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Enhancing the flavour of tomato soup with an alcoholic appetiser

Georgiana Juravle [a,*], Lucia Cintia Colibaba [b], Mihai Cătălin Zota [c], Valeriu V. Cotea [b], Charles Spence [d]

[a] Sensorimotor Dynamics Laboratory, Faculty of Psychology and Education Sciences, Alexandru Ioan Cuza University, Iasi, Romania
[b] Ion Ionescu de la Brad Iasi University of Life Sciences, Iasi, Romania
[c] Restaurant Retiro, Iasi, Romania
[d] Crossmodal Research Laboratory, Department of Experimental Psychology, Oxford University, Oxford, UK

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ABSTRACT

The perceived temperature of a dish can affect the appreciation of its flavour as well as other hedonic and sensory qualities of the food. Here, we assessed the potential of an alcoholic appetiser as a taste potentiator and investigated interactions between consumed alcohol and the temperature of a tomato soup. Using a between-participants experimental design, we investigated the appreciation of a tomato soup sample (cool vs. hot) for different presentations (with vs. without an alcoholic appetiser shot tasted beforehand). 257 participants (171 female, mean age of 34 years, SD = 12 years, age range 18–69 years) tasted the tomato soup and evaluated it with respect to several sensorial qualities (i.e., temperature, texture, freshness, intensity, flavour, and liking) and indicated the perceived dominant taste from amongst the five basic tastes. The results highlight that when tasted hot, participants like the soup more, evaluate it as being significantly more flavourful, denser, fresher, and as having a more intense taste. Further, when tasted with an alcoholic appetiser beforehand, the tomato soup is reported as having a significantly lower temperature, as well as being fresher, and more flavourful. The intake of an alcoholic appetiser significantly interacts with the soup temperature and potentiates both the sweet and umami taste of the tomato soup. These results highlight the importance of a soup's serving temperature and the potential of alcohol to enhance the flavour of the dish. The findings are discussed in the context of healthy eating and individual differences in food selection, with consideration of the importance of temperature perception in gastronomic settings.

1. Introduction

Finding ways to enhance the enjoyment of food have long concerned psychologists, food scientists, and restaurateurs (Rozin, 2005; Spence, 2017), as well as nutritionists and public health scientists (Bédard et al., 2020). Diverse approaches have been designed to improve our eating behaviour and approach to food, including food presentation, sensorial and/or hedonic alterations of the food, as well as of the environment/location where food is served (Spence, 2017), together with more general population-wide public health policy measures (World Health Organization, 2004; Wesseler, 2022).

It is well-known that food sampled at the expected temperature tastes better (Fleming, 2013; Olson et al., 1980), with temperature of the food crossmodally interacting with other sensorial and hedonic qualities of a sampled food (see, e.g., Barbosa Escobar et al., 2023, 2025; Juravle et al., 2022; Juravle and Spence, 2024). For instance, recently it has been demonstrated that people prefer to eat cornmeal hot (Juravle et al., 2024), the traditional way to present and consume cornmeal in certain geographical and cultural environments. Not only was the cornmeal liked more when tasted hot, but people also evaluated it as being softer and more elastic, especially when the cornmeal was consumed in a rounded shape, thus indicating the importance of pairing attributes such as (expected) temperature and food shape, for the enjoyment of the food. In the realm of a given culture, or even globally, people exhibit a strong preference for consuming certain dishes/drinks warm (e.g., warm coffee or tea, see Pramudya and Seo, 2018), with the expectation toward the temperature of a drink significantly impacting their liking of the sampled liquid (e.g., warm fruit juice, Zellner et al., 1988; see also Rozin, 1988). As such, manipulating a foodstuff's temperature could also prove helpful for specific populations who may have lost taste (see

* Corresponding author. Sensorimotor Dynamics Laboratory, Faculty of Psychology and Education Sciences, Alexandru Ioan Cuza University, Room 313, 3 Toma Cozma St., 700554, Iasi, Romania.
E-mail address: georgiana.juravle@uaic.ro (G. Juravle).

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Spence, 2024) and/or have altered specific receptors for certain flavours (e.g., see Bautista et al., 2013).

Furthermore, aside from typical food presentation modes, plating, and combining the individual elements of a dish, tasting a familiar dish in a different place and/or culture, with one/few twists to the well-known recipe often may surprise us and bring a new enhanced flavour for that specific dish. Note though that expectation plays an important role in evaluating food and our satisfaction with food and hence, may confirm or disconfirm its flavour (Cardello and Sawyer, 1992). Researchers and restaurateurs have investigated the 'right' order of mouth sensations in the sampling of a dish – Three principles of flavour pairing have been identified: perceptual (flavours brought together because of, for example, their sharing (dis)similar properties), conceptual (a pairing of flavours by tradition or by region), as well as an individual approach resulting from a diner's preferences/experiences (see Spence et al., 2017). Cultural associations exist that are conceptually thought of as traditional flavour enhancers of ingested food. Take, for example, the region of Eastern Europe and the Balkans, where it is customary to have a shot of strong fruit spirit, often custom-made, typically served as an aperitif at the start of a lunch meal (e.g., the *rakia,* Jasar et al., 2021; Nashar and Ivanova, 2024; the *palinka*, László et al., 2016; or the țuică, Muica and Turnock, 1996; Salanţă et al., 2015). Meanwhile, other Mediterranean cultures,such as Italian and/or Greek restaurants, serve a shot of strong alcohol as a digestif, after dinner (e.g., the *limoncello*, or the flavoured *ouzo* drink).

With the pairing of alcohol with food having a long tradition, alcohol is often consumed as an appetiser: Following an alcoholic appetiser sampling, it was found that participants' 24 h energy intake was significantly higher, as compared to a non-alcoholic appetiser condition (Westerterp-Plantenga and Verwegen, 1999). The consumption of alcohol has also been shown to boost subsequent attractiveness ratings of both animate (faces) and non-animate stimuli (landscapes, see Chen et al., 2014), as well as it resulting in people tipping more (Lynn, 1988). Moreover, a distinction has been made in what regards liking (resulting from hedonic pleasure) and wanting (resulting from a motivational drive, see Hobbs et al., 2005). Take, for example, the custom of surprise-gifting diners, which is known to enhance their liking of the food and overall restaurant-experience (e.g., the toy sometimes given to children at McDonald's, see Spence, 2017).

In this context, an unexpected gift of a shot of alcohol should also be well-positioned to enhance ratings of the food that follows. Here, in a between-participants experimental design, we tested the potential of an alcoholic appetiser to (hedonically) boost the flavour and liking of a tomato soup, as well as the modulation of a range of other relevant sensorial attributes, including the soup's temperature, texture, freshness, and (intensity of) taste. For this, the tomato soup tasting was performed with or without first consuming a shot of an alcoholic appetiser (a plum distillate). Additionally, to highlight the importance of temperature in flavour perception, separate groups of participants tasted the tomato soup hot or at a cooler room temperature. We hypothesised that flavour and liking will be enhanced for those tasting cases of sampling the tomato soup with alcohol or having a hot temperature. Additionally, we were interested to further explore any interaction that may become evident between the temperature of a (tomato soup) dish and the intake of alcoholic spirits.

2. Methods

2.1. Participants

An *a priori* power calculation with an $\alpha = .05$ and $1\text{-}\beta = .95$ indicated that a sample size of 251 participants would be necessary to detect a $f = .25$ effect in the data (G*Power 3.1, Erdfelder et al., 2009; Faul et al., 2007), should one be present (Cohen, 1988). A total of 257 participants (171 female, 94 smokers, mean age of 34 years, SD = 12 years, age range 18–69 years) took part in this study. With respect to their diet, the sample included 2 lactose-intolerant participants, 1 participant with a low sugar diet, 3 vegans, and 5 vegetarians. The participants were recruited from the clients dining at Retiro Restaurant, Iasi, Romania, and gave their informed consent to take part in the study. The study was approved by the Ethics Board of the Alexandru Ioan Cuza University Iasi, Romania (no. 245/February 09, 2024). This study conforms to the Declaration of Helsinki and to all subsequent amendments (Declaration of Helsinki, 1964; 2013). See Table 1 for the participants demographics.

2.2. Materials and apparatus

The study was conducted between December 06, 2023–February 14, 2024 in te Retiro Restaurant, Iasi, Romania. The soup was presented in small paper receptacles, while the plum spirit was served in a shot glass, or in a paper cup; see Fig. 1a for an example of stimuli presentation, such as it was seen by the participants.

The tomato soup was cooked according to a traditional recipe including fresh seasonal vegetables, harvested from the restaurant's garden: red capsicums, celery root, carrot, onion, garlic, together with peeled and pureed tomatoes (though see the historical debate and the current rulings[1] on establishing tomatoes as fruits, Dewey, 2017). The root vegetables were cooked in oil, together with the onion and garlic. Next the pureed tomatoes were added, together with water, in a proportion of 3:1. The soup was boiled and diluted with water, to achieve the desired consistency. Salt and pepper were added, as well as parsley and celery leaves. The chef cooked the soup with the goal of obtaining a texture of a moderate rating of 50 on the (0 thin – 100 dense) Texture visual analog scale (VAS) used in the present study.

The spirit utilised in the study was a 42 % volume with a relative density of .9254 plum distillate.[2]

Table 1
Participant demographics.

	Group 1 Without alcohol – cool soup	Group 2 With alcohol – cool soup	Group 3 Without alcohol – hot soup	Group 4 With alcohol – hot soup
N	65	64	64	64
Mean age (SD) in years	30.91 (11.52)	33.73 (14.07)	28.07 (12.11)	34.98 (10.71)
Gender (male/female)	14/51	25/39	7/57	40/24
Smokers (count)	22	23	21	28
Any declared dietary habits	1 vegan 2 vegetarians 1 low-sugar	1 vegetarian 2 lactose-intolerant	2 vegans 1 vegetarian	1 vegetarian

[1] According to the European Council Directive 2001/113/EC of 20 December 2001 relating to fruit jams, jellies and marmalades and sweetened chestnut purée intended for human consumption; http://data.europa.eu/eli/dir/2001/113/2013-11-18.

[2] A sensorial profile analysis of the plum spirit utilised in the study was conducted with an additional group of 10 participants (4 female, mean age 45 years, age range 27–65 years) who were required to evaluate the distillate, based on smell and taste. They were instructed to provide five word-descriptors, in Romanian language, all in singular form. The participants assessed the spirit in the same room/testing laboratory, with all the responses collected online via www.mentimeter.com. Participants used their personal mobile devices to fill in their responses. The sensory profile of the analysed plum spirit highlights plum as the most dominant note, followed by fruity and apple nuances, with additional descriptors such as quince, chemical heat, sweet, and apricot contributing to a complex aromatic composition; see Fig. 1b.

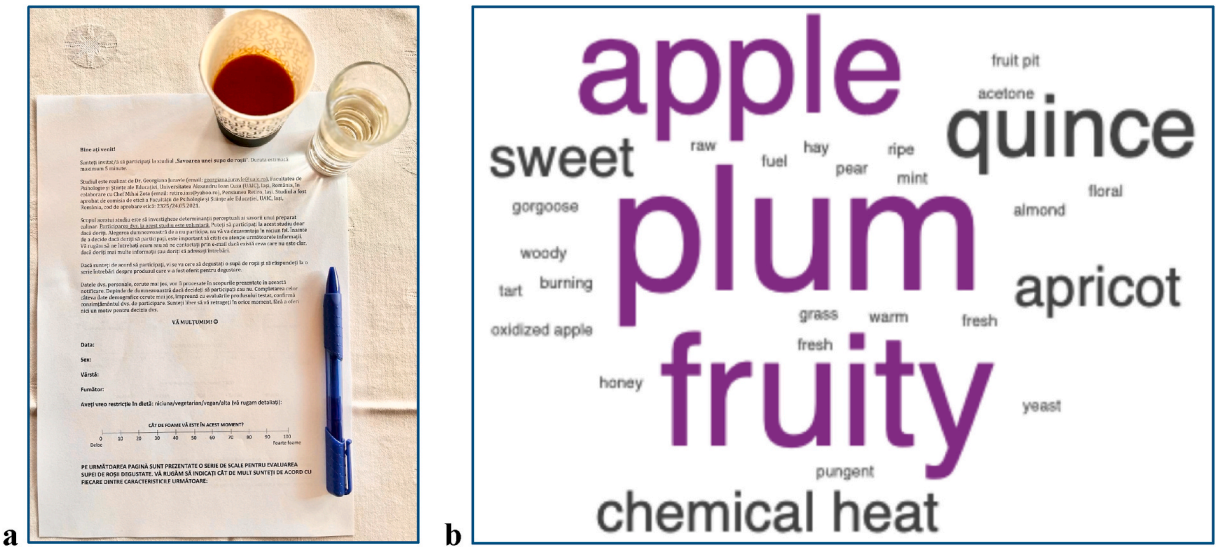

Fig. 1. (a) Example of the presentation of tomato soup served together with a shot of Romanian plum brandy during data collection in Retiro Restaurant, Iasi, Romania. **(b)** Wordcloud visual representation for the aromatic profile analysis conducted on the plum distillate used in the study. The bigger the font, the more frequent the term was used to characterise the spirit – The coloured words were the three most frequently chosen by the participants; $N = 50$ words.

2.3. Procedure and experimental design

The restaurant's regular diners were asked if they would be interested in taking part in a sensory experiment that was designed to investigate the experienced flavour of a tomato soup. At the start of the study, the participants were informed that they could quit at any point, gave their informed consent, and provided the required demographic data and answers concerning their appreciation of the tomato soup provided using a paper and pencil form provided. The form required the participants to fill in the date, their gender, and age (in years). Additional questions requested information on whether the participants were smokers or not, as well as on any type of diet that they might be on. At the start of the study, the participants were also asked to report on a VAS their current *Appetite* (0 not at all hungry – 100 very hungry).

The manipulated between-participants independent variables were Alcoholic appetiser (with vs. without a shot of strong alcohol) and serving Temperature of the soup (room temperature/cool, i.e., 20 ± 3 °C vs. hot, i.e., 80 ± 3 °C). As such, four independent groups rated the tomato soup for each of the following six VASs, recorded as dependent measures: *Temperature* (0 cold – 100 hot), *Texture* (0 thin – 100 dense), *Freshness* (0 not at all fresh – 100 very fresh), *Intensity* (0 weak – 100 strong), *Flavour* (0 not at all flavourful – 100 very flavourful), and *Liking* (0 not at all – 100 very much). One final question required participants to choose one of the five basic tastes that best fit the taste of the tomato soup: sweet, salty, sour, bitter, and umami. The experiment took about 5 min to complete.

2.4. Data analysis

The data from each of six VASs (Temperature, Texture, Freshness, Intensity, Flavour, and Liking) were inspected visually with histograms and sample/theoretical quantiles (Q-Q) plots, together with skewness and kurtosis calculations and the Levene test for the homogeneity of variance. The data from each of the six VASs was analysed with a factorial analysis of variance (ANOVA) with the between-participants factors of Alcoholic appetiser (with vs. without a shot of strong alcohol) and Serving temperature of the soup (cool vs. hot). Further, for each of the four experimental groups at the intersection of alcoholic appetiser condition (i.e., with and without an extra shot of plum spirit) and the serving temperature (cool vs. hot), frequency tables of the reported five basic tastes were calculated. The Pearson's Chi-squared test was then used to compare the observed frequencies in our sample to those tastes' frequencies predicted by chance. For this analysis, we considered equal predicted frequencies for each of the basic tastes *observed* (i.e., bitter, sweet, sour, salty, and umami basic tastes each with a predicted frequency of 20 %). Statistical analyses were performed in Matlab (R2024b, MathWorks, Natick, MA) and JASP .16.3 (JASP Team, 2022).

3. Results

Participants reported an average low-to-moderate degree of hunger ($M = 39.81$, $SD = 28.93$) and Appetite ratings did not correlate with any of the other sensorial and hedonic VAS ratings (all $ps > .111$). Further, no difference in Appetite was registered between the four different experimental groups (all $ps > .232$). Means together with 95 % CIs for each of the four tomato-soup-tasting independent groups of participants across the various VASs used in this study are presented in Fig. 2. Observed taste frequencies are provided in Fig. 3.

3.1. Liking

The results indicate a significant main effect of Serving temperature ($F(1,253) = 20.72$, $p < .001$, $\eta_p^2 = .076$) indicating that the tomato soup was liked significantly more when served hot ($M = 77.70$, $SE = 1.87$), as compared to cool ($M = 65.66$, $SE = 1.87$); see Fig. 2. There was also a main effect of Alcoholic appetiser in the Liking data ($F(1,253) = 8.92$, $p = .003$, $\eta_p^2 = .034$), indicating that those participants who tasted the soup with a shot of strong plum distillate liked the soup significantly more ($M = 75.63$, $SE = 1.87$), than those in the no-added alcohol tasting ($M = 67.73$, $SE = 1.87$). No interaction was detected in the Liking data between Serving temperature and the Alcoholic appetiser intake ($F(1,253) = .426$, $p = .515$, $\eta_p^2 = .002$).

3.2. Temperature

As a control for the table serving temperature, the data indicate a significant main effect of Serving temperature ($F(1,253) = 365.30$, $p < .001$, $\eta_p^2 = .591$), with participants' reported temperature reflecting the actual presentation of the soup: The tomato soup was rated as significantly colder when tasted at the cooler temperature ($M = 24.11$, $SE = 1.69$), than when served hot ($M = 70$, $SE = 1.70$). Importantly, the

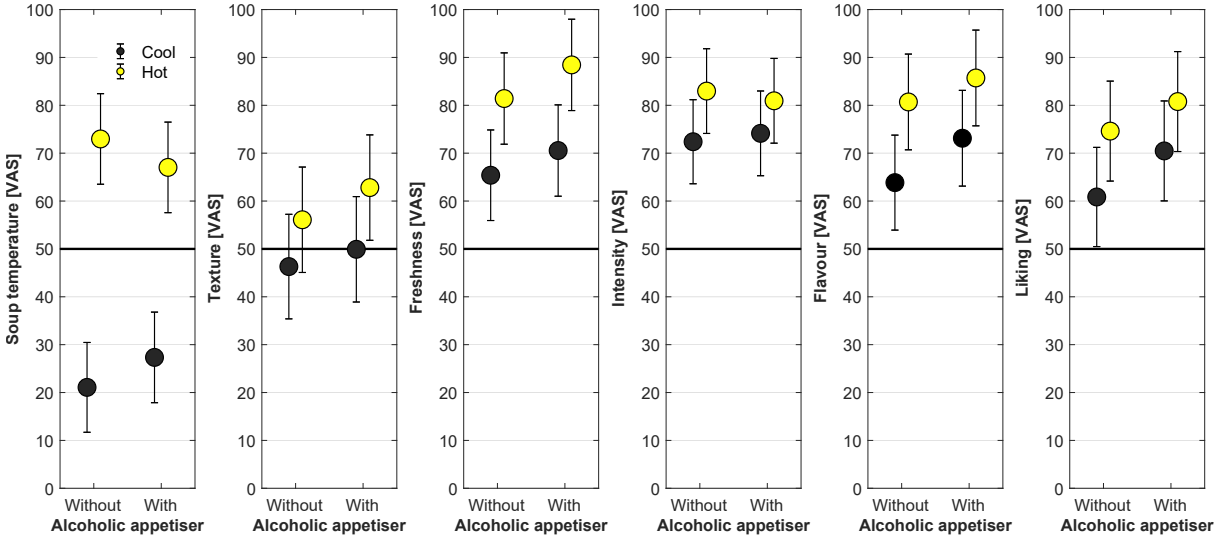

Fig. 2. Means ± 95 % confidence intervals (CIs) for each of the six visual analog scales (VASs) used to evaluate the tomato soup in the present study. The thick horizontal line indicates the mid-point of the VAS scale.

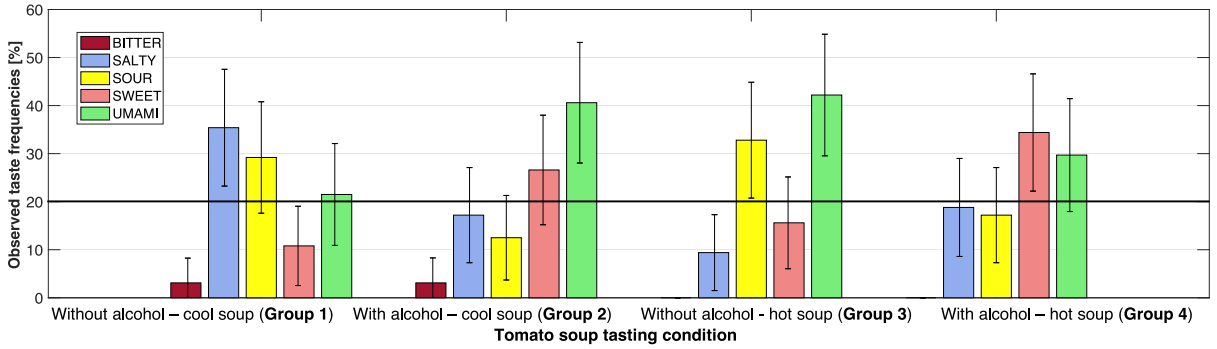

Fig. 3. Means ± 95 % confidence intervals (CIs, presented as percentages) for the appreciation of the tomato soup, according to the four experimental groups in the study (Group 1, $N = 65$; Group 2, $N = 64$; Group 3, $N = 64$; Group 4, $N = 64$). The participants were asked to pair one of the basic tastes to each tasting of the tomato soup. The horizontal line indicates chance-level responding (20 %), i.e., as calculated from the *observed* choices of basic tastes in the study.

results indicate that the presence of an Alcoholic appetiser did not impact the perceived temperature of the soup ($F(1,253) = .005$, $p = .945$, $\eta_p^2 < .001$. Nevertheless, an interaction between the two factors was found on the Temperature data ($F(1,253) = 6.49$, $p = .011$, $\eta_p^2 = .025$): The hot tomato soup was rated as hotter when served without ($M = 72.97$, $SE = 2.31$) as compared to with a shot of strong spirit ($M = 67.03$, $SE = 2.66$). On the other hand, the cool tomato soup's temperature was reported as being higher when served with the extra shot of spirit ($M = 27.34$, $SE = 2.13$), as compared to without ($M = 21.08$, $SE = 2.45$).

3.3. Texture

The results indicate a main effect of Serving temperature ($F(1,253) = 16.53$, $p < .001$, $\eta_p^2 = .061$), with the tomato soup rated as significantly denser when tasted hot ($M = 59.45$, $SE = 1.98$), than when served cool ($M = 48.12$, $SE = 1.97$). There was no significant main effect of Alcoholic appetiser on the Texture data ($F(1,253) = 3.43$, $p = .065$, $\eta_p^2 = .013$), nor any interaction between Serving temperature and Alcoholic appetiser ($F(1,253) = .31$, $p = .578$, $\eta_p^2 = .001$).

3.4. Freshness

The results indicate a main effect of Serving temperature on the Freshness data ($F(1,253) = 49.25$, $p < .001$, $\eta_p^2 = .163$), with the participants perceiving the tomato soup to be significantly fresher when consuming it hot ($M = 84.92$, $SE = 1.71$), as compared to when it was served at the cooler room temperature ($M = 67.97$, $SE = 1.71$). A significant main effect of the Alcoholic appetiser was also visible in the Freshness data ($F(1,253) = 6.37$, $p = .012$, $\eta_p^2 = .025$), indicating that the participants perceived the tomato soup to be significantly fresher when it was paired with a shot of plum spirit ($M = 79.49$, $SE = 1.71$), as compared to when it was tasted without alcohol ($M = 73.40$, $SE = 1.71$). No interaction between Serving temperature and Alcoholic appetiser was evident in the Freshness data ($F(1,253) = .15$, $p = .699$, $\eta_p^2 < .001$).

3.5. Flavour

There was a significant main effect of Serving temperature ($F(1,253) = 33.91$, $p < .001$, $\eta_p^2 = .118$), with the tomato soup rated as more flavourful when tasted hot ($M = 83.24$, $SE = 1.80$), as compared to cool ($M = 68.49$, $SE = 1.79$). Furthermore, a significant main effect of Alcoholic appetiser ($F(1,253) = 8.03$, $p = .005$, $\eta_p^2 = .031$) highlights the fact that the tomato soup was rated as tasting significantly less flavourful when served without the plum spirit ($M = 72.28$, $SE = 1.79$) as opposed to the alcohol – tomato soup pairing ($M = 79.45$, $SE = 1.80$). However, the interaction between the two factors did not reach significance on the Flavour data ($F(1,253) = .687$, $p = .408$, $\eta_p^2 = .003$).

3.6. Intensity

The results indicate a main effect of Serving temperature ($F(1,253) = 15.02$, $p < .001$, $\eta_p^2 = .056$), with the tomato soup rated as tasting significantly more intense when consumed hot ($M = 81.95$, $SE = 1.59$), than when served cool ($M = 73.26$, $SE = 1.58$). No significant main effect of Alcoholic appetiser was found ($F(1,253) = .004$, $p = .951$, $\eta_p^2 < .001$), nor was there any interaction between the two factors on the Intensity data ($F(1,253) = .713$, $p = .399$, $\eta_p^2 = .003$).

3.7. Taste

Fig. 3 highlights significant effects for the distributions of taste frequencies (means ± 95 % CIs) in the different types of tomato soup tasting in this study, i.e., tomato soup tasted cold without alcohol ($\chi^2(4) = 22.62$; $p < .001$), tomato soup tasted cold with alcohol ($\chi^2(4) = 26.16$; $p < .001$), tomato soup tasted hot without alcohol ($\chi^2(3) = 17.63$; $p < .001$), but was not significant for the tomato soup tasted hot with alcohol ($\chi^2(3) = 5.38$; $p = .146$). It is evident from Fig. 3 that for those cases when the tomato soup is tasted hot (the rightmost pair of panels in the figure), it was never reported as being bitter. Although participants do report the soup as being bitter only when they serve it cool, these few responses do not surpass chance level responding. Our results indicate that when the tomato soup was tasted cool it was perceived as tasting significantly salty or sour, or, to a lesser degree umami. If a shot of alcohol is taken before tasting the cold tomato soup, the latter is reported to taste significantly umami or sweet. The tomato soup tasted hot is perceived as exhibiting either sour or umami tastes. Irrespective of the temperature, if a shot of alcohol is served before the tomato soup, then the soup is reported a tasting significantly sweeter. Similarly, if a shot of alcohol is served before the tasting of the tomato soup, this is also perceived as tasting primarily of umami. All the other serving temperature/presentation pairings failed to surpass the chance threshold.

4. Discussion

The present study focused on tomato soup, a well-known soup that is typically served hot (e.g., in Romania, where the study was conducted, though see the Spanish gazpacho typically served cold), with the goal of assessing the potential of an alcoholic appetiser as a flavour enhancer, as well as to investigate the impact of the consumed alcohol on the experienced flavour of a cool/hot tomato soup. As expected, the hot tomato soup is liked more and is perceived as being more flavourful, as well as, with respect to the sensory qualities surveyed, it is reported as being denser, fresher, and more intense. Similarly, when sampled with a shot of strong plum spirit beforehand, the tomato soup is liked more and is appreciated as more flavourful and fresher.

The enhanced overall ratings, both sensory and hedonic, for the hot tomato soup hint at temperature being a key sensorial characteristic affecting the perceived flavour. These results are in line with previous results showing enhanced flavour ratings for hot foodstuffs (Juravle et al., 2024; Youssef et al., 2017) and suggest a flavour boost for cases when the expected temperature of a dish is confirmed at the time of sampling that specific dish. Confirming (i.e., having a dish taste as expected) or disconfirming (the sampled dish tastes different) have been investigated for both positively and/or negatively-valenced flavour expectations, with results highlighting enhanced liking of sampled food with confirmed expectations (see Piqueras-Fiszman and Spence, 2015; Yeomans et al., 2008).

Importantly, the results of the present study highlight a boost in hedonic ratings (of both Liking and Flavour) for the tomato soup when this is sampled with a shot of plum spirit consumed beforehand, as an appetiser. Such results suggest the potential of fruit alcoholic beverages as taste enhancers in the context of liquid meals. Considering the fruit alcoholic beverage that was used in the present study and the resulting crossmodal odour-taste (i.e., sweet plum with savoury tomato), the sweetness aroma of the plum may be taken as a facilitator for the enhanced alcohol-driven liking and flavour of the soup, as it appears that the tomato soup was rated as tasting significantly sweeter with a shot of strong distillate, irrespective of the serving temperature. Of note, our study has only utilised the fruit spirit as an alcoholic appetiser. Future studies might consider further assessing other alcohol samples (e.g., the flavour-less vodka), to investigate whether and how the complexity of a spirit's aroma profile interacts with a consumed dish.

For example, it has been suggested that overlapping mechanisms are activated by both ethanol and sweet solutions (Thibodeau and Pickering, 2019; Scott et al., 2019). Studies in mice have flagged a genetic basis for the involvement of sweet taste perception for alcohol intake (Blednov et al., 2008): The palatability of alcohol beverages may lead to disorders of alcohol misuse and binge drinking (Valyear et al., 2024), with alcoholics suggested to be less sensitive to sweet, to have a higher preference for sweet food, and consequently a poorer health (Silva et al., 2016). Taste phenotypes linked to alcohol behaviour and/or preference are PROP taster status, sweet liking, and thermal taster status (Thibodeau and Pickering, 2019). As such, for some phenotypic groups the enhanced perception of bitterness from ethanol could lead to an increase in unpleasantness, with the direct consequence of consuming less alcohol (Tepper, 2008). For other phenotypic groups, the enhanced perception of sweetness following alcohol consumption could in turn lead to higher liking and consuming more alcohol. As such, taking into account the close relationship between alcohol and sweet ratings of the soup, the presence of the alcoholic appetiser used in the present study may also be considered to have mechanistically acted as a palate cleanser (see also other non-alcoholic liquid cleansers, e.g., milk, water, Lucak and Delwiche, 2009).

In this context, assessing the actual mixing of the two tasted elements of the present study (i.e., an alcoholic drink, followed by a tomato soup) could also easily bring to mind the social environment of the restaurant where it was sampled. As such, a factor that may have affected the taste and liking ratings of the tomato soup could be the loudness of the restaurant (see, Spence et al., 2014). When exposed to auditory environments simulating the noise level inside an aircraft cabin, people not only appear to dislike their food, but their ratings of sweet taste are significantly lower, whereas the taste of umami appears to be significantly enhanced (Yan and Dando, 2015). Relatedly, the auditory information needs not to be the only one singled out for the flavour appreciation of the tomato soup sampled in this study: Visual inspection of Fig. 2 highlights the fact that the hot soup (depicted in yellow circles) has significantly higher sensory and hedonic ratings, as compared to the cool one (in black circles). Given that the volatile aromas are more intense from the hot, as opposed to the cool soup, this may give rise to odour-induced taste enhancement (see Spence, 2022a).

Because tomatoes do not naturally taste bitter and ethanol solutions are known to suppress bitterness (Mattes and DiMeglio, 2001), it is unsurprising that participants reported very few instances of the tomato soup as tasting bitter. Further, a taste we expected to be prevalent – namely, the salty taste – only made a significant difference from chance level when the soup was tasted cold without alcohol, all the other instances of salty not surpassing chance levels. The salty taste may be taken as a requirement/quality needed for appreciating flavour – In this respect, it has already been demonstrated that salt enhances flavour by suppressing bitterness (Breslin and Beauchamp, 1997, see also, Rogério Tavares Filho et al., 2020). The specific receptacle containing the soup also has been also demonstrated to affect saltiness ratings, with participants reporting a soup as tasting saltier when sampling it from beaker/cup-like receptacles, as opposed to tasting with a spoon (Jeon

et al., 2014; see also Spence, 2022b), though they also like the soup more when they sample it from a mug (Youssef et al., 2017). In this context, given that the elderly need five times more salt to get same taste, with those on medication needing far more salt added to soup (Stevens et al., 1991), the question arises if a temperature twist and/or fruity alcoholic shot could help enhance an attenuated taste.[3] The results of the present study would support such an approach and indicate that whereas our participants give the saltiest ratings to the cool soup (see also similar earlier results in Kim et al., 2015), when considering *only* the hot sampled soup, they appreciate the tomato soup as significantly saltier only if sampled with a shot of strong plum spirit beforehand.[4] Note that other approaches have been tested to enhance or to diminish a certain taste, such as informing participants about adding certain ingredients to a soup (Kurobayashi et al., 2008; Prescott and Young, 2002), or labelling the fat content on the sampled soup (Yeomans et al., 2001). Researchers have also (unsuccessfully) tried to reduce saltiness of a soup with adding white pepper – However, they were only able to enhance perceived bitterness (Moss et al., 2023).

The most interesting result to emerge is with respect to participants' reports regarding the umami taste: Tasting a cool tomato soup with a shot of fruity spirit significantly enhances the soup's umami taste. However, whereas the participants report the hot soup as tasting significantly umami, it appears that the effect is diminished by consuming strong alcohol. Therefore, as expected, tomato soup clearly tastes of umami, especially when served hot. Of note, our results indicate that an alcoholic appetiser served before a cold soup potentiates the umami taste to the level of a hot tomato soup. Note that research on taste potentiators consider those components typically derived from umami/kokumi as naturally-occurring taste and flavours enhancers (Vassilaki et al., 2022, see also Maga and Yamaguchi, 1983). Whereas alcohol does not give rise to the same mouth-filling sensations as delivered by umami/kokumi substances, note that temperature is classified as a trigeminal stimulus, with alcohol also known to elicit trigeminal sensations (Cayeux et al., 2023) – The burning/tingling sensation is the most dominant mouth sensation for tasting alcohol in the range of 40 % volume as used in this study (Nolden and Hayes, 2015).

5. Conclusion

Taken together, the results of the present study highlight that flavour and liking of a tomato soup may be boosted with the serving of an alcoholic appetiser. The temperature of the tomato soup is crucial in modulating participants' sensory and hedonic ratings. The hot tomato soup is characterised as having an umami tasting across all the experimental conditions tested in the present study, with the reported tastes of sweet and salty enhanced when tasting a (traditionally-served-) hot tomato soup, together with an alcoholic appetiser. Considering the importance of flavour pairing and the order of mouth sensations (Spence et al., 2017), these present results suggest small quantities of alcohol may be used as appetising taste enhancers/potentiators for augmenting a dining experience, as well as, perhaps, as palate cleansers and additional aids for sensory-impaired diners.

[3] An ethical note is needed here in what regards health and longer-term impact on health – Given the well-documented addictive nature of alcohol, more studies are needed to establish the specific alcohol metabolism and its implication in human health (Goldman et al., 2025).

[4] To differentiate the focus of the present study on *perception* and enhancement thereof from a flavour/tasting experience, if an alcoholic appetiser should be used to enhance a deficient sensory processing (e.g., in the salty taste), the approach could as well consider just the *cleansing* of the palate with the given fruity alcoholic beverage, as opposed to its actual ingestion (which would be expected to be detrimental for the gastric juices and the commencement of digestion). Such an approach takes into consideration the traditional approach of sommeliers who would rather choose a lighter alcoholic beverage at the start of a meal (e.g., a crémant), as opposed to the strong alcoholic fruity spirit utilised in the present study.

CRediT authorship contribution statement

Georgiana Juravle: Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Lucia Cintia Colibaba:** Writing – review & editing, Investigation, Formal analysis. **Mihai Cătălin Zota:** Resources, Investigation, Data curation, Conceptualization. **Valeriu V. Cotea:** Writing – review & editing, Investigation. **Charles Spence:** Writing – review & editing, Writing – original draft, Supervision, Conceptualization.

Implications for gastronomy

The present research highights several valuable insights for chefs, sommeliers, and food service professionals interested in optimizing the multisensory experience of a dish or meal. Our results highlight that tomato soup is consistently preferred hot, with reports of enhanced flavour, texture, and freshness. The introduction of an alcoholic appetiser before the soup consumption further enhances the perceived freshness and flavour of the soup. Crucially, alcohol acts as a taste potentiator, specifically amplifying the sweet and umami components of the tomato soup. Results such as these suggest that carefully curated food-beverage pairings, particularly alcoholic appetisers, may be used to manipulate and/or augment the perceived taste profiles of dishes, as well as potential additional aids for sensory-impaired diners.

Declaration of competing interest

The authors declare no conflicts of interest.

Data availability

Data will be made available on request.

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