PAPER

CONSUMER PERCEPTIONS OF NANOTECHNOLOGY APPLICATIONS IN ITALIAN WINE

N. CASOLANI[a], G.M. GREEHY[b], A. FANTINI[a], E. CHIODO[a]* and M.B. MCCARTHY[b]

[a] Facoltà di Bioscienze e Tecnologie Agro-Alimentari e Ambientali, Università degli Studi di Teramo, Via C.R. Lerici 1, 64023 Mosciano Sant'Angelo (TE), Italia

[b] Department of Food Business and Development, University College Cork, Western Road, Cork, Ireland

*Corresponding author: Tel. +39 0861 266898, Fax +39 0861 266915, email: echiodo@unite.it

ABSTRACT

This paper examines Italian consumer acceptance of nanotechnology applications in wine production, surveying wine consumers from the Abruzzo Region. Conjoint and *post-hoc* segmentation analysis establishes how consumers value different wine product attributes and place them within the context of applications of nanotechnology. Consumers appear relatively unfamiliar with nanotechnology applications, both generally and specifically to food. Although, an overall rejection of the concept of "nano wine" is evident, low acceptance scores disguise a somewhat more open attitude to specific applications of the technology. In particular, consumers appear more receptive to applications that enhance certain wine attributes. Practical implications are discussed.

- Keywords: conjoint analysis, consumer acceptance, consumer segmentation, nanotechnology, purchase intention, wine -

1. INTRODUCTION

1.1. Nanotechnology applications in food and wine

Nanotechnology is the science that studies the manipulation of matter at atomic and molecular scales; a nanometre refers to one-billionth of a metre. Nanotechnology is perceived to offer many potential benefits (MURA *et al.*, 2014), such as producing healthier foods without compromising taste (WEISS *et al.*, 2006). Applications in food packaging and food contact material include microfilms that incorporate nanomaterials to improve packaging properties, e.g. flexibility and moisture stability, and "smart packaging" that incorporates nano-sensors that detect pathogens and contaminants in food (SORRENTINO *et al.*, 2007; CHAUDHRY *et al.*, 2008).

OBERDÖRSTER *et al.* (2005) argue that the properties of materials at the nanoscale can differ considerably from conventional materials. Therefore, nanotechnology-based foods have generated significant debate, particularly about potential associated risks (CHAUDHRY *et al.*, 2008; SIEGRIST *et al.*, 2008). Specifically, concerns have been expressed regarding potential negative impacts of certain nanoparticles on the health of humans, animals and the environment (KUZMA and VERHAGE, 2006). Furthermore, the FAO/WHO (2009) argues that when the size of particles decreases, this increases the surface-to-volume ratio and therefore, creates new properties, potentially resulting in altered toxicity profiles.

To date, a limited number of "nanofoods" appear to have been made available on the market (SIEGRIST *et al.*, 2008). That said, it is difficult to truly establish the extent of the application of nanotechnology in food and beverage production at present across international markets, as there is currently no legal requirement to declare the use of such ingredients on product labels. Nevertheless, there is some indication of nanotechnology being applied within the food domain (MOMIN *et al.*, 2013; DURÁN and MARCATO, 2013).

Focusing on the wine sector, nanotechnology could potentially be applied at the following stages of production: grape-growing, wine making and packaging. Specifically, nano-compounds could improve grape growth when added to pesticides and fertilizers to increase soil fertility and crop production (ALLIANZ AG and OECD, 2005). Furthermore, nanoparticle-based pesticides could be more easily absorbed by plants than conventional pesticides, or could equally be programmed to be released more gradually over time, thereby optimising their usage (*Ibid*). Hypothetically, yet plausibly, nanotechnology could be applied during wine making to alter the characteristics of the wine including its taste, flavour or other product characteristics, including the calorie or alcohol content of the wine (ALLIANZ AG And OECD, 2005; WEISS *et al.*, 2006; DURÁN and MARCATO, 2013).

Other possible applications of nanotechnology during wine production include the use of nanotechnology-based devices and materials for nano-filtration and water treatment (MOMIN *et al.*, 2013). Nanotechnology-based devices could also potentially improve surveillance systems and the tracking of products as they move through the supply chain (WEISS *et al.*, 2006), thereby enhancing authenticity measures. Finally, pertaining to wine bottling, nanotechnology could be used to produce bottle caps that more effectively regulate gas exchange with the outside environment (DURÁN and MARCATO, 2013).

1.2. Consumer acceptance of nanofoods

It is important to understand public perceptions of nanofoods (SIEGRIST *et al.*, 2008). However, these may be difficult to measure at present, as opinions may not yet have formed, given low levels of public awareness of nanotechnology (FELL *et al.*, 2009; SIEGRIST, 2010). GASKELL *et al.* (2010) found that approximately ½ of EU-27 citizens (46%) and just over $^1/_3$ of Italian citizens (37%) were aware of nanotechnology. Gaskell and colleagues also found that a significant minority (40%) of EU-27 citizens is likely to be unsure about their feeling towards applications of nanotechnology and that awareness generally resulted in more positive views regarding its safety. However, as more information becomes available through mass media, public attitudes will become more solidified (DUDO *et al.*, 2010). Although several studies have found the impact of awareness on attitudes towards novel food technologies to be mixed (FELL *et al.*, 2009; SACCHETTI *et al.*, 2009); KAHAN *et al.* (2007) found a positive relationship between awareness of nanotechnology in general and the belief that associated benefits outweigh potential risks.

Attitudes towards and, in turn, willingness to buy nanofoods may be influenced by general values, for example risk sensitivity and attitudes towards nature, the environment, science and technology (RONTELTAP *et al.*, 2007; FELL *et al.*, 2009; STAMPFLI *et al.*, 2010). For example, numerous studies suggest that the dichotomy between nature and technology is important in determining receptivity (ROZIN, 2005; SIEGRIST *et al.*, 2008). In addition to naturalness, other product characteristics, including taste and price may impact consumer acceptance (FELL *et al.*, 2009). Willingness to buy nanofoods is also strongly influenced by risk and benefit perceptions (STAMPFLI *et al.*, 2010). Personal belief in the ability to control exposure to the technology may also influence acceptance (SIEGRIST *et al.*, 2008).

Consumers use intrinsic and extrinsic cues to form opinions regarding objective and subjective product quality (VEALE *et al.*, 2006). Grunert (2005), among others, notes that subjective hedonic characteristics, e.g. taste and pleasure, are important determinants of purchase and consumption decisions. This is particularly evident in the case of wine (OLSEN *et al.*, 2007). Wine purchase decisions are based on a complex array of factors including region of origin, grape variety and price (ATKIN *et al.*, 2006; LOCKSHIN *et al.*, 2006), in addition to other aspects including health and authenticity characteristics (CHIODO *et al.*, 2011; BARREIRO-HURLÉ *et al.*, 2008). That said, given the hedonistic nature of wine, certain health characteristics may not have the same prevalence for wine as they do for other food products. Furthermore, a greater focus by consumers on environmental aspects of wine production and distribution systems is emerging (REMAUD *et al.*, 2008).

Elsewhere, CARDELLO *et al.* (2007) and VON SCHOMBERG and DAVIES (2010) describe how the public may have concerns about novel food technologies, including nanofoods. These concerns, if not addressed, can lead to consumers rejecting these technologies and searching the supermarket shelves for products claiming to be "nano-free" (KUZMA and VERHAGE, 2006). Some of the applications of nanotechnology in wine production outlined may be negatively perceived by consumers, due to perceptions of unnaturalness and tampering with winemaking traditions. Potential concerns may also emerge in terms of the unknown health and environmental consequences of applying nanotechnology in wine production, as indicated in various studies (e.g. KUZMA and VERHAGE, 2006; CHAUDHRY *et al.*, 2008).

Nonetheless, potential associated benefits may be positively perceived. These includes benefits to: 1) consumers, for example improving the wine's health characteristics (WEISS *et al.*, 2006) by, for instance, reducing its calorie or alcohol content; 2) industry, for example improving production processes, such as the bottling process (DURÁN and MARCATO, 2013); and, 3) the environment, for example decreasing the use of pesticides during grape cultivation (ALLIANZ AG and OECD, 2005). In turn, this may lead to nanotechnology application to wine being acceptable to consumers and adopted by industry.

Following these considerations, the aim of this study was to understand the impact of the application of nanotechnology in wine production on consumers' wine purchase intention. Possible consumer reactions towards nanotechnology application to wine and varying determinants of consumer acceptance were explored, as well as the homogeneity of consumers' responses.

2. MATERIALS AND METHODS

2.1. Overview

The study involved wine consumers from the Abruzzo Region of Italy completing a face-to-face administered questionnaire. An overall profile of respondents and also profiles using an *a-priori* segmentation variable (frequency of wine consumption) is presented. Following this, consumers' preferences are analysed using a Conjoint Analysis (CA) approach. The influence of production methods (conventionally produced versus produced using nanotechnology) and product attributes (e.g. associated with health and naturalness) on product preference are examined. Within this study, conventional methods refer to production practices currently in place which comply with present PDO production regulations. "Produced using nanotechnology" refers to the use of nanotechnology in any one or more phases of the production chain, e.g. during the cultivation of grapes or packaging of wine. Conjoint and *post-hoc* segmentation analysis establishes how respondents value different wine attributes and place them within the context of the application of nanotechnology. Both the *a-priori* and *post hoc* segments are profiled based on importance placed on different wine attributes, perceptions of different applications of nanotechnology to wine and demographic variables.

The wine used within the experiment was "Montepulciano d'Abruzzo DOC", the predominant PDO wine in the Abruzzo Region and one of the largest wine denominations in Italy.

Data collection was completed in October-December 2011. In total, 221 wine consumers completed the survey. No incentive was offered to respondents to complete the questionnaire. Similarly to VERDÜ JOVER *et al.* (2004), sample stratification was based on previous studies carried out which included a similar number of study items. The sample of wine consumers is representative of the regional population in terms of age and gender, based on demographic data provided by the Italian National Institute of Statistics and referred to the same period (ISTAT, 2014), as follows: 6% of women and 5.7% of men aged 18-24 years; 10% of women and 10.3% of men aged 25-34 years; 12.2% of women and 12.2% of men aged 35-44 years; 11.8% of women and 11.4% of men aged 45-54 years; and, 10.3% of women and 9.8% of men aged 55-64 years.

2.2. Questionnaire

Respondents were screened to ensure: 1) they did not work in the agro-food sector; 2) purchased or consumed wine at least once a month on average; 3) were between the ages of 18 and 64; and, 4) were either an Italian citizen or had

been living in Italy for at least five years. The questionnaire, presented in Italian, posed questions regarding frequency of wine consumption and habits; attitudes towards wine production and wine purchasing/consumption habits; factors that influence choice of wines; and, awareness of nanotechnology and its applications in food and beverage production.

Low levels of public awareness of nanotechnology, as previously outlined, presented a clear challenge in terms of deciding whether to present prior information about the technology to respondents. Consequently, in designing this experiment, we looked to those who have examined consumers' appraisals of novel food technologies in the past and best practice in terms of an appropriate CA approach (e.g. SIEGRIST *et al.*, 2009; SCHNETTLER *et al.*, 2012).

An underlying principle of conjoint analysis research is that it should be as realistic, reasonable and understandable as is feasibly possible (COX *et al.*, 2008). Thus, similar to SIEGRIST *et al.* (2009), our study was conducted in terms of a "virtual market", i.e. what consumers would do if they were informed (via a label) that a product is produced using nanotechnology and had some prior awareness of the concept of nanotechnology. Therefore, following the aforementioned general questions, in the context of ensuring a minimal level of awareness of nanotechnology among respondents in advance of completing the CA experiment, a brief (neutral) definition of nanotechnology and its potential food applications (Appendix 1) was presented. The definition provided is similar in content and structure to that which was included in SIEGRIST *et al.*'s (2009) study.

Following the provision of this definition, the 10 wine labels (based on the conjoint analysis profiles generated - see section 2.3) were presented for scoring. Attitudes towards the use of nanotechnology in wine production were then measured. Specifically, questions were posed regarding attitudes towards the use of nanotechnology in wine production in general and attitudes towards different applications in wine production for a variety of purposes. Finally, demographic information was gathered. All statements and associated scales are summarised in Table 1.

2.3. Conjoint analysis

Conjoint analysis (CA), a market research approach used to support product and service design, has been widely applied to consider the impact of different product attributes on food and beverage purchase decisions (MAKOKHA *et al.*, 2006; SZOLNOKI *et al.*, 2010). CA assumes that consumers are able to evaluate a range of products/services along key dimensions, called factors (attributes) and involves constructing a series of different product profiles (concepts) that represent a possible product or service. In the case of this research, the CA experiment involved different combinations of information about wine that may (or may not) be modified using nanotechnology, i.e. different profiles. The aim of this approach is to estimate the importance of each factor (product attribute) presented to consumers.

For categorical product attributes, the utility function consists of part-worth estimates for each level of the attribute. Market simulation models use this information to predict how each respondent would choose among alternative products. Therefore, CA enables an understanding of how people make choices between products or services across different combinations of levels and attributes. The CA method has several advantages, including the possibility to measure consumer preferences for each attribute level using more realistic decision models (SCHAUPP, 2005). Using CA, the researcher can answer questions such as what product attributes are important/unimportant to the consumer.

CA has previously been applied to explore consumer perceptions of the application of specific novel food technologies (e.g. ARES and GAMBARO, 2007; BECH-LARSEN and GRUNERT, 2003; CARDELLO *et al.*, 2007; COX *et al.*, 2008; HAILU *et al.*, 2009; SCHNETTLER *et al.*, 2012; ANNUNZIATA and VECCHIO, 2013), including nanotechnolo-

Appendix 1: Definition of nanotechnology presented to respondents in advance of conjoint analysis experiment (English version)

"New and advanced technologies with applications in food are constantly being developed. Nanotechnology is one such technology, which deals with nanoparticles (particles that are 100 nanometres or less in dimension). A nanometre is one-billionth of a metre. A sheet of paper is about 100,000 nanometres thick. Some nanoparticles are naturally occurring, for instance, it is nano-size particles that make milk appear white. Materials can possess new properties at this nanoscale and this technology makes interesting innovations possible in food.

Nanotechnology, potentially, has widespread applications in food, including uses in food products, processing and packaging. It can be used to make food products with additional benefits such as better availability of vitamins or longer shelf-life without altering the taste, appearance or texture of food. However, possible consequences or risks of using nanotechnology for humans and the environment are largely unknown.

On the one hand, additional benefits may enhance our health and improve products. On the other hand, the use of nanotechnology in food stuffs may be associated with potential risks".

Table 1.

Type of Questions	Question or Statements Posed/ Attributes Listed	Scales	Source
Frequency of consumption.	How often do you consume wine on average?	4-point frequency scales *(1 is "everyday" and 4 is "at least once a month")*	Developed by researchers.
Wine consumption habits.	I always drink the same variety of wine. I always drink wine produced in my region. I always drink wine from the same territory.	7-point Likert scales *(1 is "disagree strongly" and 7 is "agree strongly")*	Developed by researchers and adapted from Seghieri et al. (2007).
Attitudes towards wine production and wine purchasing/ consumption habits.	Wine is an important part of Italians' culture. I am proud of Italian tradition in wine production. I spend a lot of time deciding which bottle of wine to purchase.	7-point Likert scales *(1 is "disagree strongly" and 7 is "agree strongly")*	Developed by researchers.
Attributes influencing wine choice. How important are each of the following when selecting wine?	Region of production; brand; type of cork; price; age of the wine; grape variety; packaging; territory of origin; alcohol content; sulphite content; and, calorie content.	7-point importance scales *(1 is "extremely important" and 7 is "extremely unimportant")*	Developed by researchers and adapted from and Gil & Sánchez (1997) and Atkins & Johnson (2010).
Awareness of nanotechnology.	Have you ever heard of nanotechnology? Have you ever heard of nanotechnology being used in food and beverage production?	Yes/No	Developed by researchers.
Nanotechnology acceptance.	I do not want nanotechnology to be applied in wine production. I consider the use of nanotechnology in wine production to be acceptable. I would be happy to consume wine produced using nanotechnology.	7-point Likert scales *(1 is "disagree strongly" and 7 is "agree strongly")*	Developed by researchers.
Acceptance of nanotechnology applications in wine production. *How acceptable do you consider it to use nanotechnology to:*	Produce lower calorie wine. Produce lower alcohol content wine. Modify the colour of wine. Modify the structure and properties of the cork. Enhance the taste of wine. Reduce the amount of pesticides used when growing the grape. Produce less expensive wine. Enhance authenticity.	7-point acceptance scales *(1 is "extremely unacceptable" and 7 is "extremely acceptable")*	Developed by researchers.

Overview of questionnaire statements and associated scales.

gy (SIEGRIST *et al.*, 2009), and associated product attributes. Furthermore, various CA studies have explored preferences for different wine attributes (e.g. GIL and SÁNCHEZ, 1997; ATKIN *et al.*, 2006; MARTÍNEZ-CARRASCO *et al.*, 2006) including, for instance, price, origin and grape variety/vintage.

Bearing in mind the attributes examined across these CA studies, within this work, a full profile conjoint analysis was applied in order to determine consumers' preference (purchase intention) for the following wine attributes: price, method of production and benefits. The conjoint experiment was generated using SPSS 19. Product profiles were presented as wine labels with different information included on each label (Appendix 2 includes an example of one of the labels). The text included in each wine label was presented in Italian.

Appendix 2: Example of a wine label used in the conjoint experiment (English and Italian versions of Profile 8).

Similar to O' CONNOR *et al.* (2005), SORENSON and BOGUE (2006) and SIEGRIST *et al.* (2008), a ten-point purchase intention rating scale was used to measure purchase preference. Assigning a score from 1 to 10, based on willingness to purchase the product, emulated a real-life wine purchase situation. A rating, rather than ranking, scale was considered most suitable as the former *"avoid[s] validity and reliability problems as a consequence of the large number of concepts presented to respondents for evaluation"* (SORENSON and BOGUE, 2006: 705)

The wine attributes that varied across the profiles are outlined in Table 2.

In order to make the conjoint labels presented were as realistic as is feasibly possible (COX *et al.*, 2008; SIEGRIST *et al.*, 2009), the labels included additional standardised information. This approach is not novel, as several other CA studies (e.g. LABOISSIÈRE *et al.*, 2007) have included additional attributes in their experiments, which were not then included in the CA plan. Each of the labels contained the following standardised information:

- Name of the producer: *"Azienda Agricola La Collina"*
- Designation of origin: *"Montepulciano d'Abruzzo DOC"*
- Product description: *"This red wine is ideal to serve with roast meat. Serve at 18-20°C"*

The product attributes (e.g. price) that varied were the specific focus of consideration. In terms of the variable attributes, the selected price levels (€5.99 and €11.99) are reflective of two different price segments; premium and super-premium wines, as recommended by HEIJBROEK (2003). Furthermore, they are representative of the price points for several brands of Montepulciano d'Abruzzo wine currently offered in Italian supermarkets.

Where the wine was not produced using nanotechnology, i.e. was produced using conventional methods, the method of production was not stated on the label. In many conjoint studies applied to food labelling (e.g. SILAYOI and SPEECE, 2007; COX *et al.*, 2008), the level "absence of information" or "no claim" is included for certain attributes. This results in various degrees of information being included on the different product labels (i.e. for some of the product profiles). This lack of information for certain attributes is reflective of real life purchase situations. In comparison, when produced us-

Table 2.

Attribute	Level 1	Level 2	Level 3	Level 4
Price	€5.99	€11.99		
Method of Production	Conventionally produced *(Method of production not stated on label)*	Produced using nanotechnology *(stated on label)*		
Benefits	Lower sulphite levels *(Sulphite information excluded from label)*	Lower calorie content	Lower alcohol content (9% instead of 12.5%)	No claim on label

Attributes (and levels) that varied across wine profiles.

ing nanotechnology, it was explicitly stated on the wine label.

Within this conjoint experiment, if the wine had a sulphite level lower than 10 mg/l (the limit established from the Regulation (EU) No 1169/2011 for omitting the indication of the presence of sulphites from the label), sulphite information was not included on the label. Thus, in keep with our research goals, this attribute level best resembles market place situations.

Therefore, how the "benefit" attribute levels were presented is based on what is practical, relevant and realistic within the marketplace (GIL and SÁNCHEZ, 1997). Furthermore, the approach used for the "benefit" attribute levels is similar to that of other published CA studies in the context of the inclusion of a "no claim" or "no information" level (e.g. DELIZA *et al.*, 2003; KRYSTALLIS and NESS, 2005).

The rating task was carried out applying the full-profile conjoint analysis method using SPSS 19.0. This software calculated the utility values for each level of each factor. CA is useful in evaluating purchase intentions (SÁNCHEZ and GILL, 1998). An "average importance" value was also calculated for each factor that reflects the relative range of utility values for the levels within each factor (CARDELLO *et al.*, 2007).

When adopting the full-profile method, the number of possible profiles can increase rapidly due to the various combinations of factors and levels. The design must be balanced with a sufficient rotation of the factors and number of profiles in order to maintain the overall significance of the experiment. Therefore, a fractional factorial design (orthogonal array) was used which presented a suitable fraction of all possible combinations of the factor levels. Table 3 summarises the 10 profiles generated in SPSS 19; two holdouts were included to ensure the validity of the test.

In the results section, an overall profile of respondents is presented as well as profiling using an *a-priori* segmentation variable (frequency of wine consumption). Following this, perspectives on nanotechnology are considered. Conjoint and *post-hoc* segmentation analysis establishes how respondents value different wine product attributes. The influence of production methods (conventionally produced versus produced using nanotechnology) and other product attributes (e.g. associated with health and naturalness) on product preference are examined.

3. RESULTS

3.1 Consumers' behaviours and attitudes to wine

Fifteen percent, 33% and 24% of respondents indicated that they had a daily, weekly or fortnightly wine consumption habit respectively. The remaining 28% were relatively infrequent consumers, with consumption levels at around once monthly. Respondents reported that they do not always drink the same varieties of wine ($\bar{x}$ = 4.69; S.D. = 1.63), drink wine from their region ($\bar{x}$ = 4.01; S.D. = 1.91) or drink wine from the same territory ($\bar{x}$ = 4.07; S.D. = 1.94). Generally, participants indicated that they spend

Table 3.

Profile	Price	Method of Production	Benefits	
1	€ 5.99	Conventionally produced *(Method of production not stated on label)*	Lower sulphite content *(Sulphite information excluded from label)*	Design
2	€ 11.99	Produced using nanotechnology	Lower sulphite content *(Sulphite information excluded from label)*	Design
3	€ 5.99	Conventionally produced *(Method of production not stated on label)*	Lower calorie content	Design
4	€ 5.99	Produced using nanotechnology	No claim on label	Design
5	€ 5.99	Produced using nanotechnology	Lower alcohol content	Design
6	€ 11.99	Conventionally produced *(Method of production not stated on label)*	No claim on label	Design
7	€ 11.99	Conventionally produced *(Method of production not stated on label)*	Lower alcohol content	Design
8	€ 11.99	Produced using nanotechnology	Lower calorie content	Design
9	€ 5.99	Produced using nanotechnology	Lower sulphite content *(Sulphite information excluded from label)*	Holdout
10	€ 11.99	Produced using nanotechnology	Lower alcohol content	Holdout

List of profiles used in conjoint analysis experiment (fractional factorial design).

some time selecting which wine to purchase ($\bar{x}$ = 4.55; S.D. = 1.50).

The general sentiment of the sample to Italian wine was very positive, which was reflected in their view that wine forms an important part of Italian culture ($\bar{x}$ = 5.84; S.D. = 1.52) and in their expression of pride in Italian wine tradition ($\bar{x}$ = 5.97; S.D. = 1.28). When selecting wine, price, region of production and grape variety were among the most important selection attributes (Fig. 1). A paired sample t-test highlighted that as an information cue, price was significantly more important than all other cues ($p < 0.001$).

Using frequency of consumption as an *a-priori* segmentation variable, we observed significant differences in wine behaviour patterns. One-way ANOVA analysis ($p \leq 0.002$) highlights that everyday consumers were more likely to drink wine from a variety of territories when compared to the fortnightly and monthly consumers. While the patterns of the daily and weekly consumers were similar, the weekly consumers ($p \leq 0.001$) were also more likely to spend time engaging in the selection of wine than their fortnightly or monthly counterparts. In addition to this analysis, evidence of differences in the importance of quality attributes in the selection of wine was also apparent. Levels of importance for territory of origin ($p = 0.03$), cork ($p < 0.01$), price ($p < 0.01$), age ($p < 0.01$), variety ($p = 0.018$) and packaging ($p < 0.01$) varied across the segments (ANOVA analysis with *post hoc* Bonferroni). The everyday consumers placed more importance on territory of origin ($p \leq 0.031$) and variety ($p < 0.02$) than the fortnightly consumers; while the weekly consumers placed more importance on the age ($p < 0.01$) and less importance on the price ($p \leq 0.03$) than the fortnightly and monthly consumers. Interestingly, irrespective of their consumption level, all held similar sentiments towards Italian wine.

To assess the relative importance of each attribute for each segment, a paired sample t-test was applied. This indicated that it was only in the case of fortnightly and monthly consumers that price was significantly more important than other key information cues. In the case of both everyday and weekly consumers, no significant differences were identified in terms of price, region, grape variety and territory of origin. This suggests that frequent consumers of wine rely equally on a greater variety of information cues in their selection of wine.

The segments differed significantly ($\chi^2 = 9.46$; $p = 0.024$) based on gender, with males being more likely to be daily drinkers, accounting for 71% of the everyday category. In comparison, 62% of the monthly category was female. There were no significant differences with regard to age and frequency of consumption.

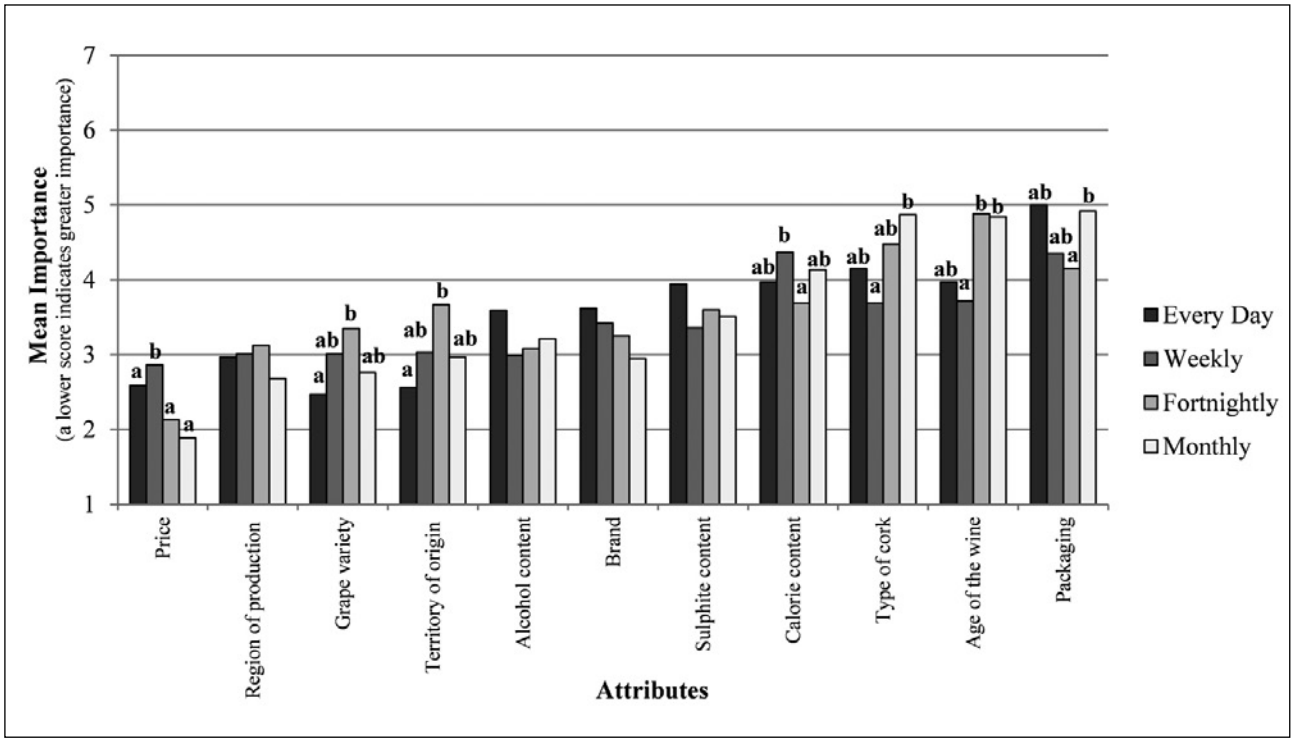

Fig. 1 - Mean importance of attributes influencing wine purchase decisions by frequency of consumption.

Note: Scale from 1 to 7, where 1 is extremely important, 7 is extremely unimportant and 4 is neither important nor unimportant. Letters above the bars reflect significant differences between frequencies of consumption groups at the 95% confidence level.

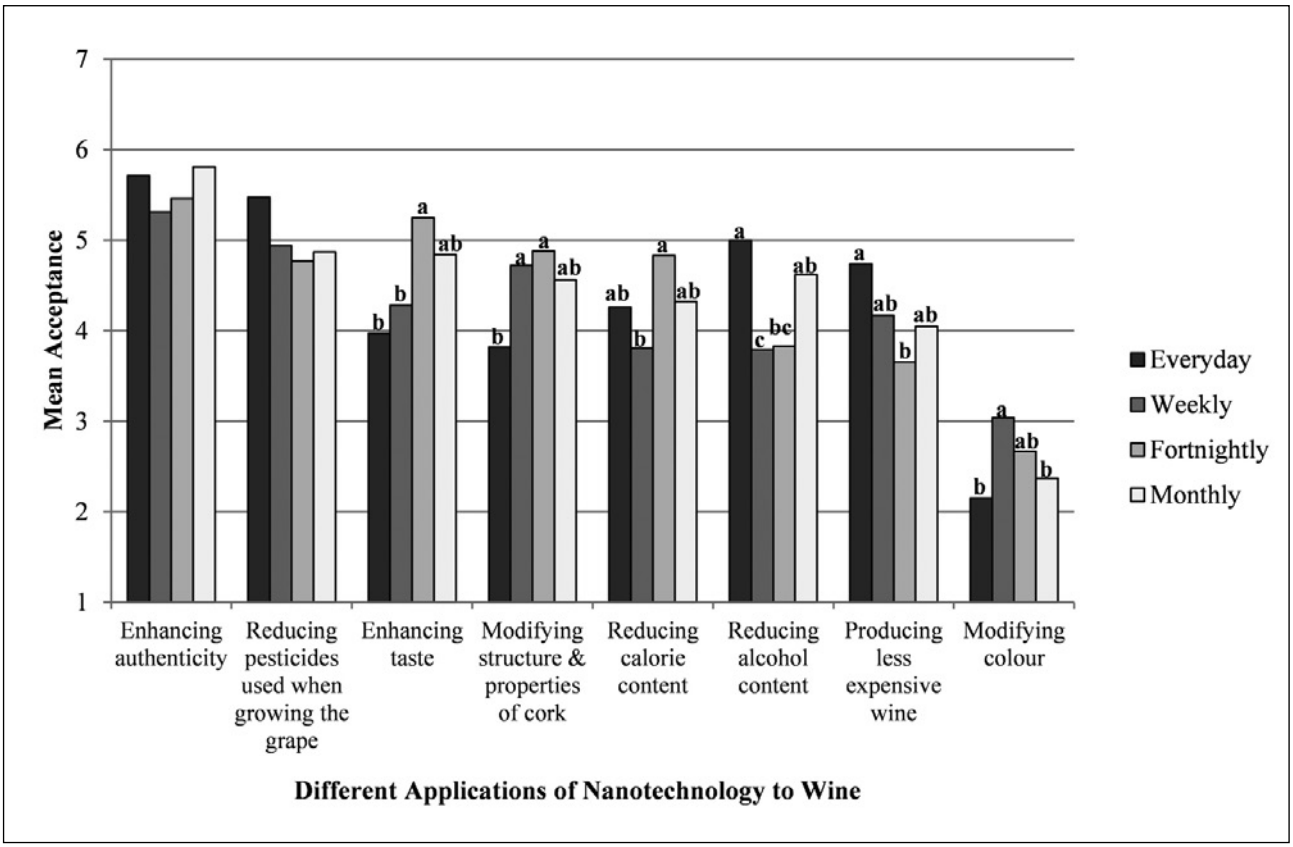

Fig. 2 - Acceptance of applying nanotechnology to obtain the following benefits by frequency of consumption.

Note: Scale from 1 to 7, where 1 is extremely unacceptable, 7 is extremely acceptable and 4 is neither acceptable or unacceptable. Letters above the bars reflect significant differences between frequencies of consumption groups at the 95% confidence level.

To provide a rich account of consumer acceptance of adopting nanotechnology in wine production, the next section explores respondents' awareness of and perspectives on nanotechnology. It examines acceptance of nanotechnology applications in wine, both generally and specifically, at the segment level based on frequency of consumption.

3.2. Awareness and attitude towards nanotechnology

The majority of the sample was unaware of nanotechnology applications in general (58%). This lack of awareness increased considerably for food applications (84%). To get an initial indication of attitudes towards nanotechnology, following the provision of information on this technology, respondents were asked about their level of acceptance of the use of nanotechnology in wine production using three statements (Table 1). Unidimensionality of this measure was assured on the basis of principal axis factor analysis, with 84% of variation explained by a single factor and factor loadings ranging from 0.51 to 0.86. Reliability of the measure was also good (α = 0.936). An overall acceptance score was calculated based on a mean score for the three statements. Widespread acceptance of nanotechnology in wine production is unlikely ($\bar{x}$ = 3.06; S.D. = 1.75) and was not significantly different across consumption levels.

To further understand levels of acceptance, an examination of potential applications of nanotechnology that offer specific benefits was undertaken. Although the applications presented are hypothetical at present, they may become a reality in the future. This suggested that certain applications are more acceptable than others, as summarised in Fig. 2. Enhancing the authenticity of wine, relates to improving the traceability and safety of the wine and ensuring the preservation of product characteristics linked to its origins. This enhancement was considered the most acceptable application, followed by reducing the use of pesticides and enhancing sensory characteristics. Paired sample t-tests highlight that the application of nanotechnology to enhance the authenticity of wine was significantly more acceptable ($p < 0.001$) than its applications for other purposes. However, this disguised differences across consumption levels. While the monthly consumers displayed the same pattern as the overall sample, the everyday and weekly consumers considered applications to reduce the

usage of pesticides equally as acceptable as applications to enhance authenticity.

Enhancing taste was the third most acceptable application and was significantly less acceptable than authenticity improvements. That said, in the case of the fortnightly group, taste along with modifying cork and reducing calories were judged as equally as acceptable as authenticity improvements. Furthermore, taste benefits were significantly less acceptable than benefits such as price and reduced alcohol content for everyday consumers. ANOVA analysis confirmed that the everyday and weekly consumers were significantly less accepting ($p \leq 0.01$) of taste benefits when compared with the fortnightly consumers. Finally, colour modification was the least acceptable application across all consumption levels.

ANOVA analysis highlights that the everyday consumers were significantly more accepting of low alcohol benefits when compared to weekly ($p = 0.008$) or fortnightly ($p = 0.019$) consumers. Furthermore, they were significantly less accepting of modifications to the cork and colour in comparison to the fortnightly ($p = 0.018$) and weekly ($p = 0.013$) consumers respectively. The weekly consumers were significantly more accepting of modifying colour than the monthly ($p = 0.031$) and were significantly less accepting of reducing calories than the fortnightly ($p = 0.008$) consumers. No other significant differences in acceptance were noted across the segments.

The following section further explores wine preferences, presenting the findings of the conjoint experiment which involved wine products based on combination of attributes, one of which was "produced using nanotechnology". This conjoint analysis therefore provides additional insights into varying levels of acceptance of applications of nanotechnology in wine production across the sample. *Post-hoc* segmentation analysis enables further understanding of how different consumer value different wine attributes and place them within the context of the application of nanotechnology.

3.3. Conjoint and post-hoc segmentation analysis

The conjoint analysis suggests that, across the sample, price was the most important factor influencing wine preference (47.8%) with a preference for lower priced wine (utility = 1.08) being evident (Table 4). Method of production (35%) was the second most important attribute. In this case, conventionally produced wine (utility =0.79) was preferred over wine produced using nanotechnology (utility = -0.79). Benefits (17.2%) were the least important factor influencing preference. Benefits with positive utility values were lower sulphite levels (0.4) and lower calorie content (0.21). In fact, the negative utility of applying nanotechnology (-0.79) may be traded-off against, for example, the positive utility of a lower price (1.08) coupled with either lower sulphite levels (0.4) or lower calorie content (0.21). In terms of the other benefits offered, a negative utility for lower alcohol content (-0.23) indicates that consumers disliked this suggested benefit.

Table 4.

% of Sample	Total Sample (n = 221) 100%	Price Sensitive (n = 131) 59.3%	Traditionalist (n = 46) 20.8%	Indifferent (n = 44) 19.9%
Intercept	4.77	4.96	4.40	4.62
Price				
€5.99	1.08	1.61	0.49	0.13
€11.99	-1.08	-1.61	-0.49	-0.13
Relative importance (%)	47.80	50.78	20.40	18.44
Method of Production				
Conventionally produced	0.79	0.90	1.07	0.19
Produced using Nanotechnology	-0.79	-0.90	-1.07	-0.19
Relative importance (%)	34.99	28.37	43.95	27.46
Benefits				
Lower sulphite levels	0.40	0.12	1.14	0.46
Lower calorie content	0.21	0.66	-0.59	-0.29
Lower alcohol content	-0.23	-0.11	-0.52	-0.27
No claim on label	-0.38	-0.67	-0.03	0.11
Relative importance (%)	17.20	20.85	35.65	54.10
R of Pearson	0.99	0.99	0.96	0.90

Utility values of levels in the conjoint experiment and cluster segment.

Table 5.

Price						
Construct	**Level**	**Total (%)**	**Sensitive (%)**	**Traditionalist (%)**	**Indifferent (%)**	**χ^2 (P-value)**
Gender	Male	50	40	61	66	11.40 (<0.001)
	Female	50	60	39	34	
	Total	100	100	100	100	
Age	18-24	12	8	0	34	108.1 (< 0.001)
	25-34	20	22	0	36	
	35-44	25	33	4	21	
	45-54	23	24	35	9	
	55-64	20	13	61	0	
	Total	100	100	100	100	
Frequency of consumption	Everyday	15	11	28	16	62.92 (<0.001)
	Weekly	33	16	52	61	
	Fortnightly	24	32	9	14	
	Monthly	28	41	11	9	
	Total	100	100	100	100	

Segment characteristics.

The "ideal" profile (i.e. the profile respondents were most willing to purchase) was Profile 1, with the following characteristics: €5.99, conventionally produced *(method of production not stated on label)* and lower sulphite content *(sulphite information excluded from label).* The least preferred profile is hypothetical and was not presented in the profiles that respondents scored. This hypothetical profile did not include any proposed benefits, was priced at €11.99 and produced using nanotechnology.

To identify different consumer segments based on product attribute utility scores derived from the conjoint experiment, "*K-MEANS cluster analysis*" was employed across two to five clusters. Each of these was evaluated and three clusters were identified as best representing the data.

Of these three segments, the first and largest segment (59.3% of respondents), labelled "*price sensitive*"; price (50.8%) was the most important product attribute, followed by method of production (28.4% of importance) and subjective benefits (20.8% of importance). Low priced (1.61), conventionally produced (0.9), lower calorie (0.66) and lower sulphite (0.12) wine offered the greatest positive utilities.

The second segment (20.8% of respondents), labelled "*traditionalist*", placed most importance on method of production (43.9%), followed by subjective benefits (35.6%) and price (20.4%). They displayed a strong negative utility for nanotechnology produced wine (-1.07) relative to conventionally produced wine. This negative utility may not be traded-off by the positive utility of a lower price (0.49). The only benefit offering a positive utility was lower sulphite levels (1.14).

Finally, the third segment (19.9% of respondents), labelled "*indifferent*", considered benefits to be the most important attribute (54.1%), followed by method of production (27.5%) and then price, which they considered to be the least important attribute (18.4%). However, not all proposed benefits offered utility; the benefit of interest for this segment was low sulphite levels (0.46), with no other benefits offering utility.

Compared to the other segments, the "*price sensitive*" included significantly (χ^2 = 11.395; p = 0.003) more females (60%) than males (40%) and were among the least frequent consumers of wine, with 73% of them consuming wine, at most, once fortnightly (Table 5) compared to 19% and 23% for the "*traditionalist*" and "*indifferent*" segments respectively (χ^2 = 108.092; p < 0.001). Furthermore, the consumers belonging to the first segment were more inclined to always purchase the same variety of wine (p ≤ 0.001), from the same territory (p ≤ 0.034) when compared to the consumers of the other two segments.

ANOVA analysis with *post hoc* Bonferroni suggests that, in comparison to the two other segments, the *price sensitive* placed greater importance on price and region and less importance on age and packaging when selecting wine (p ≤ 0.022). They were also the most open to appli-

Table 6.

Please indicate how acceptable you consider it to use nanotechnology to:	Sample *Mean* (St. Dev.)	Price Sensitive *Mean* (St. Dev.)	Traditionalist *Mean* (St. Dev.)	Indifferent *Mean* (St. Dev.)
Enhancing the authenticity wine.	5.55 (1.58)	5.65 (1.81)	5.24 (1.32)	5.57 (0.97)
Reducing the amount of pesticides used when growing the grape.	4.96 (1.87)	4.81 (2.09)	4.98 (1.39)	5.41 (1.53)
Enhancing the taste of wine.	4.62 (1.72)	4.89 (1.76)	3.91 (1.66)	4.57 (1.47)
Modifying the structure and properties of the cork.	4.57 (1.62)	4.63 (1.85)	4.37 (1.10)	4.64 (1.33)
Reducing the calorie content of wine.	4.26 (1.75)	4.57 (1.89)	3.35 (1.21)	4.30 (1.47)
Reducing the alcohol content of wine	4.22 (1.84)	4.50 (2.05)	3.70 (1.41)	3.95 (1.38)
Producing less expensive wine.	4.10 (1.70)	4.08 (1.72)	3.85 (1.75)	4.43 (1.56)
Modifying the colour of wine.	2.62 (1.42)	2.29 (1.35)	2.91 (1.26)	3.32 (1.49)

Acceptance of applications of nanotechnology by segment.

cations of nanotechnology that reduced calorie content and the least open to those to modify colour ($p \leq 0.026$) (Table 6). They placed greater importance on alcohol and calorie content of wine and were more receptive to applications that reduce alcohol content and enhance taste than the *traditionalist* ($p \leq 0.032$). However, the *price sensitive* had the lowest overall acceptance score ($\bar{x} = 2.83$; S.D. = 1.87), which was significantly lower ($p < 0.01$) than that of the *indifferent* segment ($\bar{x} = 3.75$; S.D. = 1.73)

The *traditionalist* segment was older, in fact 90% were 45 years or over; this compares to 9% and 37% for the *indifferent* and *price sensitive* segments respectively. They also represented the most frequent consumers of wine, with almost 30% consuming wine everyday and almost 80% of the segment consuming wine at least weekly. The *traditionalists* were the most different to the *price sensitive* in their perspectives on wine and were less interested in changes to the current characteristics of wine, as indicated by their lower receptivity to many of the suggested benefits associated with the application of nanotechnology. However, no significant difference in overall acceptance ($\bar{x} = 3.08$; S.D. = 1.31) was evident between the *traditionalist* and two other segments.

The *indifferent* segment included predominately younger respondents; 70% were 36 or younger. Furthermore, males (66%) were disproportionately represented within the segment. They were also quite frequent consumers of wine, with 77% consuming wine at least weekly.

The findings illustrate that utility scores offer an effective means of dividing the market and establishing different perspectives on wine attributes across the *post hoc* segments. Each segment displayed a negative utility for applying nanotechnology. However, the extent of such negative attitudes (utilities) and the relative importance placed on applying nanotechnology in comparison to the other attributes (i.e. price and benefits) varied across the segments.

4. DISCUSSION AND CONCLUSIONS

In this paper, we sought to understand consumer acceptance of nanotechnology within a product category that is strongly embedded in Italian culture. The analysis of consumers indicates that tradition continues to be important in choice decisions in the wine category; however, price plays a more important role in wine choice. These factors combined with region of production and grape variety are key choice attributes.

Based on the findings, Italians are relatively unfamiliar with applications of nanotechnology, both generally and specifically to food. As suggested by others (e.g. FELL *et al.*, 2009), we observed a cautious response to the concept of nanotechnology. Indeed, within the sample, there was an overall rejection of the concept of "nano wine". However, low acceptance scores disguised a somewhat more open attitude to specific applications of this technology. It is clear that for many, acceptance is considered on a case by case basis, and the bundle of benefits offered by a product is central to evaluations of the associated technology. Acceptance of the technology increases when the specific application satisfies an unfulfilled need. Thus, while the concept of the technology results in a reluctant response, this changes when more concrete product examples of personal relevance are considered.

Within this study, consumers were most receptive to applications that result in improved authenticity and reduced use of pesticides. The findings therefore concur with the views of Bruhn (2007) and Siegrist (2008) that if an objective of a communication is to successfully market and sell novel food technology products, including nanotechnology-based foods and beverages, attention should be given to communicating explicit, tangible benefits of relevance to consumers.

The conjoint analysis results suggest that, across the sample, price was the most signifi-

cant factor influencing wine preference followed by method of production; with consumers displaying a preference for conventionally produced rather than "nano" wine. Given the significance of price, it is not surprising that some consumers may be willing to purchase "nano wine" if it is priced lower than its conventional counterpart and additional benefits are offered.

This work implies that segmentation is a useful platform for exploring consumer acceptance of nanotechnology application in wine production. For example, while the *price sensitive*, *traditionalist* and *indifferent* segments all displayed negative utility for nanotechnology, the extent of such negative attitudes (utilities) could be traded-off against a lower price and the enhancement of other product characteristics which were valued by particular segments (e.g. lower sulphite levels). However, the extent of "trading-off" between these attributes clearly depended on the segment in question. In addition, the *a-priori* and *post hoc* segmentation analysis demonstrates that variation exists in how groups of individuals evaluate and consume wine. In particular, significant variation was evident in wine behaviour patterns and the importance placed on different wine attributes (i.e. region of origin, cork, price, age, variety and packaging) and was also apparent in consumers' evaluations of the different nanotechnology applications.

Heterogeneity in behaviour across consumer segments, in addition to variation in terms of the importance placed on wine product attributes have been highlighted in several other studies. Empirical evidence supports the finding of this work that frequent consumers of wine rely on a greater variety of information cues in their wine selection. Specifically, ATKIN and JOHNSON (2010) found that core consumers (i.e. those who drink wine at least once a week) draw more heavily on place-of-origin cues than infrequent consumers. Elsewhere, PERROUTY *et al.* (2006) found that perceived expert consumers make use of a greater number of attributes, particularly region, brand, variety and price when evaluating wine products compared to perceived non-expert (novice) consumers. The former also evaluate relationships between attributes more deeply than novices.

Within this study, although authenticity improvements were considered the most acceptable application of nanotechnology to wine overall, the segments were not homogenous in their assessments of the other applications presented. For example, the more frequent wine consumers considered applications to reduce the use of pesticides to be as acceptable as those that enhance authenticity. Furthermore, the conjoint and *post-hoc* segmentation analysis illustrate how, although the *price sensitive* segment had the lowest overall acceptance score, they were more responsive than the *indifferent* and *traditionalist* segments to applications that reduce calorie content. This finding, once again, demonstrates that acceptance is lower at the conceptual/abstract level than the product attributes level, thereby illustrating the merits of segmenting the population.

Both segmentation approaches can guide approaches to targeting different consumer groups. In particular, insights from the utility based segmentation may be useful in designing and developing a "nano wine" that is targeted at the most suitable market segments. Based on the findings, a *traditionalist* segment would be an inappropriate target market for "nano wine", given the high importance this cautious group places on conventional production methods. Conversely, considering optimum commercialisation and marketing strategies for "nano wine", producers and distributors may be interested in offering a competitively priced "nano wine" that has reduced sulphite levels to an *indifferent* segment that frequently consume wine and could therefore be a profitable target market. Furthermore, another strategy might be to offer a competitively priced "nano wine" with reduced calorie content to *price sensitive* consumers.

The emerging positive reactions towards applications that enhance wine authenticity align with the connotations of wine being a "natural" product, strongly associated with heritage, origin and region, as ROMANO and NATILLI (2009) have previously argued. This "natural" perception of wine is particularly evident in the case of traditional wine producing and consuming countries including Italy, where PDO and PGI wines are prevalent. Building on this research, marketers should recognise the influence of perceived "naturalness" on wine preferences and develop communication strategies around emphasising how nanotechnology can, in fact, enhance "natural" qualities of wine, e.g. improve authenticity and lower sulphite levels, rather than tamper with its "natural" properties.

To sum, although the application of nanotechnology is not generally positively perceived in wine production, low measures of overall acceptance may conceal greater acceptance of specific applications which enhance valued wine attributes.

Finally, we recognise the potential limitations of this study. Specifically, while this work is in keeping with the approach of SIEGRIST *et al.* (2009) and SCHNETTLER *et al.* (2012), we are cognisant that the provision of information about one of the product attributes, i.e. nanotechnology, may be viewed by some as a departure from traditional CA approaches. Equally, within this work, we acknowledge the argument previously made by Siegrist *et al.* (2009) in their conjoint study that provision of a different description of nanotechnology, may have more positively or negatively impacted responses to the application of nanotechnology within the CA experiment.

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