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Methodology for determination of two new sensory thresholds: Compromised acceptance threshold and rejection threshold

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ABSTRACT

The existing methodologies for determining thresholds generate unreliable estimates of the point at which the intensity of a stimulus begins to compromise acceptance or result in sensory rejection of a product. Thus, a new methodology was proposed for determination of two new sensory thresholds: the compromised acceptance threshold (CAT) and the rejection threshold (RT). In this new methodology, increasing or decreasing series of stimulus intensity are measured together with a standard stimulus (control sample) by means of acceptance tests. In the present study, the CAT and RT were determined for sucrose concentrations in grape nectar, demonstrating that when reducing the sucrose concentration of grape nectar form 9.00% (w/v) to 6.87% there begins to occur impairment of product acceptance (CAT), and when reducing the sucrose concentration from 9.00% to 3.83% there begins to occur sensory rejection (RT) of the product. When compared to existing threshold determination methodologies, the proposed methodology permitted for calculating, with greater reliability, the points at which compromise of acceptance (CAT) and sensory rejection (RT) of the product begin to occur. In addition to the case study presented, the proposed methodology has a wide range of applications in science and in the food, cosmetic and pharmaceutical industries.

1. Introduction

The detection threshold methodology generates an unreliable estimate of stimulus intensity from which the acceptance of the product is affected, since the first sensory alterations perceived by the individual may not result in change to sensory acceptance of the product (Prescott, Norris, Kunst, & Kim, 2005). In many cases, a product may only be rejected when intensity exceeds the lower detection limit. Based on this context, Prescott et al. (2005) proposed the consumer rejection threshold (CRT). This new concept sought to determine the intensity of a stimulus from which the preference of a product is altered, based on assessing consumer preference using paired preference tests within the constant stimulation method of the threshold methodology. Thus, increasing or decreasing series of stimulus intensity (for example, concentration of a substance or treatment temperature) are tested against a standard stimulus (control sample), with regards to consumer preference.

The methodology proposed by Prescott was accepted by the scientific community and has been used in several studies (Harwood, Ziegler, & Hayes, 2012a; Harwood, Ziegler, & Hayes, 2012b; Lima Filho et al., 2014; Ross, Zwink, Castro, & Harrison, 2014; Saliba, Bullock, & Hardie, 2009; Yoo, Saliba, Prenzler, & Ryan, 2012). However, to determine the rejection threshold by the consumer, Prescott et al. (2005) used preference tests instead of acceptance tests. Acceptance tests with a hedonic scale indicate how much consumers like (sensory acceptance) or dislike (sensory rejection) a product, and preference tests indicate which sample is preferred (Stone, Bleibaum, & Thomas, 2012). The fact that one sample is less preferred in relation to the other does not necessarily mean that it is rejected sensorially. Therefore, in cases where one wishes to investigate the point at which there begins to occur significant change in the sensory acceptance or the point at which there begins to occur sensory rejection of the product, acceptance tests are more indicated than preference tests. Therefore, we intend to propose a new methodology for determination of two new sensory thresholds: the compromised acceptance threshold (CAT), which indicates the intensity of the stimulus in which the acceptance of the product becomes significantly altered; and the rejection threshold (RT), referring to the transition point between sensory acceptance and rejection.

The proposed methodology was applied as a tool to reduce the sucrose concentration of grape nectar. The elevated consumption of sucrose is partially a consequence of the high sugar content of processed foods and can result in several diseases, including diabetes, cardiovascular disease and excessive weight gain. Studies have shown that grape nectar is one of the foods with the highest content of total sugars sold in Brazil (IDEC, 2014; PROTESTE, 2012). Thus, in addition to proposing

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a new methodology, the objective of the present study was to determine the CAT and RT for sucrose concentration in grape nectar, i.e., determine how much sucrose can be removed without compromising acceptance (CAT) and result in sensory rejection (RT) of the product.

2. Material and methods

The present study was approved by the Ethics Committee on Human Research of the Federal University of Viçosa (UFV), Brazil, under number 773,185. The analyses were performed at the Sensory Analysis Laboratory of the UFV, in individual booths with white light.

Results of the methodology for determining the CAT and RT were qualitatively compared with results of the methodology for determining the consumer rejection threshold (CRT), proposed by Prescott et al. (2005). In addition to the statistical analysis, the main difference of the CAT and RT methodologies compared with the CRT is that acceptance tests are used for determination of the proposed thresholds, directly evaluating the effect of the stimulus on product acceptance; while in the CRT methodology preference tests are performed.

The experiments to determine the CAT, RT and CRT were conducted using the same panel of consumers. Thus, it was sought to prevent changes in the results in function of using different groups of consumers with different acceptance standards.

The methodologies were applied to grape nectar and the stimulus evaluated was sucrose concentration.

2.1. Material

The nectars were prepared from grape juice concentrate, without added sugar, purchased from an industry in Minas Gerais, Brazil. In preparing the samples, grape juice concentrate was diluted with water at the proportion of one to one (1:1). After dilution, the juice was divided into six lots, one lot for preparation of the control sample and five for the samples to be compared with the control sample (stimulus samples). In each lot different quantities of sucrose were added at the concentrations determined in preliminary testing. Subsequently, the samples were stored at approximately 8 °C until completion of the sensory tests.

2.2. Determination of sucrose concentrations in the grape nectars (preliminary tests)

The determination of sucrose concentrations in the samples was performed based on the results of previous studies (Lima Filho, Minim, Silva, Della Lucia, & Minim, 2015).

In the study of Lima Filho et al. (2015), 32 women and 29 men (61 judges), between 18 and 33 years old, performed preference ranking tests with grape nectar samples containing sucrose concentrations of 5% (w/v), 8% (w/v), 9% (w/v), 10% (w/v), 11% (w/v) and 13% (w/v). When analyzing the results by means of the Christensen test, it was found that grape nectars containing 8%, 9%, 10%, 11% and 13% sucrose did not differ with regards to preference ($p > 0.05$) and were those preferred by consumers (Lima Filho et al., 2015). Thus, we selected the nectar containing 9% sucrose as the control sample since it was one of the most preferred by consumers and because it has a sucrose concentration similar to that of some grape nectar brands sold in Brazil.

To determine the sensory thresholds a stimulus intensity range should be used that includes the threshold to be determined (Lawless & Heymann, 2010). For this, the grape nectar containing 8% sucrose was selected as the first sample to be compared with the control, i.e., the sample containing 8% sucrose was the lower limit of the stimulus intensity range studied. This is because in the ranking test the nectars containing 9% and 8% sucrose did not significantly differ with regards to preference ($p > 0.05$). As will be discussed later, a direct comparison between preference and acceptance or rejection is erroneous; however, the fact that two samples do not differ from each other with regards to preference may be an indication that they do not differ with regards to acceptance. Thus, there was increased confidence that the thresholds calculated were greater than the chosen lower limit, which was confirmed by the results of the present study.

From the sample containing 8% sucrose, the concentration of the samples was gradually decreased to a concentration of 0% sucrose. Thus, the sucrose concentrations selected for determining the CAT, RT and CRT were 9% (w/v) (control sample), 8% (w/v), 6% (w/v), 4% (w/v), 2% (w/v) and 0% (w/v).

It should be noted that for industrial application of the methodology to determine the CAT and RT, this process of determining the stimulus intensity of the control sample is simplified, since the control sample is the product already produced by industry.

In order to facilitate understanding throughout the article, the sample containing 9% sucrose was referred to as the “control sample” and the other samples, whose sucrose concentrations were reduced (8%, 6%, 4%, 2% and 0%), were called “stimulus samples”.

2.3. Consumers

Regular consumers of grape nectar were recruited among students and employees of UFV and residents of the city of Viçosa — Minas Gerais, Brazil. The study was conducted by a panel of 150 consumers, composed of 82 women and 68 men with ages between 18 and 45. Most (81%) were between 20 and 29 years old.

All participants reported liking grape juice, and most said they consume grape juice once or twice a month (30.3% of consumers), while the second largest group reported at least once a week (29.7%). The grape-derived beverages most consumed by the participants were grape nectar (consumed by 54.5% of participants) and grape juice concentrate (38.6%).

2.4. Consumer rejection threshold

Determination of the CRT followed the procedures proposed by Prescott et al. (2005). Therefore, for its determination 150 consumers conducted five sessions of paired preference tests (Stone et al., 2012). Within each section, each pair of samples consisted of a grape nectar control sample (9% sucrose) and a stimulus sample (with reduced sucrose concentrations of 8%, 6%, 4%, 2% or 0%). Consumers were asked to taste the samples and indicate their preference on the provided forms. After rinsing their mouth with water, consumers received a new pair of samples every 5 min. The samples were presented in order of decreasing sucrose concentrations between sessions, and the position of the control sample, within each pair, was randomized as recommended by Prescott et al. (2005).

The collected data was used to prepare a graph of the proportion of consumers who preferred the control sample (y-axis) as a function of the sucrose concentrations studied (x-axis). The CRT was calculated by interpolation considering the concentration corresponding to the proportion of consumers who preferred the control sample required for statistical significance ($p = 0.05$), according to the binomial distribution table for the paired preference test (ISO, 2005; Prescott et al., 2005).

2.5. Compromised acceptance threshold and rejection threshold

The methodology for determining of the CAT and RT has the same procedures for sensory analysis and data collection, differing only in analysis of the results and determination of the thresholds.

To determine the CAT and RT, the 150 consumers performed five sessions of acceptance tests (Stone et al., 2012). In each acceptance session two samples were served to the consumers, one of which was the control sample (9% sucrose) and the other was one of the stimulus samples, at one of the concentrations determined in the preliminary tests. The grape nectar samples for determining of the CAT and RT were the same as those in determination of the CRT.