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Abstract

Recently, the South African wine industry launched the world's first 'no sulphite added' wine made from indigenous *Rooibos & Honey bush* toasted wood chips. This wood chip contains antioxidants properties known to protect the wine from oxidation. On the other hand, SO_2, as a preservative, is often perceived by wine consumers as causing headaches and migraine. Differentiated wines based on their SO_2 content may be a profitable marketing avenue for the struggling industry. We interviewed more than 600 wine consumers to investigate perceptions on wine preservatives and to elicit willingness to pay for the innovative alternative based on *Rooibos & Honey bush* wood chips. Alongside the wine preservatives, we also examine consumers' preferences for organic wine attribute and wine quality measured by 100-points quality score, and the cost. Based on the results from the mixed logit model, we find that consumers are willing to pay additionally R56.48(€3.53)per bottle of wine with natural *Rooibos & Honey bush wood chips*, while they are ready to pay R19.52(€1.22) more for organic wine and R1.60(€0.10) for each point on quality score. Consumer preferences are not statistically different between red and white wine but differ considerably across consumers, in particular, those who believe SO_2 in wine cause headaches are willing to pay for replacing sulphur-based preservatives by a natural one at least three times more. Marketing implications are offered for the wine industry.

Keywords: Wine Preservatives; Willingness to Pay; Discrete Choice Experiment

JEL: O31; Q10; P46

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1 Introduction

South Africa's wines are progressively internationally competitive, with a viable and positive trend since 1994. The wine industry is the eighth in overall volume production globally and contributes approximately 4% of the world's wine. It exports half of its produce and its local wine per capita consumption is estimated at 7.73 litres (SAWIS, 2016). The wine industry contributes R36,1 billion out of a total nominal GDP of well over R1,2 trillion; R6.23 billions of taxes to the South African government per annum; household income worth R23,579 million and farmer's income worth R5.03 billion per year (SAWIS, 2016). It plays an important role in South Africa's labour market providing over 300,000 jobs. More importantly, the industry is linked to the rest of the economy in various ways, directly through producers' purchase of goods such as fertilizers, herbicides and pesticides, and services such as insurance, financial, research & development and advisory services. Despite the benefits rendered, the wine industry is under serious threat.

In recent decades, the input cost of production has increased greatly in the South African wine industry. From 2006 to 2017, a steady upward trend in input production costs raised concerns about the welfare and sustainability of the industry. The increase and changes in production input costs has negatively affected the primary producers to levels where over a thousand grape farmers have shut down operations (VinPro, 2017). Out of a total of 3,145 remaining grape farmers 13% are producing at sustainable income levels, 44% are operating at break-even point and the rest are making losses. Furthermore, the area under vine cultivation has reduced drastically from 102,146 hectares in 2006 to 95,775 hectares in 2016 (VinPro, 2017).

In response to the potential impact of uncertain events, farmers implement diverse risk management strategies in the context of their production plans, the available finance, physical and human capital, and the degree of aversion to risk. These risk management strategies may include (and not limited to) crop diversification, crop insurance, effective coordination, technology and innovation. For example, innovation is widely accepted to be a driving force for agricultural development. Progressively, scientists and extension agents recognize the key role of innovative farmers and acknowledge their experiments and innovations for agricultural development (Chambers & Thrupp, 1994; Klerkx & Leeuwis, 2008; Reij & Waters-Bayer, 2014) and for farming systems resilience (Fischer, Shah, & Van Velthuizen, 2002; Milestad & Darnhofer, 2003). In line with innovation, the South Africa wine industry can explore the natural preservative alternative as a revenue source to mitigate the struggling industry.

Since time in memorial sulphur dioxide (SO_2) has been used by winemakers to preserve wine (Lester 1995). Because of its antioxidant and antibacterial properties, SO_2 plays an important role in not only preventing oxidation but also maintaining freshness (Goode & Harrop, 2011). It is significant to note that trace amounts of SO_2, about 10–40 ppm, i.e. 10–40 mg per litter, are naturally formed by wine yeast during fermentation (Chengchu et al. 2006), but winemakers add extra SO_2 through-out production (Burgstahler & Robinson, 1997) to prevent spoilage and enhance aging potential (Goode & Harrop, 2011). So, while too much of sulphur can ruin a bouquet, the wine can spoil quickly when sulphur is missing.

Although some studies have refuted the over estimation of the health effect of SO_2 (Valley and Thompson, 2001), there is overwhelming evidence that SO_2 may induce adverse reactions in wine drinkers suffering from sulphite sensitivity (Amato, Ballco, López-Galán, De Magistris, & Verneau, 2017; Costanigro, Appleby, & Menke, 2014; D'Amico, Di Vita, & Monaco, 2016; Grogan, 2015). A wider share of the consumer population perceives that drinking even moderate amounts of wine, particularly the red varieties, triggers minor health effects, including respiratory and gastrointestinal symptoms, headaches and migraine (Lester, 1995; Robin, 2010; Gaiter and Brecher, 2000). It is estimated that about 1% of wine consumers are sulphite sensitive (Papazian, 1996).

Even though medical science has not reached a consensus on whether SO_2 does in fact cause the reported minor health effects, public health authorities have made it mandatory for wine makers to restrict usage of sulphur in wines and display its quantity on wine bottles. For instance, in South Africa – our study site – legislation requires that dry white wine produced after January 1995 may not contain more than 160 mg/l sulphur. Off-dry and sweeter wines may contain up to 200 mg/l, while sulphur content is allowed to be up to 300 mg/l for late harvests. The limit for dry red wine is at 150 mg/l. Organic wines still contain sulphur, albeit at very low levels – however, if the level of sulphur is below 10 mg/l, the product may be labelled "no sulphur added". The shelf life of these wines is necessarily limited.[2]

As we have just noted, organic wines usually require using less sulphur. In some countries, like in the USA, all organic wines are SO_2 free (Alcohol and Tobacco Tax and Trade Board, 2014). This is, however, not the case in South African where wines can be classified as organic regardless of whether it contains SO_2 or not. Because the absence of added SO_2 in wines can be viewed as a quality differentiation factor, and that 'no sulphite added' wines may appeal to healthy conscious consumers, it makes this study important. Since the advent of these health effects, winemakers around the world are encouraged to find alternative health ways to preserve wine. Even though replacement of SO_2 is uncommon, there has been some development in the production of wine with lower SO_2. Examples of some of the different techniques include carbon dioxide additive, chemical preservation, fermentation, filtration, firming, oxidative wine making, pasteurisation, reductive winemaking, stabilisation, sterile bottling, and temperature management. Other ways include hydrostatic pressure, pulsed electric fields, ultrasound radiation and ultraviolet radiation (Falguera et al., 2013). A continued search for unique and innovative wine products has sparked interest in the world wine market and finding alternatives to SO_2 is that one goal.

Breaking stage in this niche, South Africa in 2013 produced the first wine made from natural preservatives (*Rooibos & Honeybush*). Rooibos (Aspalathus linearis) and Honey bush (Cyclopia) plants are indigenous to the Western and Eastern Cape Province of South Africa (Du Toit et al., 1998; Small & Catling, 2009) and have been harvested and processed mainly to produce herbal teas (Joubert et al., 2008). Research concerning the antioxidant capacity has been conducted by the Department of Oenology at the University of Stellenbosch in

[2] In the European Union, in its Regulation 1333/2008 amended by Commission Regulation 59/2014, has set a limit for total SO_2 of 150 mg/l in red wines and 200 mg/l in white wines, and because some individuals are sensitive to SO_2, it is mandatory to include 'contains sulphites' on the label if total SO_2 is over 10 mg/l (i.e. SO_2, content of not more than 10 mg/kg or 10 mg/l is not considered to be present). EC Regulation 203/2012 sets the limit for organic wines to 100 mg/l for red wines and to 150 mg/l for white and rose wines. Organic and natural winemakers restrict its usage even further, for instance, The Charter of The Authentic – Natural Winemakers' Association requires in the Czech Republic limits SO_2, to 90 ml/l for red and orange wines and to 100 ml/l for white and rose wines, see http://vinarstvivykoukal.cz/wp-content/uploads/2016/07/Stavek-Charta-autentistu-A2.pdf.

collaboration with two wineries (Audacia and KWV) to utilise this indigenous wood for wine preservation (Rankine, 2004; Joubert et al., 2008; Robinson et al., 1999; Berry Bros. & Rudd Ltd., 2016). Drawing attention to consumer behaviour in the marketplace has highlighted a trend of consumers choosing healthy food products. Most consumers, especially in recent times, are attentive to the artificial additives and prefer to purchase organic foods (Hoffman et al., 2014). Since 'no sulphite added' wines seem attractive to health-conscious consumers, it would be interesting to explore this potential niche market in depth to gauge consumer's perceptions on the importance of 'no sulphite added' wines. This decision is important because it would reveal whether or not wine players (in the South Africa wine context) can exploit this source of avenue in an effort to save a struggling industry. Perhaps one key piece that would inform wine players is how valuable 'no sulphite added' wine is to consumers, and what share of consumers would consider such a trait as important in their buying decisions.

A few peer-reviewed papers have already addressed consumers' willingness to pay (WTP) for wine without added SO_2 (see, e.g. Costanigro et al., 2014; Grogan 2015; Amico & Divita, 2016; Amato et al., 2017). Even though there is an agreement about negative effects of SO_2 on health and even that consumers are ready to pay more money to avoid added SO_2 in wine, no study has examined consumers' preferences for SO_2 alternative. Novelty of this study is to estimate the premium price that wine consumers are willing to pay for a SO_2 alternative as clearly described in the experiment.

To cover the research gap, our study uses a primary survey and discrete choice experiment (DCE)[3] to analyse preferences for three qualitative non-monetary attributes of wine: natural preservatives, organic production, and quality measured by 100-point score, and the fourth attribute is price. Specifically, we would like to answer the following four research questions: (1) Are consumers ready to pay for wines made with natural preservatives (Rooibos & Honey bush), organic production, and with a higher quality score?; (2) Do preferences for wine colour and hence marginal willingness to pay for the three qualitative wine attributes differ for red and white wine?; (3) Since sulphur-based preservative is perceived to trigger headaches, are consumers who believe that SO_2 in wine cause headaches willing to pay more for the wine attributes, particularly for *Rooibos & Honey bush* preservatives?; and, lastly, (4) Do preferences vary among various consumer characteristics such as, gender, race, and the frequency of wine drinking? We use the stated preference approach to understand the perceptions and in particular how consumers would value a wine that was produced using *Rooibos & Honey bush* as a preservative for both the conventional and organic production.

We find that wine consumers in South Africa are willing to pay a price premium of €3.53 per bottle of wine if *Rooibos & Honey bush* rather than SO_2 is used as a wine preservative, and this premium does not differ between red and white wine. Out of 611 wine consumers interviewed, about 68% believe that consuming moderate volume of wine causes headache and the same consumers are willing to pay for the natural preservatives three times more (€5.67) than those who do not think that SO_2 in wine cause headaches (€1.82). Price premium for organic wine is smaller, about €1.22, and it does not differ much between the two segments. Wine quality (measured by 100-point Quality Score) matters as well, but respondents are willing to pay only about €0.10 and €0.15 for the two segments. There is large heterogeneity in consumers preferences.

[3] Even though the DCE has some limitations like hypothetical bias (see, Lusk & Schroeder, 2004), it allows researchers control for exogenous factors that may otherwise weaken the results and also ensures that the effects of each attribute on preferences is identified (Kroes & Sheldon, 1988).

The remainder of the paper is organised as follows. Section 2 reviews the literature. Section 3 describes the methodology and the data used for the analysis. Next section summarizes the empirical results, and the last section 5 concludes.

2 Literature Review

There is no valuation study that examined consumers' preferences for an alternative to sulphur-based wine preservatives. There are, however, a few studies that have analysed preferences for wines with 'no sulphites added' (Costanigro et al., 2014; Grogan 2015; Amico and Divita, 2016; Amato et al., 2017). For example, Costanigro et al. (2014) analysed the willingness to pay for non-sulphated wines in the USA using a rank ordered logit estimation of best-worst choices. U.S. consumers are, on average, willing to pay $1.23 (€1.11) per bottle of wine to avoid added SO_2. They also found that 34% of respondents experienced headaches after drinking wine and these consumers are ready to pay more for a wine with no sulphur, $1.23 (€1.11).

Grogan (2015) examined the value of added sulphur in French organic wines and found that the addition of SO_2 preservative reduced the price of red organic wine by 23% for wines that were intended to be drank immediately after purchase, however, this effect becomes positive for wines that were intended to be cellared for at least one to three years. Adding SO_2 had neutral to positive effect for most white wines.

Similarly, as in Grogan's French study, D'Amico et al. (2016) analysed purchase interest of Italian wine consumers for organic wine with no added sulphur. They found that the majority of Italians (54.5%) were not willing to pay a premium for no added sulphur, and only 10% would pay a small premium. Environmental consciousness and 'wine curiosity' led consumers to pay a higher price for organic wines with no added sulphur wines. On the other hand, naturalness and designation of origin increased the probability of paying a premium price for wine with no added sulphur. The study also discovered that insufficient information is a barrier for accepting higher price of organic wines and wines with no added sulphur. This study also highlighted the need to educate consumers on health effects in order to get a positive evaluation of health-related attributes of wine.

A more recent study by Amato et al. (2017) analysed consumers' willingness to pay for wine bearing a SO_2-free label in Italy and Spain using a Tobit model. Results in both countries show that consumers who associated the headaches with drinking wines with SO_2 are also willing to exchange the habitually consumed bottle of wine with a no-added sulphite wine and even they would be willing to pay something extra for such wine.

In addition to research that directly examined the effect of added SO_2 on wine price and consumer decisions, other studies examined consumers' preferences and willingness to pay for wines perceived to be healthier. For example, a study by Barreiro- Hurlé et al. (2008) revealed a positive valuation for resveratrol-enriched wine, a health-promoting ingredient. Organic wines were also often perceived as being health-promoting (Barreiro-Hurlé et al., 2008; Fotopoulos et al., 2003), and health-conscious consumers were particularly receptive to marketing campaigns promoting natural (and organic) wines (Goode & Harrop, 2011).

Another stream of literature has focused on organic wines (Remaud et al., 2008; Antonazzo et al., 2015). These studies have highlighted the effect of environmental concerns, and, as Olsen et al. (2012) argue, the price premium for organic wine may be viewed as the

financial "self-sacrifice" made in order to protect the environment. It is important to note though that 'organic' is a multifaceted attribute encompassing numerous consumer values, and consumers may even have difficulty explaining why they value organic wine over other varieties (e.g., Barreiro-Hurlé et al., 2008).

The last group of studies focus on various intrinsic (such as sensory characteristics) and extrinsic wine attributes (like price, grape origin, vintage, or brand). Gil and Sánchez (1997) varied wine price, age, and origin and found that, in the absence of other quality cues, the origin is the most important wine attribute. Robertson et al (2018) examines the subjective knowledge about wine associated with relative importance of four extrinsic product attributes. They found knowledge to be increasingly important to wine age, brand, and the region of wine origin, whilst the price of wine was the dominant attribute regardless of the level of product knowledge.

Similarly, Mueller et al. (2001) used informed sensory hedonic test to understand the interplay of wine sensory characteristics and extrinsic attributes such as packaging, price and brand awareness. With enrichment of choice experiments by the sensory tests they were able to simulate consumers' purchase which allowed to examine preferences for new wines and predict their market uptake. Lockshin et al. (2006) and Mtimet & Albisu (2006) examined how market involvement influences the valuation of wine attributes such as brand, region of production, quality medals, and aging.

To sum up, despite relatively large literature on consumers preferences for wine attributes, including organic quality and not-using SO_2 as wine preservative, literature that would elicit consumers' preferences for natural preservative is non-existent. This study therefore fills the gap by investigating consumer preferences for *Rooibos & Honey bush* (natural preservative) and evaluates specifically whether or not and to what extent consumers are willing to pay for wines that are preserved by it.

3 Methods and Data

3.1 Sampling and implementation strategy

Historically, black South Africans were prohibited from purchasing and consuming clear liquors, making white consumer group the largest group of wine drinkers (Ndanga et al., 2009). However, after a change of regime (post-apartheid) and with the growing number of black middle class, whites are no longer the majority wine consumers. Still, there is no background statistics on wine consumer segments. For that reason, a multistage sampling was used to select areas and places to conduct the interviews. In the first stage, Cape Town city was purposely chosen from Western Cape Province[4] because it has the largest number of people and wine consumers (STATsSA, 2016). The second stage involved randomly selecting clusters of shopping malls across the city. These shopping malls encompass retail businesses that sell wine, i.e. restaurants, liquor-stores, supermarkets and bars. The third and final stage involved randomly selecting wine customers who went shopping in the pre-selected shops to form the sample. Eligibility criteria included any person above the age of 18 years old (this is the legal alcohol drinking age for South Africa) and who had consumed at least a bottle of wine (750

[4] Western Cape is a province of South Africa, located on the South-West coast of the country. The province produces 95% of wine in South Africa and has 6.6 million inhabitants out of which two-thirds live in the metropolitan area of Cape Town which is also a provincial capital and tourist destination.

ml) for the last 6 months. Participants were approached by the enumerators[5] and asked if they can voluntarily take part in a wine survey for academic purposes. No incentive was offered to the survey participants. The interview was conducted in English and the enumerators used a pen-and-paper mode of interviewing.

A survey instrument was comprehensively pre-tested.[6] The questionnaire consists of four sections. The first section contained a brief explanation of the purpose of study without getting into details about what the study was all about to minimise a potential framing bias. Questions regarding wine acquisition practice were asked. The second section dealt with consumer information and knowledge about SO_2 content in wine, perceived health effects, cultivar production types and quality score of wine. The discrete choice experiment was presented in the third section. In an event respondent choose no change (status quo), respondents were asked to provide their main reason in order to identify protest responses. The final section collected socio-economic and other relevant information about the respondents. To facilitate understanding and making the survey more pleasant to respondents, visual information was included (see, Figure 1).

The main survey was conducted between July 8–22, 2019, and a total of 611 participants completed the survey. The demographic characteristics of the sample are reported in Table 1. While the sample may not be representative of the South Africa population, the recruiting strategy was highly successful in targeting respondents in areas where the majority of wine consumers reside. Almost everyone was buying at least a bottle of wine in a typical month. The majority of respondents (78%) are in their age of 21-50 years. There are 42% males and 51% females, while 7% choose not to provide information about their gender.

Majority of the respondents reside in Africa (80%), some in Europe (10%), 4% and 3% came from Northern America and Asia, respectively, and the rest (3%) come from other parts of the world. Regarding race, our sample included 33% Caucasian, 31% African, 23% coloured (mixed race), and the minority being Indian and Asian (5% each). In addition, over 66% held a university degree. Median net annual household income is between R200,000 and R350,000 (€12,500–€21,875) coinciding with the average annual household income for South Africa at R270,000 (StatsSA, 2019). However, one third of the respondents preferred not to provide information about their income.

In order to understand how respondents, perceive SO_2 in wine, we asked them several questions. First, we ask "*do you have allergies on sulphur contained foods and beverages such as wine*?" followed by a question "*do you know, or have you heard of someone who suffers from sulphite allergies in wine*?" Final and the key question was *"do you believe that drinking even moderate amounts of wine give you headache?*" About 25% of respondents reported being allergic to SO_2 in foods and beverages; 61% claim to know someone who suffers from SO_2 effects. About 68% believed that drinking even moderate volume of some type of wine may result in headache. We name this group as '***headache'***, while the remaining respondents constitute a group named '***no-headache'.***

[5] Five enumerators were recruited from a pool of Master degree students from the University of Cape Town. To ensure quality of data collection and control, only postgraduate students were recruited, trained and assessed prior to pretesting of the instrument.

[6] The survey instrument was pretested in two waves with 44 and 52 wine consumers in the Western Cape Province of South Africa from the 10-14 June 2019, and 24-28 June 2019, respectively. Based on respondent's feedback, the survey instrument was modified to improve readability and comprehension.

About 15% of the respondents' drink wine almost every day, 19% drink wine a few times a week, 27% and 22% drink wine at least once a week or a fortnight, and only 5% drink wine rarely. When analysing observed preference, we name 'heavy drinkers' as those who drink wine almost every day or a few times a week, and 'light drinkers' being those who drink wine once a month or less often (61% of our sample). 'Heavy' wine drinkers' and 'light' wine drinkers constitute approximately 34%, and 17%, of the sample size, respectively.

When making their choice, our survey participants had in their mind a wine with a price of about 195 Rand (std=116) for a (750 ml) bottle, with a minimum at 35 Rand and a maximum at 900 Rand. In euro equivalents, our respondents on average are typically buying a bottle of wine for €11.5 (std=6.85), with €2.07 and €53 for the cheapest and the most expensive wine respectively. This price also set the cost of the status-quo wine to which a price premium is added for the alternative wines.

Table 1. Socio-demographic characteristics of the sample (n = 611).

	Percent
Gender	
Males	42%
Females	51%
Age	
18-20	4%
21-30	32%
31-40	24%
41-50	22%
51-60	15%
61-70	3%
Education	
High (secondary) school	12%
Some technical certificate/diploma	19%
Bachelor's degree	22%
Honors degree	18%
Professional/Master degree	16%
Doctorate degree	11%
Income	
R50,000 and less (€3,125 and less)	12%
R50,000 to R100,000 (€3,125 - €6,250)	5%
R100,000 to R150,000 (€6,250 - €9,375)	5%
R150,000 to R200,000 (€9,375 - €12,500)	5%
R200,000 to R350,000 (€12,500 - €21,875)	7%
R350,000 to R500,000 (€21,875 – €31,250)	9%
R500,000 to R750,000 (€31,250 – €46,875)	8%
R750,000 to R1,000,000 (€46,875 - €62,500)	5%
R1,000,000 to R2,000,000 (€62,500 - €125,000)	5%
R2,000,000 and more (€125,000 and more)	4%
I prefer not to answer	33%
Wine Consumption	
Almost every day	15%
Few times a week	19%
Once a week	27%
Once a fortnight	22%
Once a Month	12%
Very rarely	5%
Headache	68%

3.2 Experiment design

Designing a DCE involves the selection and combination of the attributes and their levels to construct the alternatives included in hypothetical choice situations presented to respondents (Hoyos, 2010). Respondents are then asked to think about the situation in which they would be making their choices. Identification of the attributes in our experiment was facilitated by literature review addressing particularly recent studies (Costanigro et al., 2014; Amico and Divita, 2016; Amato et al., 2017). In line with the state-of-the-art recommendations for stated preference studies (Johnston et al., 2017; Champ et al., 2017), the design of our study

was also based on findings from qualitative pretesting we conducted within focus groups with wine consumers from the Cape Town area. The qualitative pretesting confirmed the suitability of the survey design and ensured the relevance and understanding of the attributes.

For our study, the alternatives were described using a predefined set of attributes with levels that were experimentally varied around the level expected by the respondents. We used four attributes: Wine *preservative* (SO_2-based vs. Rooibos & Honey bush), *Type of viticulture production* (conventional vs. organic), *Wine quality score,* and *Price* (see, Table 2).

Table 2. Attributes and levels of the discrete choice experiment

Attribute	**No. of levels**	**Levels**
Preservatives	2	SO_2-based, Rooibos & Honey bush
Type of viticulture production	2	Conventional, Organic
Wine quality score	6	60, 75, 82, 88, 92, 100
Price (increase compared to what you usually buy)	5	Rands: 0, 30,45,60,75 (Euro equivalent: 0, 1.77, 2.66, 3.54, 4.43)

There are two types of wine *preservatives* in our choice experiment: Rooibos & Honey bush and SO_2 -based preservative. *Type of viticulture production* may either be organic (wine produced using organic grown grapes) or conventional (wine produced using grapes grown with added chemicals i.e. fertiliser, pesticide). The two viticulture types were included to allow a direct comparison of the valuation of conventional wines preserved with SO_2 versus conventional wines preserved with *Rooibos & Honey bush,* and again organic wines preserved with SO_2 versus organic wines preserved with *Rooibos & Honey bush*. This distinction allows the assessment of the influence of *Rooibos & Honey bush* in both viticulture production types. Wine *quality score* is defined according to the Wine Spectator (2012) scores, whose expert ratings are recognised globally.[7] Quality levels also represent our proxy for a wide range of attributes i.e. brand name, taste, origin which would otherwise make evaluation bulky had we included them in the experiment. We use the point-values of the quality score to avoid uncertainty, as described in Table 2.

Lastly, *price* was defined as the extra cost (premium) respondents are asked to pay in addition to the price they usually pay for a 750ml bottle of wine. While the decision to pay a premium price for using *Rooibos & Honey bush* and other attributes in wine is essentially driven by the cost and benefits derived from its consumption, the individual choice is difficult to anticipate because of reasons i.e. information deficit and perceived or experienced health effects. The wine price was shown as an increment of what a consumer typically pay for a bottle of wine and the premium included nominal Rand values: 30, 45, 60, and 75, and Euro

[7] The scores are defined accordingly as 95–100, classic: a great wine; 90–94, outstanding: a wine of superior character and style; 85–89, very good: a wine with special qualities; 80–84, good: a solid, well-made wine; 75–79, mediocre: a drinkable wine that may have minor flaws; and not recommended wine graded by 50–74 points.

equivalents are also shown on the cards in bracket.[8] In relative terms, the offered bids represented 15% to 38% of average price of the status-quo wine. Since the bids were offered in absolute values, wine price premiums ranged between 3.3% and 214%, with the mean at 37%.

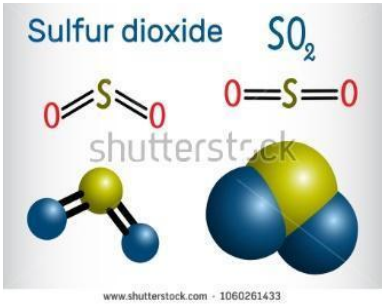
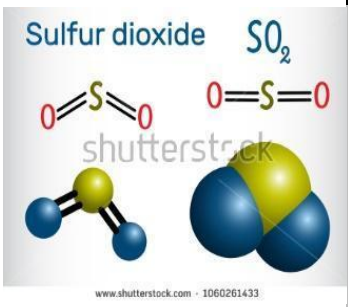
The choice situations presented three alternatives, with one referred to as wine that is typically purchased (the status quo). We described the status quo option as conventional wine with SO_2-based preservatives, graded by 75-points quality score and priced as what respondents usually pay (i.e. associated with zero additional costs). An example of a choice card as presented to respondents is shown in Figure 1. We then asked, "which out of the three alternatives do you prefer?", and we repeated this question for everyone four times, always showing different choice situations.

Since preference for red wine and white wine may differ, wine colour was assigned to each respondent at random. Half of our sample that received the choice cards with costs in Rand was stating preferences for red wine, while the second half was valuing white wines, i.e. we use a split-sample treatment.

Using NGENE software, we generate a Bayesian-efficient designs (Collins and Rose, 2006; Ferrini and Scarpa, 2007; Scarpa and Rose, 2008), with twelve unique choice combinations grouped into three, giving four choice cards to every respondent.

[8] We used the exchange rate 0.059 Euro per Rand, based on South Africa Reserve Bank prevailing rate at the time. www.resbank.co.za

Figure 1. Example of a choice situation

	Red Wine A	Red Wine B	Wine you usually buy
Preservatives	**Rooibos & honey bush** 		
Viticulture production	**Conventional** 	**Organic** 	**Conventional** 
Wine quality Score	**100 (great top wine)**	**60 (not recommended)**	**75 (a drinkable wine that may have minor flaws)**
Additional cost per bottle	R45 (€2.8) more	R60 (€3.75) more	**as you usually pay**
Which option do you prefer?	○	○	○

3.3 Econometric Framework

Choice Experiments technique has grown in popularity since its introduction by Batsell and Lodish (1981), and Louviere and Woodworth (1983). The use of the technique has been extended to many disciplines such as transportation, agriculture and environment, telecommunication, marketing and human health (Alberini and Ščasný 2018; Barreiro-Hurlé et al., 2008; Boncinelli et al., 2019; Brugarolas Mollá-Bauzá et al., 2005; Capitello et al., 2016; Cozzolino et al., 2011; Lockshin et al., 2010; Magistris & Royo, 2014; Rose and Bliemer 2009; Scozzafava et al., 2018). Applications also include conservation of wine varieties or valuation of wild crop conservation (Tyack and Ščasný 2018; 2020). Even-though DCE has limitations on hypothetical bias (see, Lusk & Schroeder, 2004) it allows the study of products that are not yet available on the market (Ščasný et al., 2018) or policies that are not yet implemented (Alberini et al., 2018; Ščasný et al., 2017). Experimental designs not only allow researchers

control for exogenous factors that may otherwise weaken the results, but also ensures that the effects of each attribute on preferences is identified (Kroes & Sheldon, 1988).

Choice model relies on the random utility theory (McFadden, 1974), which assumes that individual *n* chooses the alternative *j* in choice situation *t* with regard to the highest utility:

$$U_{njt} = X_{njt}\alpha_n + \beta_n \cdot (Y_n - PRICE_{njt}) + \varepsilon_{njt} \qquad (1)$$

where *X* represents a vector of alternative specific attributes (PRESERVATIVES, VITICULTURE PRODUCTION, QUALITY SCORE), Y is income, PRICE is price of wine, the vector of coefficients α and coefficient β are estimated and ε_{njt} is a stochastic component identically and independently distributed with a constant variance $k_n^2\,(\pi^2/6)$, with k_n^2, being an individual-specific scale parameter. Instead of separately estimating the parameters for each respondent, we follow a common practice and assume that the parameters follow specific distributions, which leads to the mixed logit model (Revelt and Train 1998).

Note that the coefficients are indexed by individuals' *n*, allowing for (unobserved) preference heterogeneity. In fact, as a consequence of taste and people concerns, consumers may respond differently on different wine attributes, leading in turn to heterogeneity with respect to individuals expected net benefit and hence WTP for 'no sulphite added' wine. We accommodate such heterogeneity by employing econometric models that accommodate both the observable and unobservable component of individual utility from offered alternatives.

Mixed logit with all factors random, freely and fully correlated is estimated using maximum simulated likelihood technique (Revelt & Train, 1998) in STATA 15. An individual will choose alternative *j* if $U_{njt} > U_{nkt}$, $\texttt{for all } k \neq j$, and the probability that alternative *j* is chosen from a set of *C* alternatives is given by:

$$P(j|C) = \frac{exp\,(X_{njt}\alpha_n + \beta_n \cdot (Y_n - PRICE_{njt}))}{\sum_{k=1}^{C} exp\,(X_{nkt}\alpha_n + \beta_n \cdot (Y_n - PRICE_{nkt}))} \qquad (2)$$

The usual procedure is to estimate the distribution of the utility coefficients (i.e. the model in preference-space) and then to estimate the willingness-to-pay as a ratio of two utility parameter estimates, as $-\frac{\hat{\alpha}}{\hat{\beta}}$.

In our alternative specification, we are interested to know whether preference for specific consumer segments differ. For this purpose, we fit the random utility model, additive in parameters, as follows:

$$U_{njt} = X_{njt}\alpha_{1n} + S \times X_{njt}\alpha_2 + (\beta_{1_n} + \beta_2 \cdot S) \cdot (Y_n - PRICE_{njt}) + \varepsilon_{njt} \qquad (3)$$

where *S* is a vector of dummies to describe specific segments such as: people who believe that drinking even moderate amount of wine causes headache ('headache', see Table A2), race (African, Caucasian) and gender (female), see , Table A3, or frequency of wine consumption (heavy drinker, light drinker), see Table A4, to control for observed preference heterogeneity. We assume the coefficient for the interaction terms to be fixed, that allows us to measure a difference in preference for respective consumer segment and given attribute from the random

mean.[9] Assuming the indirect utility function is additive in its attributes, the final WTP estimate for segments S in the specification is given as $-(\frac{\widehat{\alpha 1}+\widehat{\alpha 1}\cdot S}{\widehat{\beta 1}+\widehat{\beta 2}\cdot S})$.

We also assume this specification to explore preference heterogeneity in wine colour, pooling the data from the two sub-sample. Since we do not find preference for the attributes to differ between red and white wines, see Table A1, we estimate all mixed logit models with pooled data. WTP are estimated by delta method, using nlcom STATA command.

4 Estimation results

Results for mixed logit model estimated in the preference space with all factors random and freely correlated are presented in Table 3. We pool the data, without distinguishing wine colour. All coefficients are statistically significant at any convenient level and have expected signs, conforming to a priori expectations. It implies that respondents are willing to pay a premium for each of the three wine attributes and the likelihood to purchase a bottle of wine is decreasing with the increase in price. We also discover large unobserved preference heterogeneity for each of the four random attributes, indicated by the large and strong statistically significant standard deviations of the means.

WTP estimates are presented in Table 4, column (1). Respondents are willing to pay for natural-based *Rooibos & Honey bush* preservatives €3.53 per bottle, while the marginal price for organic winemaking is €1.22, a finding consistent with the idea that organic and *SO_2* added' wines are differentiated attributes, though *Rooibos & Honey bush* evokes a richer and more complex set of values. These findings are consistent with a study by Costanigro et al. (2014) who found that headache sufferers are willing to pay more for wines without added sulphites than for organic wines. WTP for each point of quality score is at € 0.09 per 750ml bottle of wine. Comparing to the average price of wine that respondents had in mind while stating values, i.e. 200 Rand or €11.85, the premium comprises 30 % of the wine price for Rooibos & Honey bush-based preservative, 10 % for organic wine, about 0.8 % per each point in Quality Score

When comparing the difference between wine colour, we find no difference in preferences for the quality attributes between red and white wine, see MXL estimates in Table 1A in Appendix. WTP estimates are reported in Table 1A, Panel B. Although quality and organic production seems to be valued slightly more for red wine, needless to say, neither of the two WTP estimates are statistically different.[10]

[9] We note that the main (random) effect in these MXL models represent utility of consumers in the baseline group, while fixed coefficients for all interactions between the wine attribute and consumer characteristics measures the differences in the utility of given segments from the utility of the baseline group.

[10] WTP for Rooibos and honey bush preservatives is €3.71 for white and €3.43 for red wine (Wald statistics is 0.16, and p=0.6928); WTP for organic attribute is €1.21 and €1.09, respectively (Wald=0.07, p=0.7949); and WTP for 1-point at Quality Score is €0.093 for red and €0.088 for white wine (Wald=0.05, p=0.8316).

Table 3. Parameter estimates, MXL, pooled

	Means ***(s.e)***	***Standard deviations*** ***(s.e)***
rooibos	2.5031***	3.3848***
	(0.2420)	(0.3090)
organic	0.8659***	1.7663***
	(0.1842)	(0.2740)
quality	0.0663***	1.0969***
	(0.0091)	(0.0115)
price	-0.7087***	1.9161***
	(0.0783)	(0.0838)
Model characteristics		
likelihood	-1833.6175	
LR Chi2	1130.57	
No. obs.	7,332	
r(respondents)	611	
k(parameters)	14	

Notes: *, **, and indicates significance of the WTP mean estimates at 10 %, 5 %, and 1 %. Standard errors are provided in parentheses. All random parameters are fully correlated, with 1000 draws for simulations.

When we control for differences in preferences for consumers who believe that SO_2 in wine causes headaches (see MXL estimate in Table A2 in Appendix), we find willingness to pay for natural preservatives (Rooibos & honey bush) as well as for wine quality is at least three-times larger than for consumers who do not believe so, compare €5.67 vs. €1.82 for rooibos, and €0.151 vs. €0.045 for Quality score in Table 4, whilst their WTP for organic wines do not statistically differ from the other (€1.53 vs. €0.93, with Wald=1.28 and p-value=.2572), see Table 4, column (2) for 'headache' consumers and column (3) for the reference group with 'no headache' consumers. We conclude that, at the margins, individuals who believe their health may be affected by SO_2 in wine are also more sensitive to wine additives and are ready to pay a higher premium for wines perceived to be healthier and of a higher quality.

Table 4. Willingness to pay estimates per bottle of wine, means in Euro (see, parameter estimates for headache segment in Appendix A2).

	Pooled data (1)	Headache (2)	No 'Headache' (3)
rooibos	3.5317***	5.6704***	1.8190***
	(0.3683)	(0.9253)	(0.2979)
organic	1.2217***	1.5306***	0.9301***
	(0.2650)	(0.4893)	(0.2547)
quality	0.0937***	0.1506***	0.0449***
	(0.0126)	(0.0275)	(0.0103)

Notes: *, **, and *** indicates significance of the WTP mean estimates at 10 %, 5 %, and 1 %. Standard errors are provided in parentheses. Wald statistics for the quality test of the WTP means for headache vs. no headache segment is 15.79 (p = 0.0001) for rooibos; 1.28 p=0.2572) for organic; and 13.92 (p=0.0002) for quality.

We estimated several mixed models, following eq. (3), to explore observed preference heterogeneity with respect to gender, race, and wine consumption frequency[11]. Table 5 presents the WTP estimates based on MXL model with the interactions with gender (female) and race (being African, and Caucasian), having non-female, Asian and Coloured as the reference category. As a reminder, since we assume the additive specification of MXL model, the fixed coefficients for the interaction terms measure the difference in the utility from the random mean, see MXL result in Table A3 in Appendix.

We find that females are valuing more for organic wines than males, Africans value Rooibos & Honey bush preservatives less than Caucasians, while preferences for Caucasians do not differ from other race (those included in the reference category). This is expected considering that on average Caucasians and Africans in South Africa are at the opposite ends of wealth and income distribution, with *other race* placed in between. WTP estimates, reported in Table 5, shows that non-African males will pay approximately €4.8 for rooibos-based preservatives, while non-African females are willing to pay €3.8 to avoid SO_2 added to wine.

African males and females are willing to pay much less – €2.7 and €2.2 respectively. Interestingly only females are willing to pay for organic attributes, about €2.1 and €1.3 for Caucasian and African respectively, while WTP for organic wines for males is not statistically distinguishable from zero, with an exception of male Caucasian who are willing to pay similar amount as African or other race females, but this estimate is weakly significant only. Males

[11] Parameter estimates and tests are compiled in Appendix. Controlling for other socio-economic variables (e.g., income, education, and other measuring wine preferences) resulted in no significant differences in preferences and are not reported here. These results are available upon authors request.

are, however, ready to pay more than females for wines with higher Quality Score (€0.077 compared to €0.056 for Africans, and €0.095 compared to €0.079 for the other race), except Caucasian males and females who are actually willing to pay the same premium of €0.12.

Table 5. Willingness to pay estimates per bottle of wine, by gender and race, means in Euro

	male + other race	**male + Caucasian**	**male + African**	**female + other race**	**female +Caucasian**	**female +African**
rooibos	4.7533***	4.8661***	2.6779***	3.7979***	3.7561***	2.2075***
	(0.9426)	(1.1957)	(0.5751)	(0.6707)	(0.7999)	(0.4353)
organic	0.3100	1.2791*	0.5492	1.2303**	2.1276***	1.2588***
	(0.5277)	(0.6759)	(0.4316)	(0.4534)	(0.6145)	(0.3624)
quality	0.0945***	0.1532***	0.0638***	0.0794***	0.1240***	0.0560***
	(0.0247)	(0.0372)	(0.0187)	(0.0198)	(0.0265)	(0.0147)

Notes: *, **, and *** indicates significance of the WTP mean estimates at 10 %, 5 %, and 1 %. Standard errors are provided in parentheses.

Last, we analyse the differences in preferences for consumers who differ in their wine consumption frequency, see MXL results in Table A4 in Appendix. We find that heavy drinkers would pay more for natural preservatives than light drinkers (€5.28 vs €3.21), organic attributes (€1.96 vs €0.72), and quality score (€0.14 vs €0.11). Heavy drinkers seem to care more about wine additives and are willing to pay a premium for natural preservatives, organic attribute and high Quality score for wine. Light wine drinker care less about organic attribute which is statistically not significant. See, WTP estimates in Table 6.

Table 6. Willingness to pay estimates per bottle of wine for Heavy vs Light wine drinkers, means in Euro

	Heavy drinkers	Light drinkers
natural	5.2811***	3.2056***
	(1.1534)	(0.7842)
organic	1.9583***	0.7247
	(0.6592)	(0.5167)
quality	0.1420***	0.1055***
	(0.0333)	(0.0265)

Notes: 'Heavy drinker' is a consumer who drink wine at least a few times a week, and 'light drinkers' is a consumer who drinks wine once a month or less often. *, **, and *** indicates significance of the WTP mean estimates at 10 %, 5 %, and 1 %, Standard errors are provided in parentheses. Wald statistics for the quality test of the WTP means for heavy vs. light segment is2.24 (p = 0.1345) for rooibos; 2.40 (p=0.1215) for organic; and 0.83 (p=0.3629) for quality.

5 Discussion and conclusions

More than half of the sample of 611 wine respondents from South Africa believes that drinking even moderate amounts of some type of wine causes headaches. A discrete choice experiment was conducted to explore preferences of consumers in The Cape Town area for natural preservatives, organic wine, and quality measured by 100-point Quality Score, and price attributes. Novelty of this study is to estimate the premium price for not having added SO_2 in wine by substituting the conventional wine preservative with *Rooibos & Honey bush* – a natural preservatives. This is the first analysis of its kind. We find that consumers from the Cape Town area are willing to pay for organic winemaking at about is €1.2 per bottle. Only Caucasian males are willing to pay for the organic quality and on average they are willing to pay as much as non-Caucasian females (€1.3), while Caucasian females are willing to pay for organic winemaking €2.1 per bottle of wine. Wine quality matters as well – on average consumers are ready to pay €0.10 per each point on Quality Score.

With regard to the key attribute – Rooibos & Honey bush preservatives – consumers are willing to pay even more, on average, €3.5, though males are willing to pay slightly more than females. Caucasian males will pay €4.8 that is almost double what African males will pay, €2.7. Caucasian females will pay €3.7 compared to African females who are ready to pay €2.2.

In comparison to other studies, Amato et al (2017) found that Italians and Spanish wine drinkers will pay €1.19 and €1.57 respectively to avoid added SO_2. Similarly, Costanigro et al (2014) found that USA wine consumers are WTP approximately €1.19 per bottle of wine. It is important to note that the previous studies relied on a hypothetical SO_2-free alternative and hence they did not use real preservative like in our case (i.e. using natural preservatives-Rooibos and Honey bush).

Since using SO_2 as wine preservative is very likely associated with adverse health effects, we investigated whether those who believe in these effects are also ready to pay higher premiums for healthier wines. Indeed, we find that these consumers are willing to pay at least three times more for SO_2-free natural preservative and quality scoring than those who do not believe so. They are also ready to pay for organic winemaking, but their premium is only two thirds higher. Importance of these differences is much more if we put into consideration the high percent (68%) of respondents who believe SO_2 causes headache in our sample.

We found no difference in preferences between the colour of wine (red or white) however, willingness to pay for these three wine attributes differ between red and white wines. Heavy drinkers would pay more for natural preservatives in wine than light drinkers. This is good message for the winemakers, since high investment cost induced by introducing the new natural preservative may be recovered faster.

Our findings confirm that consumers' decisions to purchase a bottle of wine in South Africa is more influenced by natural preservatives and organic attributes rather than higher quality score. Our findings present a significant contribution, at least in the South Africa context, to understand preference and hence a niche for the natural preservative market. The share of respondents who believe SO_2 causes headaches is astonishingly large and their preference for wine with less adverse health effect is also much stronger. These consumers represent an apparent, potentially important market segment for the wine industry and wine producers interested in wine product differentiation.

Based on our findings, we recommend that the wine industry should be clearer on the organic winemaking protocol, in particular, it should make clear on what constitutes organic wine, perhaps it should emulate the US protocol that regards organic wine as wine made without added sulphur. It is clear though that respondents are aware about natural preservatives and are in tune with the natural/organic movement for healthier living. Because there's no strong scientific consensus on whether SO_2 in wine causes headache, investigation in medical research to establish the root cause of headaches promises significant rewards for the wine industry.

Before embarking on investment, wineries should consider the additional costs involved with *Rooibos & Honey bush* alternatives and compare them with the premium for 'no sulphite added' wines that they may expect. Our empirical study provides the industry the first evidence for consumers' acceptance of a new novel natural wine preservative and more specifically how the wine consumers may respond.

To fully understand consumer behaviour in relation to natural preservatives, more effort should be put to understand factors of wine consumer choice to provide a better targeted marketing strategy suitable for capturing consumer preference for natural preservatives in wine. Needless to say, preferences of a wider sample should be investigated. In this sense, quite small sample size (≈600) and narrow geographic extent (the Cape Town metropolitan area) are the main limitations of our study. Still, our results are in line with previous literature that are based on "no added sulphites" contingent scenarios and are silent about any realistic sulphur-free alternative, as in our case study.

Appendix

Table A1. Estimation results, MXL with colour interactions

Panel A – Parameter estimates

	Mean (s.e)	**SD (s.e)**	**Interactions with red wine**
rooibos	2.7012***	3.3068***	-0.4001
	(0.3175)	(0.3101)	(0.3759)
organic	0.7933***	1.8402***	0.0201
	(0.2637)	(0.2834)	(0.3089)
quality	0.0641***	0.0907***	-0.0020
	(0.0120)	(0.0133)	(0.0142)
price (in euro)	-0.7276***	0.8832***	0.0564
	(0.1031)	(0.0857)	(0.1165)
Model characteristics			
Log likelihood	-1833.271		
LR Chi2	1127.78		
No. obs.	7,332		
r(respondents)	611		
k(parameters)	18		

Panel B – WTP estimates per bottle of wine, means in Euro

	Red wine	White wine
rooibos	3.4287***	3.7125***
	(0.5210)	(0.5154)
organic	1.2122***	1.0904***
	(0.3654)	(0.3581)
quality	0.0926***	0.0882***
	(0.0168)	(0.0161)

Notes: *, **, and *** indicates significance at 10 %, 5 %, and 1 %, respectively. Standard errors are provided in parentheses. All random parameters are fully correlated, with 1000 draws for simulations. Wald statistics for the quality test of the WTP means for colour segment is 0.16 (p = 0.6928) for rooibos; 0.07 (p=0.7949) for organic; and 0.05 (p=0.8316) for quality.

Table A2. Parameter estimates, MXL with headache interactions

	Mean (s.e)	**SD (s.e)**	**Interactions with headache**
rooibos	2.1259***	3.3019***	0.5800
	(0.3616)	(0.2989)	(0.4033)
organic	1.0870***	1.8310***	-0.3566
	(0.3124)	(0.2673)	(0.3490)
quality	0.0525***	0.0895***	0.0193
	(0.0131)	(0.0118)	(0.0163)
price (in euro)	-1.1687***	0.8493***	0.6915
	(0.1256)	(0.0817)	(0.1345)
Model characteristics			
Loglikelihood	-1806.2427		
LR Chi2	1066.11		
No. obs.	7,332		
r(respondents)	611		
k(parameters)	18		

Notes: *, **, and *** indicates significance at 10 %, 5 %, and 1 %, standard errors are provided in parentheses. All random parameters are fully correlated, with 1000 draws for simulations.

Table A3. Parameter estimates, MXL with interactions on gender and race

	Mean (s.e)	SD (s.e)	Interaction with female	Interaction with African	Interaction with Caucasian
rooibos	2.9056***	3.2454***	-0.0740	-0.7970*	-0.3700
	(0.3938)	(0.2993)	(0.3704)	(0.4552)	(0.4453)
organic	0.1894	1.8332***	0.7277**	0.2429	0.4770
	(0.3242)	(0.2701)	(0.3131)	(0.3766)	(0.3749)
quality	0.0577***	0.0913***	0.0014	-0.0075	0.0220
	(0.0152)	(0.0115)	(0.0144)	(0.0179)	(0.0173)
price	-0.6113***	0.9123***	-0.1342	-0.1761	0.0902
	(0.1220)	(0.0832)	(0.1193)	(0.1478)	(0.1428)
Model Characteristics					
Log likelihood	-1822.3397				
LR Chi2	1090.13				
No.obs	7,332				
r(respondents	611				
k(parameters)	26				

Notes: *, **, and *** indicates significance at 10 %, 5 %, and 1 %, respectively. Standard errors are provided in parentheses. All parameters are fully correlated, with 1000 draws for simulations.

Table A4. Parameter estimates, MXL with frequency of wine drinking interactions

	Random factors		**Fixed interactions**	
	Mean (s.e)	**SD (s.e)**	**Interactions with heavy drinkers**	**Interactions with light drinkers**
rooibos	2.4721***	3.4320***	0.2285	-0.1926
	(0.3131)	(0.3101)	(0.4321)	(0.5180)
organic	1.0082***	1.6719***	-0.0068	-0.4929
	(0.2443)	(0.2835)	(0.3439)	(0.4081)
quality	0.0641***	0.0983***	0.0085	0.0109
	(0.0116)	(0.0117)	(0.0170)	(0.0204)
Price (in euro)	-0.8659***	0.9153***	0.3545**	0.1548
	(0.1055)	(0.0861)	(0.1389)	(0.1649)
Model characteristics				
Log likelihood	-1826.8435			
LR Chi2	1109.95			
No. obs.	7,332			
r(respondents)	611			
k(parameters)	22			

Notes: *, **, and *** indicates significance at 10 %, 5 %, and 1 %, respectively. Standard errors are provided in parentheses. All random parameters are fully correlated, with 1000 draws for simulations.

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