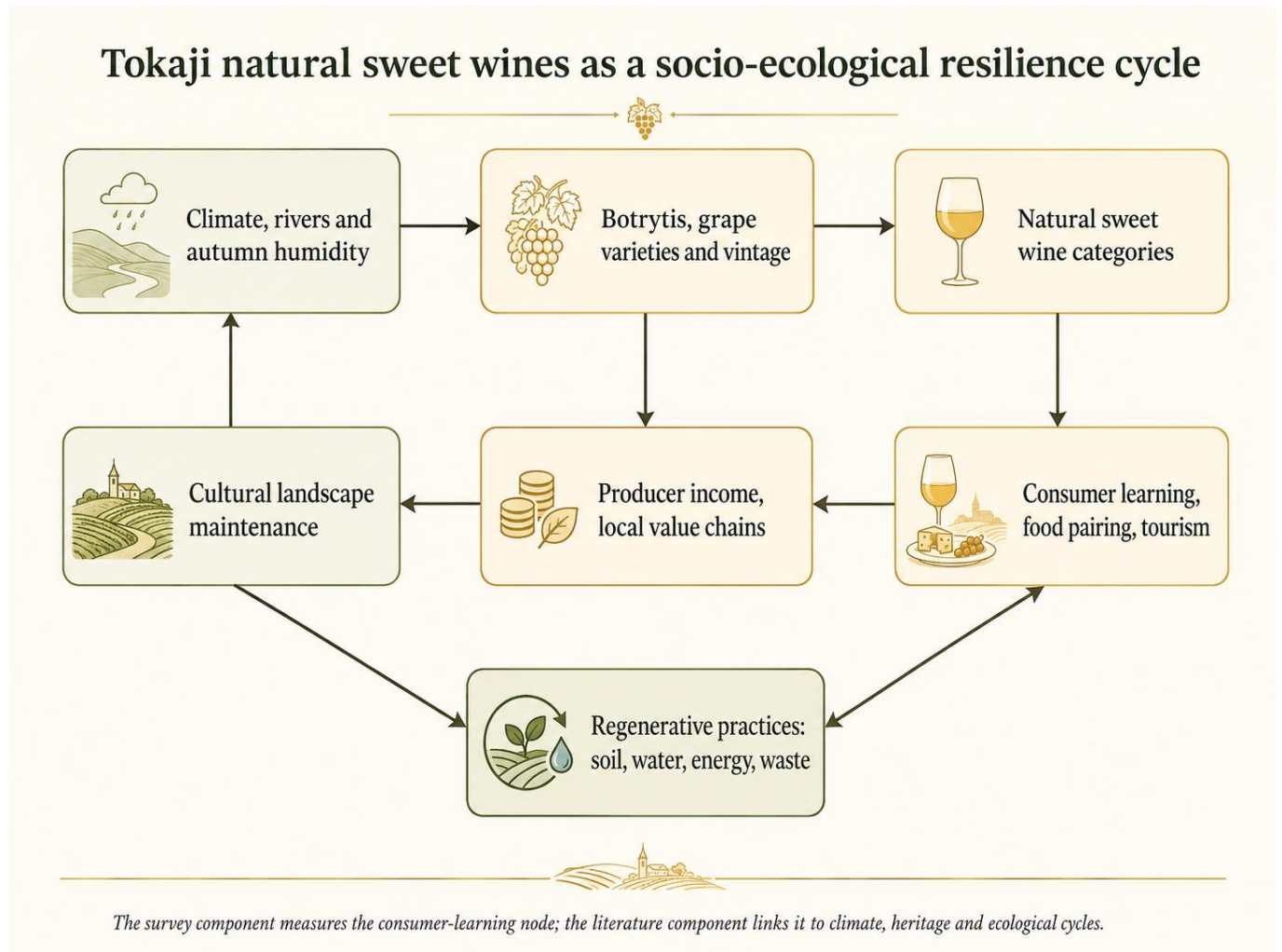


Figure 2. Conceptual model: Tokaji natural sweet wines as a socio-ecological resilience cycle. Source: authors' own elaboration based on Tokaj PDO product logic, UNESCO cultural-landscape interpretation and regenerative multifunctional-agriculture models.

Sources were included if they addressed at least one of the following domains: wine consumer preferences; sensory perception and sweet liking; Tokaj or botrytized wines; climate risks in viticulture; regenerative rural tourism and multifunctional agriculture; circular resource use and ecological cycles; or cultural landscape conservation. Sources were excluded when they were purely promotional, unsupported by traceable authorship or unrelated to wine, rural tourism, cultural heritage or ecological-cycle management.

#### Survey design, participants and recruitment

The survey was conducted online using Google Forms between 30 July 2024 and 26 August 2024. The target population was adult Hungarian wine consumers aged 18

years or above who were not employed in viticulture or winemaking. The questionnaire was anonymous and self-administered. No probability sampling frame was used; the sample was therefore a convenience sample. The final dataset contained 100 valid responses.

Respondents were divided into three pre-defined analytical groups in the source dataset: Tokaji sweet-wine consumers and buyers ( $n=37$ ), sweet-wine rejecters ( $n=43$ ) and potential sweet-wine consumers ( $n=20$ ). The group classification was based on answers concerning sweet-wine consumption, Tokaji dessert-wine purchase and openness to persuasive or educational marketing tools. Because the classification was not derived from a probabilistic

segmentation model, group comparisons are interpreted as exploratory.

#### *Questionnaire structure and measured variables*

The questionnaire combined closed questions, multiple-choice questions, open-ended questions and five-point Likert-type scales. The Likert scale for wine-choice factors

ranged from 1 = not important/characteristic to 5 = very important/characteristic. Table 2 summarizes the blocks used in the analysis; Appendix 1 gives an English translation of the questionnaire details relevant to replication.

Table 2. Structure of the consumer questionnaire and variables used in the analysis.

Questionnaire block	Main content	Analytical role
Eligibility and background	Adult wine consumer; not employed in viticulture/winemaking	Screening and sample description
Wine consumption and purchase	Frequency of wine consumption; wine types usually purchased; monthly spending for home consumption, gifts and special occasions	Wine-involvement context
Wine-choice factors	Packaging, flavour, colour, price, vintage, expert recommendation, winemaker, wine region and country of origin	Main ordinal variables for group comparison and correlations
Wine knowledge and involvement	Liking wine; knowing wine types and Hungarian wine regions; knowing which wine suits which occasion; wine as experience	Contextual interpretation of consumer learning
Sweet-wine perceptions	Regular sweet-wine drinking, dislike of flavour, old-fashioned image, perceived gift value, Tokaji Aszú as national/international symbol	Main dependent perception variables
Tokaji-specific knowledge and openness	Occasions, food pairing, preferred Aszú style, perceived difference between late-harvest wine and Aszú, Aszú cocktail experience/openness	Educational and tourism implications
Socio-demographics	Gender, age, residence, education, monthly income per capita	Sample profile and limitation assessment

#### *Statistical analysis*

The original manuscript used ANOVA and reported some correlations as  $r^2$ . In the revised analysis, ordinal Likert-type variables are treated conservatively. Descriptive results are reported as counts, percentages, means, standard deviations, medians and interquartile ranges. Group differences were tested using Kruskal-Wallis tests. Effect size is reported as epsilon squared. Where a Kruskal-Wallis test for sweet-wine perception items was significant, post hoc pairwise Mann-Whitney U tests were interpreted with Holm correction. Associations among wine-choice factors were analysed using Spearman rank correlation and are reported as Spearman rho, not  $r^2$ .

Because many tests were performed on a small convenience sample, the statistical results are interpreted as exploratory signals rather than confirmatory evidence. Correlations were not interpreted causally. Results with  $p < 0.05$  are described as statistically significant within this pilot dataset, but substantive interpretation gives priority to effect sizes, pattern consistency and theoretical plausibility.

#### *Ethics, consent and data protection*

The survey was anonymous and limited to adult respondents. No names, contact details or sensitive personal data were collected. Participation was voluntary, and completion of the questionnaire indicated informed consent. Institutional approval or waiver documentation can be provided by the corresponding author if requested by the journal. The dataset should be stored in anonymized form, with open-ended responses checked for potentially identifying details before sharing.

## RESULTS

#### *Sample profile*

The dataset contained 100 valid respondents: 37 current consumers/buyers of Tokaji sweet wines, 43 rejecters and 20 potential consumers. The sample was strongly urban and highly educated. Budapest residents accounted for 69% of the full sample, and respondents with higher education or postgraduate degrees accounted for 93%. For this reason the sample represents a specific, mostly urban and educated wine-consumer segment rather than the Hungarian population.

Table 3. Respondent characteristics by analytical group, with counts and percentages. Percentages are calculated within each group.

Characteristic	Category	Consumers/buyers n (%)	Rejecters n (%)	Potential n (%)	Total n (%)
Gender	Female	20 (54.1%)	30 (69.8%)	15 (75.0%)	65 (65.0%)
	Male	17 (45.9%)	13 (30.2%)	5 (25.0%)	35 (35.0%)
Age	18-25	1 (2.7%)	0 (0.0%)	3 (15.0%)	4 (4.0%)
	26-40	9 (24.3%)	14 (32.6%)	7 (35.0%)	30 (30.0%)
	41-60	25 (67.6%)	26 (60.5%)	10 (50.0%)	61 (61.0%)
	Over 60	2 (5.4%)	3 (7.0%)	0 (0.0%)	5 (5.0%)
Residence	Budapest	24 (64.9%)	32 (74.4%)	13 (65.0%)	69 (69.0%)
	Large city	7 (18.9%)	6 (14.0%)	2 (10.0%)	15 (15.0%)

Characteristic	Category	Consumers/buyers n (%)	Rejecters n (%)	Potential n (%)	Total n (%)
	Small city	5 (13.5%)	3 (7.0%)	5 (25.0%)	13 (13.0%)
	Village	1 (2.7%)	2 (4.7%)	0 (0.0%)	3 (3.0%)
Education	Higher education	28 (75.7%)	33 (76.7%)	18 (90.0%)	79 (79.0%)
	Postgraduate	6 (16.2%)	8 (18.6%)	0 (0.0%)	14 (14.0%)
	Secondary school leaving certificate	2 (5.4%)	2 (4.7%)	0 (0.0%)	4 (4.0%)
	Vocational/technical school	1 (2.7%)	0 (0.0%)	2 (10.0%)	3 (3.0%)
Monthly income per capita	HUF 100,000-200,000	0 (0.0%)	1 (2.3%)	0 (0.0%)	1 (1.0%)
	HUF 200,000-300,000	5 (13.5%)	6 (14.0%)	3 (15.0%)	14 (14.0%)
	HUF 300,000-400,000	10 (27.0%)	9 (20.9%)	5 (25.0%)	24 (24.0%)
	Above HUF 400,000	22 (59.5%)	24 (55.8%)	12 (60.0%)	58 (58.0%)
	No answer	0 (0.0%)	3 (7.0%)	0 (0.0%)	3 (3.0%)

*Importance of general wine-choice factors*

Flavour was the most important general wine-choice factor in all three groups (Fig. 3). Mean scores were 4.73 among consumers/buyers, 4.79 among rejecters and 4.80 among

potential consumers on the five-point scale. The Kruskal-Wallis test showed no significant group difference for flavour (H=0.12, p=0.944). This corrects the earlier p-value contradiction: the general wine-choice factors did not show statistically significant group differences at  $p < 0.05$ .

**Wine-choice factors by consumer group**

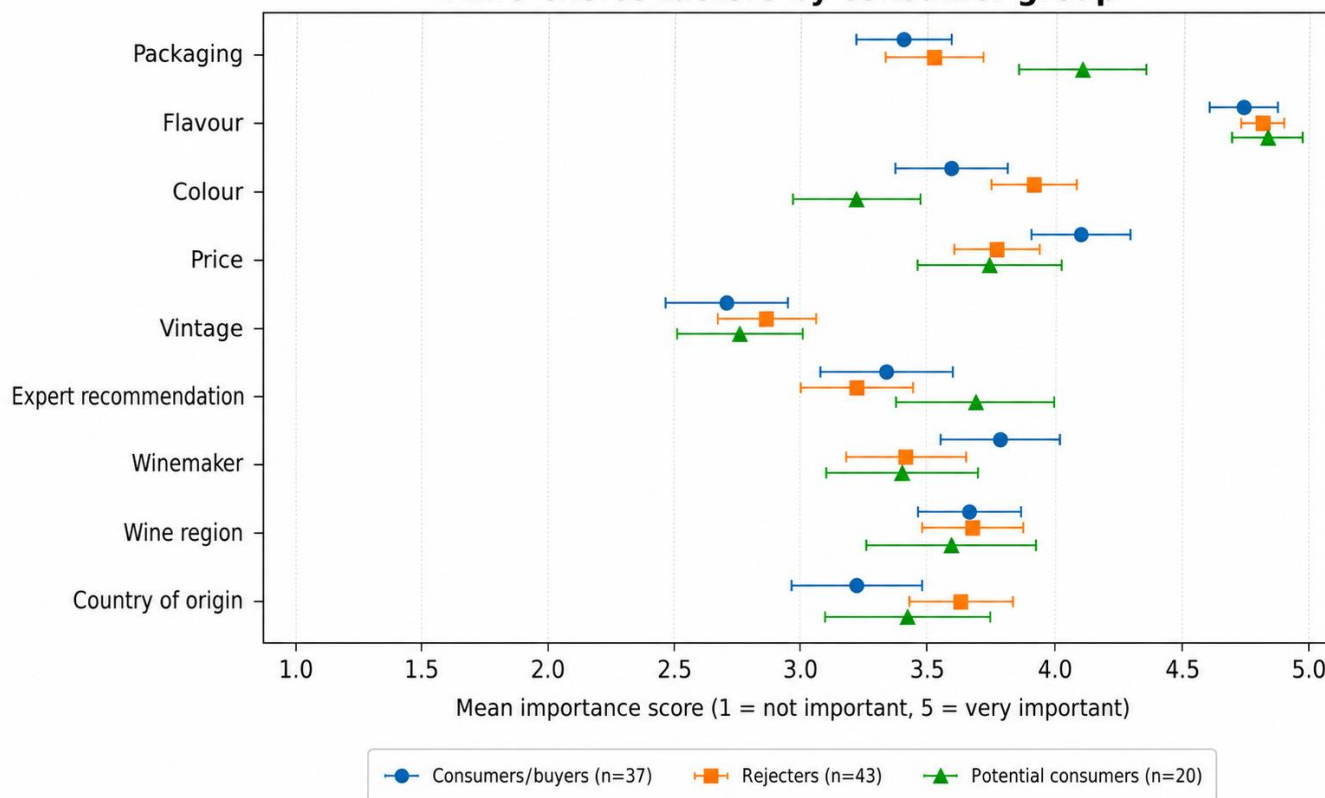


Figure 3. Mean importance scores for general wine-choice factors by consumer group. Error bars show standard errors.

Table 4. Wine-choice factors by group and Kruskal-Wallis tests. All variables were measured on a five-point scale.

Factor	Consumers/buyers mean ± SD	Rejecters mean ± SD	Potential mean ± SD	H	p	epsilon2
Packaging	3.46 ± 0.87	3.56 ± 1.01	4.05 ± 0.94	5.17	0.075	0.033
Flavour	4.73 ± 0.73	4.79 ± 0.47	4.80 ± 0.52	0.12	0.944	0.000
Colour	3.62 ± 1.14	3.91 ± 0.95	3.30 ± 0.98	5.85	0.054	0.040

Factor	Consumers/buyers mean ± SD	Rejecters mean ± SD	Potential mean ± SD	H	p	epsilon2
Price	4.05 ± 0.94	3.77 ± 0.87	3.75 ± 1.07	2.34	0.311	0.003
Vintage	2.86 ± 1.27	3.00 ± 1.11	2.90 ± 0.97	0.44	0.801	0.000
Expert recommendation	3.41 ± 1.34	3.30 ± 1.21	3.70 ± 1.22	1.49	0.474	0.000
Winemaker	3.76 ± 1.14	3.47 ± 1.26	3.45 ± 1.10	1.75	0.416	0.000
Wine region	3.68 ± 1.08	3.67 ± 1.02	3.60 ± 1.23	0.00	0.999	0.000
Country of origin	3.30 ± 1.31	3.63 ± 1.09	3.45 ± 1.19	1.22	0.542	0.000

Although no wine-choice factor differed significantly among the groups, several patterns are useful for further research. Packaging was rated somewhat higher by potential consumers (mean 4.05) than by the other groups, while price and winemaker reputation were somewhat higher among current consumers/buyers. These differences should not be overinterpreted because global p-values were above 0.05 and the potential-consumer subgroup included only 20 persons.

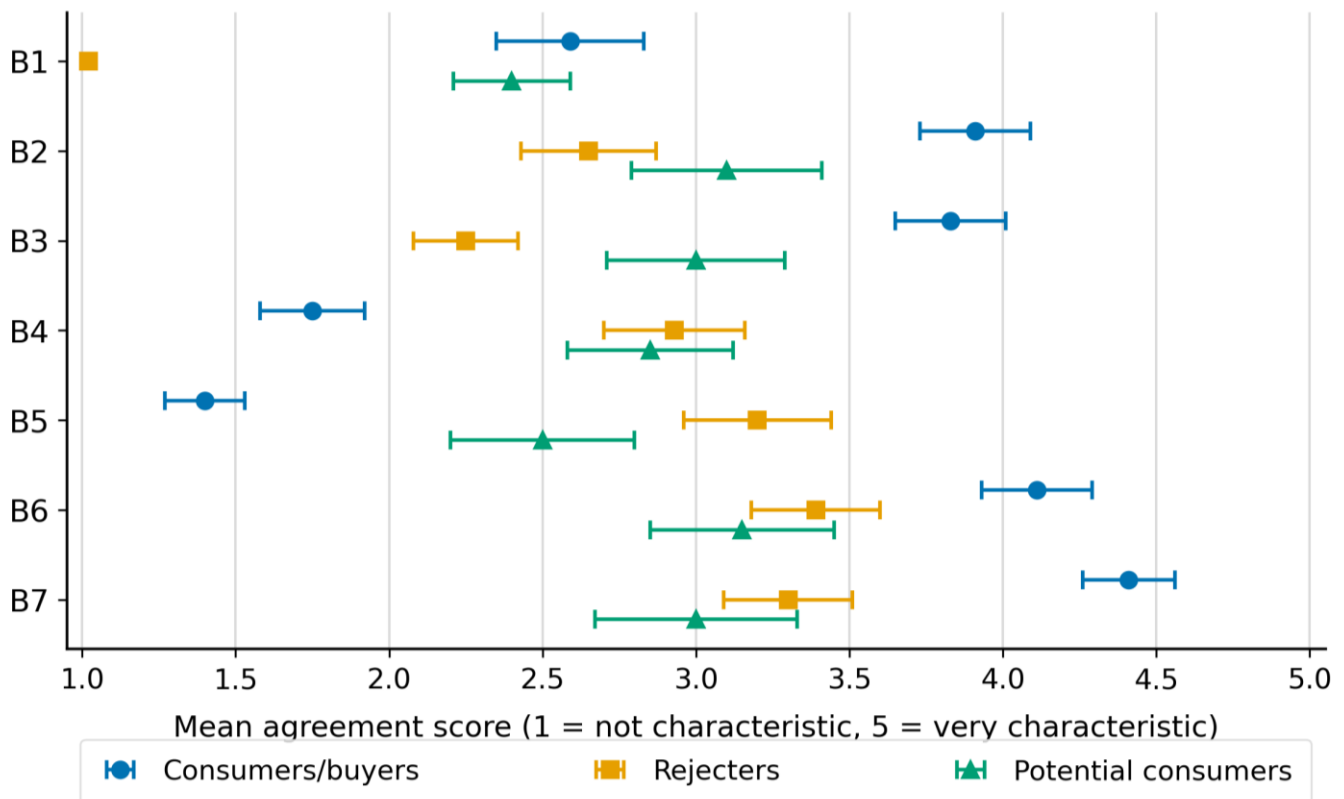
*Sweet-wine perceptions and barriers*

The largest group differences occurred not in general wine-choice criteria, but in beliefs about sweet wine and Tokaji sweet specialities. Rejecters agreed more with the statement that they do not like the flavour of sweet wine (mean 3.21) than consumers/buyers (mean 1.41). Consumers/buyers rated Tokaji sweet specialities more strongly as top wines, as products they like to give and consume, and as products

that can represent Hungary internationally. Potential consumers tended to be intermediate: they were not current consumers/buyers, but their mean scores often lay between current consumers and rejecters.

Among current consumers/buyers, vintage correlated with expert recommendation, winemaker, wine region and country of origin, indicating that these consumers may interpret wine through a bundle of provenance and expertise cues. Among rejecters, expert recommendation correlated with winemaker, and winemaker correlated with wine region. Among potential consumers, several strong correlations appeared, especially between wine region and country of origin, but this subgroup was small; these results should be treated as hypotheses for a larger study.

**Selected perceptions of Tokaji natural sweet wines**



B1 regular drinking; B2 top wines; B3 gift and consume; B4 gift but do not drink; B5 do not like flavour; B6 national drink; B7 represents Hungary internationally.

Figure 4. Selected sweet-wine perception items by group. Error bars show standard errors; B-codes are explained in the figure note and Table 5.

Table 5. Sweet-wine perception items by group. All items were measured on a five-point agreement/characteristic scale.

Sweet-wine perception item	Consumers mean	Rejecters mean	Potential mean	H	p	Main Holm-adjusted post hoc differences
One wine type, nothing special	2.24	2.79	2.60	3.20	0.202	
Like flavour but drink less because it is fattening	1.70	1.65	2.30	9.89	0.007	Consumers/buyers vs Potential consumers (Holm $p=0.037$ ); Rejecters vs Potential consumers (Holm-adjusted $p<0.05$ )
Sweet wine is not trendy	2.00	1.63	2.20	4.59	0.101	
Sugar covers wine faults	1.51	1.72	1.95	1.62	0.444	
Tokaji sweet specialities are among the top wines	3.92	2.65	3.10	16.47	<0.001	Consumers/buyers vs Rejecters (Holm $p<0.001$ ); Consumers/buyers vs Potential consumers (Holm-adjusted $p<0.05$ )
Gift and consume Tokaji sweet specialities	3.84	2.26	3.00	28.61	<0.001	Consumers/buyers vs Rejecters (Holm $p<0.001$ ); Consumers/buyers vs Potential consumers (Holm-adjusted $p<0.05$ )
Give as gifts but do not drink	1.76	2.93	2.85	16.19	<0.001	Consumers/buyers vs Rejecters (Holm $p=0.001$ ); Consumers/buyers vs Potential consumers (Holm-adjusted $p<0.05$ )
Do not like the flavour of sweet wine	1.41	3.21	2.50	28.06	<0.001	Consumers/buyers vs Rejecters (Holm $p<0.001$ ); Consumers/buyers vs Potential consumers (Holm-adjusted $p<0.05$ )
Old-fashioned / grandparents wine	1.30	1.95	1.70	7.89	0.019	Consumers/buyers vs Rejecters (Holm $p=0.016$ )
Good, sweet wine is always expensive	2.86	2.56	2.25	3.35	0.187	
Tokaji Aszú is Hungary national drink	4.11	3.40	3.15	9.20	0.010	Consumers/buyers vs Rejecters (Holm $p=0.030$ ); Consumers/buyers vs Potential consumers (Holm-adjusted $p<0.05$ )
Tokaji Aszú represents Hungary internationally	4.41	3.30	3.00	19.93	<0.001	Consumers/buyers vs Rejecters (Holm $p<0.001$ ); Consumers/buyers vs Potential consumers (Holm-adjusted $p<0.05$ )

#### Correlation patterns among wine-choice factors

Spearman correlations were used to explore whether respondents who valued one wine-choice attribute also valued others. Only correlations with  $|\rho| \geq 0.50$  and  $p < 0.05$  are reported in Table 6 to avoid a large and difficult-to-interpret matrix. The notation is Spearman rho; no coefficient is reported as  $r^2$ .

Among current consumers/buyers, vintage correlated with expert recommendation, winemaker, wine region and

country of origin, indicating that these consumers may interpret wine through a bundle of provenance and expertise cues. Among rejecters, expert recommendation correlated with winemaker, and winemaker correlated with wine region. Among potential consumers, several strong correlations appeared, especially between wine region and country of origin, but this subgroup was small; these results should be treated as hypotheses for a larger study.

Table 6. Selected strong Spearman correlations among general wine-choice factors.

Group	Factor 1	Factor 2	Spearman rho	p	n
Consumers/buyers	Vintage	Expert recommendation	0.552	<0.001	37
Consumers/buyers	Vintage	Winemaker	0.661	<0.001	37
Consumers/buyers	Vintage	Wine region	0.668	<0.001	37
Consumers/buyers	Vintage	Country of origin	0.556	<0.001	37
Consumers/buyers	Expert recommendation	Winemaker	0.664	<0.001	37
Consumers/buyers	Wine region	Country of origin	0.516	0.001	37
Rejecters	Expert recommendation	Winemaker	0.673	<0.001	43
Rejecters	Winemaker	Wine region	0.630	<0.001	43
Potential consumers	Packaging	Price	0.519	0.019	20
Potential consumers	Flavour	Price	0.530	0.016	20
Potential consumers	Colour	Vintage	0.524	0.018	20
Potential consumers	Colour	Expert recommendation	0.527	0.017	20
Potential consumers	Vintage	Expert recommendation	0.520	0.019	20
Potential consumers	Expert recommendation	Winemaker	0.565	0.009	20

Group	Factor 1	Factor 2	Spearman rho	p	n
Potential consumers	Expert recommendation	Wine region	0.608	0.004	20
Potential consumers	Winemaker	Country of origin	0.542	0.014	20
Potential consumers	Wine region	Country of origin	0.835	<0.001	20

## DISCUSSION

### *Consumer interpretation: flavour is necessary but not sufficient*

The revised analysis changes the interpretation of the original manuscript. It is not accurate to state that the survey confirmed a national causal reason for the decline in sweet-wine consumption. The survey shows that, within this non-representative sample, flavour was the most important wine-choice factor for all groups, while sweet-wine rejecters reported stronger dislike of sweet-wine flavour. This is an important distinction. General wine choice is driven by flavour across the full sample, but the rejection of sweet wine appears linked to a specific learned or expected flavour profile.

This interpretation is consistent with sensory and consumer-behaviour research showing that wine acceptance is not fixed but shaped by previous experience, associative learning, context and familiarity (Melo et al., 2011; Iatridi et al., 2019; Spinelli et al., 2024). Therefore, consumer education should not simply advertise sweetness. It should explain acidity, aromatic complexity, botrytized character, texture, serving temperature, glass size, food pairing and responsible occasions of consumption.

### *From wine marketing to regenerative wine tourism*

For Tokaj, the most relevant practical implication is that market recovery should be embedded in regenerative wine tourism rather than isolated promotional campaigns. Wine tourism can create direct contact between consumers and the landscape, allowing visitors to experience vineyards, cellars, volcanic soils, river-influenced microclimate, botrytis-dependent vintages, food pairing and the historical labour behind Aszú, Szamorodni, Fordítás and Máslás.

The multifunctional agricultural model is relevant because wine regions can offer a complete product and service structure: wine and grape-derived products; tastings and wine education; gastronomy; vineyard and cellar tours; events; local crafts; accommodation; cultural routes; and direct sales (Nemethy and Lagerqvist, 2016). In Tokaj, this structure can reduce the vulnerability of producers to vintage variability and provide income even in years when noble-rot production is limited.

However, regenerative tourism must avoid greenwashing. Claims about organic farming, biodiversity, water management, renewable energy, low-waste cellars or local food supply should be documented and communicated transparently. The reviewer concern about Ecocycles relevance is addressed only if marketing and tourism are connected to measurable ecological and cultural-landscape outcomes: soil cover and erosion control, reduced synthetic inputs where feasible, responsible water use, biodiversity protection, visitor-flow management, circular use of pomace and lees, energy efficiency and community benefit.

### *Climate adaptation and cultural-landscape resilience*

Tokaji natural sweet wine production depends on climatic and hydrological conditions that favour noble rot without destroying the crop. Drought, heat waves, altered autumn precipitation and changes in humidity may reduce the frequency or quality of botrytized vintages. Climate adaptation in Tokaj therefore requires vineyard-scale and landscape-scale measures, including clone and variety selection, canopy and training adaptation, soil organic matter protection, erosion control, water-retention measures and careful harvest timing.

The social dimension is equally important. If consumers no longer value Tokaji natural sweet wines, producers may have weaker incentives to maintain the laborious practices, cellar traditions and product diversity that underpin the World Heritage value of the region. Consumer education can therefore contribute indirectly to cultural-landscape resilience by sustaining demand for the products that carry the landscape story.

### *Practical improvement propositions*

The following propositions are derived from the survey patterns and the ecological-cultural framework:

- Replace sweetness-centred communication with flavour-centred communication. Explain the balance of sweetness, acidity, botrytized aroma, ageing and texture.
- Use guided comparative tastings that place late-harvest wine, sweet Szamorodni and Aszú next to dry Furmint, aged dry Szamorodni and selected food pairings.
- Develop small-format, responsible-consumption tasting experiences in restaurants and wine bars to reduce the barrier created by bottle size and occasion uncertainty.
- Integrate Tokaji sweet wines into regenerative wine-tourism routes that include vineyards, cellars, river landscape, volcanic soils, gastronomy and cultural heritage.
- Use rare categories such as Fordítás and Máslás to interpret circularity, value extraction from marc and lees, and the historical logic of low-waste winemaking.
- Measure and communicate sustainability practices with evidence, for example cover crops, biodiversity actions, energy savings, wastewater treatment and local sourcing.
- Develop a representative follow-up survey and a sensory/choice experiment to test whether education, food pairing and sustainability information increase willingness to taste, buy and pay.

### *Limitations*

The study has important limitations. The sample was small (N=100), non-probabilistic, urban, highly educated and relatively high-income. The potential-consumer group contained only 20 respondents, so each respondent represents five percentage points. The survey was cross-sectional and self-reported; it did not include sensory tasting, blind evaluation, sales data, willingness-to-pay experiments or longitudinal tracking. The group classification was based on the source dataset rather than on

a formal latent-class or cluster model. Many statistical tests were performed, so the risk of false-positive findings remains even with cautious interpretation. Finally, the climate and ecological discussion is based on literature and official documentation, not on new measurements of microclimate, soil, biodiversity or winery resource flows.

## CONCLUSIONS

This study does not claim to have confirmed a national cause of sweet-wine decline in Hungary. Instead, it provides exploratory pilot evidence from a specific urban and highly educated respondent group. In this sample, flavour was the most important general wine-choice factor across all groups, while self-reported dislike of sweet-wine flavour and lower symbolic valuation distinguished rejecters from current consumers/buyers. Potential consumers often occupied an intermediate position, suggesting that consumer learning and context may matter.

For the Tokaj Wine Region, these findings should be interpreted within a wider socio-ecological system. Tokaji natural sweet wines are climate-sensitive heritage products whose future depends not only on market communication but also on landscape management, adaptation to changing humidity and temperature patterns, preservation of traditional production knowledge, and regenerative wine tourism. The proposed model links product education, food pairing, responsible tasting, wine routes, local gastronomy and transparent sustainability practices to the resilience of the Tokaj cultural landscape.

Future research should use stratified national sampling, larger age-balanced groups, blind sensory evaluation, food-pairing interventions, willingness-to-pay experiments, longitudinal sales data and climate-production datasets. Such research would allow the hypotheses generated here to be tested more rigorously and would help producers and regional institutions design evidence-based strategies for Tokaji natural sweet wines.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The survey was anonymous, voluntary and limited to adult wine consumers. Ethical review was waived because the study was a low-risk consumer survey that did not collect identifiable or sensitive personal data. Completion of the questionnaire indicated informed consent.

## DATA AVAILABILITY

An anonymized dataset and codebook can be made available by the corresponding author on reasonable request. Public release of the raw dataset is not recommended without additional anonymization because the small subgroups and

combined demographic variables may increase re-identification risk.

## USE OF GENERATIVE AI TOOLS

During revision after review, generative AI assistance was used for language editing, structural alignment with the *Ecocycles* template, table and figure redesign, and statistical reporting based on the author-supplied dataset. The authors reviewed the revised manuscript, verified the sources and data interpretation, and remain fully responsible for the scientific content.

## PUBLIC INTEREST STATEMENT

Tokaji natural sweet wines are part of a World Heritage cultural landscape and depend on rare climatic and ecological conditions. Understanding why consumers accept or reject these wines can help producers, restaurants, tourism providers and regional institutions design education and gastronomy programmes that support both heritage preservation and sustainable regional development.

## APPENDIX 1. SURVEY QUESTIONNAIRE DETAILS (ENGLISH TRANSLATION)

The questionnaire was originally administered in Hungarian. The following English translation gives the content required for methodological transparency. Several questions allowed multiple answers or short open-ended responses.

1. How often do you consume wine? Response options included daily several times per week, once per week, monthly, or less often/occasionally.
2. How much money do you spend on wine per month for home consumption, gifts and special occasions?
3. Which statement is true for you concerning wine consumption?
4. For what purpose do you usually buy wine?
5. On what basis do you buy wine?
6. Where do you usually buy wine?
7. When buying wine, how important are the following wine characteristics? Scale: 1 = not important, 5 = very important. Items: packaging/label/bottle shape, flavour, colour, price, vintage, expert recommendation, winemaker, wine region, country of origin.
8. Please evaluate the following statements. Items included: I like wine; I know different wines; wine consumption belongs to entertainment; I know which wine suits which occasion; I know Hungarian wine regions; wine drinkers are decent people; wine consumption is an experience; I do not like it when people consume alcohol around me.
9. What wines do you usually buy? Options included dry white, dry rose, dry red, semi-dry/semi-sweet white, semi-dry/semi-sweet rose, semi-dry/semi-sweet red, sweet white, sweet rose, sweet red, Tokaji dessert wine speciality, sparkling wines and other.
10. How often do you consume sweet wine?
11. What do you think about sweet wine? Rate each statement on a five-point scale. Items included: one wine type, nothing special; I like its flavour but consume less because it is fattening; I like its flavour and consume it regularly; not trendy; sugar covers wine faults; some varieties such as Tokaji sweet specialities are the top of wine; I like to give and consume Tokaji sweet specialities; I give them as

gifts but do not drink them; I do not like the flavour; old-fashioned/grandparents wine; good sweet wine is always expensive; Tokaji Aszú is the national drink of Hungary; Tokaji Aszú can represent Hungarian wine and Hungary internationally.

12. On what occasions do you consume Tokaji sweet wine specialities?
13. With what food do you consume Tokaji sweet wine specialities?
14. Please briefly describe the style of Aszú you prefer.
15. What is the difference between a late-harvest sweet wine and Tokaji Aszú?
16. What are modern Tokaji Aszú wines like in your opinion?
17. Have you ever tasted a wine cocktail made from Tokaji Aszú?
18. What do you consider valuable in Tokaji Aszú?
19. Have you ever offered Tokaji Aszú to a foreign acquaintance?
20. If you wanted to give a gift to a foreign acquaintance, what would you choose? Items included palinka, wine, Tokaji wine, embroidery, paprika product, clothing with Hungary inscription, other.
21. Gender.
22. Age group.
23. Place of residence.
24. Highest level of education.
25. Monthly household income per capita.

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