International Co-operation on Theories and Concepts in Traffic Safety

Driving simulator study on the behaviour of drivers after consuming wines with different sulphite contents

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Introduction. Driving under the influence of alcohol is one of the major causes of road crashes. As blood alcohol levels rise, the driver's ability to control the vehicle is progressively reduced, significantly increasing the likelihood of errors. Alcohol affects the regions of the brain responsible for decision-making, inhibiting risky behaviour, and processing sensory information crucial to driving, such as vision and hearing. Sulphites play an important role in wine production and can affect the rate of alcohol metabolism, which in turn affects the cognitive, psychomotor, and behavioural performance of drivers. However, while the influence of blood alcohol concentration (BAC) on driving performance is well documented, the effects of sulphite content remain still unexplored. This study aims to investigate the effect sulphite contents in a conventional wine (SO_2 legal limit = 150 mg/l) on driving performance.

Method. Wine production. Two wines, identical except for the sulphite content (i.e., 86 vs. 126 mg/l), were produced from the same grapes and with the same alcoholic strength by volume (15.2 %). The grapes were destemmed and crushed (Enoveneta, Piazzola Sul Brenta, Italy). The must was placed in CO_2-saturated inox tanks and inoculated with 20 g/hL of active *Saccharomyces cerevisiae* dry yeast (Lalvin BRL 97, Lallemand Inc.) for alcoholic fermentation. During the alcoholic fermentation, the temperature (26 ± 1 °C) and the sugar reduction were checked daily. Nutrients were added twice at a rate of 15g/hL (Fermaid E, Lallemand Inc.). In addition, two punch downs per day were carried out during the first three days, followed by two pump-overs until the end of the maceration, which lasted 8 days. The cap was then pressed (Velo SpA, Altivole, Italy) and the pressed wine was added to the free-run part. Then, 1 g/hL of *lactic bacteria* Oenococcus oeni VP41 MBR ML (Lallemand Inc.) was added to inoculate the malolactic fermentation. Finally, the wine was racked and 50 mg/l SO_2 was added. The wine was then stored at 0°C for two weeks for cold stabilization, then filtered and bottled. Directly in the bottles, SO_2 additions of 70 mg/L were made to achieve the desired final higher total SO_2 content (126 mg/L), while the addition of 30 mg/L was made to achieve the lower SO_2 content (86 mg/L). Driving simulation experiment. Thirty-two drivers (16 female) aged 25-55 years were included. A triple-blind, within-subject experimental design was used (approval of the Ethics Committee of the Politecnico di Torino n.15681, 8 April 2022). Each participant was involved in three driving sessions on different days under (i) sober, (ii) 1.5 units of alcohol with low SO_2 content and (iii) 1.5 units of alcohol with high SO_2 content. The order of the driving sessions was randomised for all participants and took place in the morning. Drivers were instructed not to eat after waking up until the end of the experiment. The driving sessions started 20 min after the wine consumption at the BAC peak corresponding to the legal limit for driving in Italy (0.05 g/dl). The driving session consisted of 5 km of two-lane rural highway (speed limit 90 km/h, lane 3.75 m wide, shoulders 1.5 m), followed by 4 km of urban road (speed limit 50 km/h, lane 3 m wide, flanked by 2.2 m parallel parking lanes and

2.5 m sidewalks). We monitored (i) speed along straight, and (ii) speed and (iii) standard deviation of lateral position (SDLP) on curved sections of the rural road. In the urban environment, we also monitored (iii) the reaction time at the yellow light, (iv) the minimum time to collision (MTTC) when the driver interacted with a pedestrian in a midblock crosswalk, and (v) the headway in a car-following situation. Linear mixed-effects models were used to assess the effect of the independent factors on the driving behaviour variables.

Results and conclusions. Results (Figure 1) indicate that sulphites did not have a statistically significant effect (always $p > .05$) on driving speed and on the SDLP in the rural section. Similarly, the results showed no influence of sulphites on the urban section (always $p > .05$), on the driver's interaction with pedestrians at pedestrian crossings, on the reaction at yellow traffic lights and on the time taken to follow a car in front. When comparing the scenarios with and without alcohol consumption, again the differences were not statistically significant, confirming the appropriateness of the legal limit used in Italy and other countries. Gender also showed no statistically significant differences in behaviour for any of the variables studied ($p > .05$). However, the LMM showed that driver ID as a cluster variable was always significant ($p < .001$), indicating that other subjective factors that we did not control were influencing the dependent variables investigated. All the results from this highly controlled experiment were consistent that sulphites did not affect driving performance and safety. As a result, we argue that sulphites alone do not pose a significant risk to driving performance at legal BAC levels. However, the interaction between sulphites and higher BAC levels deserves further investigation. We therefore recommend that future research be conducted to determine whether the effects of sulphites may become significant at higher levels of wine consumption. Given that different studies suggest that sulphites in wine have very different effects on individuals, it cannot be excluded that there may still be an effect on driving performance and road safety in some individuals.

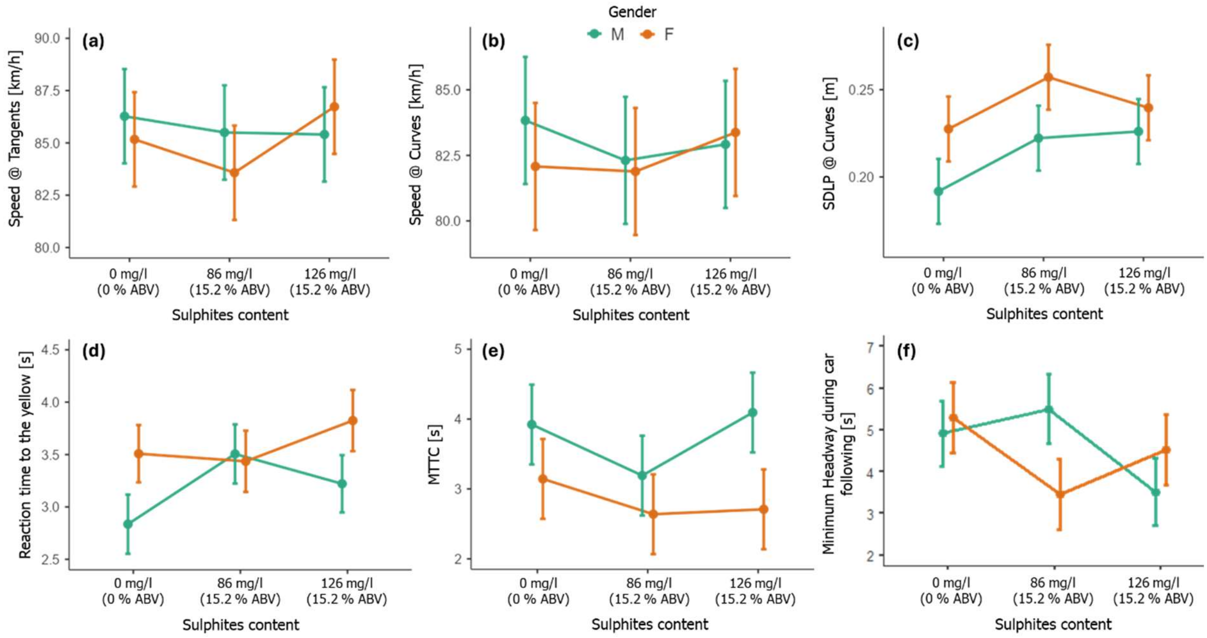

Figure 1: Speeds along (a) straight and (b) curved sections, and (c) SDLP along curved sections of rural road. Reaction time to the appearance of the yellow traffic light (d). MTTC between the car and the pedestrian at the crosswalk (e), and (f) minimum time-headway during car-following. Bars indicate the standard error of the mean.