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Developing models systems for testing the sensory properties and consumer acceptance of new fruit cultivars: The example of kiwifruit

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ABSTRACT

Horticultural industries, like most consumer goods industries, pursue new product development, but face the significant additional challenge that prototypes for consumer testing are not readily available. One possible solution involves the development of realistic model systems in which sensory qualities can be systematically altered to mimic the proposed new cultivars. The present research tests a model system for assessing taste/flavour innovations in fruit, using kiwifruit as an example. Flavour/taste solutions were injected into pieces of fruit tissue. These fruit samples were subjected to descriptive sensory analysis and consumer acceptability testing to reveal that systematic changes in the sensory characteristics of fruit could be achieved and novel flavours introduced. The response patterns in the data fit expectations (e.g., samples injected with sucralose were higher in sweetness) and consumer participants evaluated the model system favourably in terms of ability to provide a good approximation of what it would be like to eat a whole kiwifruit with the novel flavour characteristics. Limitations and advantages of the tissue-based model system are compared with other possible model systems and the relevance of this approach to other types of fruit in guiding new product development is discussed.

1. Introduction

The horticultural product marketplace is very competitive and characterised by a large number of poorly differentiated commodity products with low unit price. Thus, innovation is a primary pursuit. Although innovation is likely to occur at all levels in the value chain, innovation of new cultivars is especially important because they can offer a 'step-change' in the fruit characteristics, which can attract new customers and/or attract premium prices. ZESPRI® GOLD kiwifruit is a powerful example of the premium that a novel cultivar can attract (e.g., Kiwiflier, 2009), and different countries and organisations have set up breeding programmes to pursue the development of kiwifruit with novel sensory characteristics. The natural diversity in the *Actinidia* genus, with more than 60 species documented, means that there is plenty of opportunity for innovation with respect to taste, flavour, texture, flesh colour and size (Ferguson, 1990; Ferguson & Huang, 2007). Currently only a few kiwifruit cultivars are of commercial importance and a key challenge that breeders face is deciding which novel traits to pursue. Sound decision making is critical because of the length of the innovation cycle. In stark contrast to some manufactured food/beverage categories, where a new flavour variant can be launched within 6 months or less, the development of a new type of fruit takes many years – up to 15 years in the case of kiwifruit made using traditional breeding techniques (Patterson, Burdon, & Lallu, 2003). Against this timeline, it is essential to have certainty about consumer appeal of a novel trait before the lengthy process of breeding a new commercial cultivar with this trait begins. In this regard, kiwifruit is no different to many other types of fruit, of which pipfruit (e.g., www.prevar.co.nz), summerfruit (e.g., www.summerfruit.co.nz) and tropical fruit (e.g., Kulkarni, Bally, Brettell, Johnson, & Hamilton, 2002) are just a few examples.

The aim of the present study was to develop and assess a model system for the testing of the sensory properties and consumer acceptance of new fruit cultivars. Consider a consumer-driven approach to product development where marketing research has identified an opportunity in the market place for apples with a novel minty flavour note, mango with a novel berry flavour note or kiwifruit with a characteristic note of pineapple flavour. In the case of kiwifruit, assuming that pineapple flavours were discovered in a wild population, the fruit from these plants would likely be unsuitable for prototype testing with consumers. Fruit from wild populations typically have poor texture, low levels of sweetness, too much acidity, or even off-flavours (Ferguson et al., 1996). Even if enough fruit could be secured to conduct commercial scale consumer testing, these anticipated negative quality aspects would likely dominate participants' responses and hinder accurate assessment of liking for the novel flavour note and its commercial

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potential. Yet, robust knowledge on whether or not consumers will like a novel flavour/taste is important in reaching a go/no-go decision to proceed with development.

Without access to prototypes, product developers and market researchers may have to rely on information from model systems. One way of developing a model system is to incorporate novel flavours/tastants directly into an existing fruit to mimic the novel cultivar. Previous work has found that juices (Ball, Murray, Young, & Gilbert, 1998) and fruit pulps (Marsh, Friel, Gunson, Lund, & MacRae, 2006; Marsh, Friel, Gunson, Lund, & MacRae, 2006; Rossiter, Young, Walker, Miller, & Dawson, 2000) can be used as vehicles to successfully alter the flavour and taste profile of kiwifruit. However, because texture of fruit tissue plays an important role in determining consumer acceptability for kiwifruit (Harker, Gunson, & Jaeger, 2003), and other types of fruit (e.g., Jaeger, Andani, Wakeling, & MacFie, 1998; Donahue & Work, 1998; Lester, 2006), juices and pulps are poor candidates for prototypes that can be tested with consumers. Moreover, the breakdown of fruit tissue during chewing determines flavour release (Harker & Johnston, 2008), meaning that the perception of a novel flavour in a pulp/juice system could be quite different from that in a whole fruit. In the absence of a high quality fruit possessing the novel flavour/taste trait(s), the next best option would be pieces of fruit tissue with altered flavour/taste profiles. Our approach to achieve this was through injection of solutions of flavours/tastants directly into tissue of existing commercially available fruit cultivars. Kiwifruit is the focus of this research, but we have also used the presented approach in apple tissue (Altisent et al., 2009) and suggest that it can be directly transferred to other types of fruit (see later for more discussion).

To achieve the stated aim of developing and validating a new model system, we: (1) developed protocols for injecting flavour/taste solutions in fruit tissue; (2) assessed through descriptive sensory analysis that the sensory profiles changed predictably; (3) confirmed that consumer acceptability for the fruit prototypes developed through flavour/taste injection matched expectations based on the sensory profiles; (4) explored effects of consumer traits relating to approach/avoidance behaviour for novel foods on acceptability; and (5) obtained consumer feedback on the model system. The final step was critical since it offered a consumer-focused perspective on the effectiveness on the tissue-based model system.

In the past (Jaeger et al., 2003b; Jaeger & Harker, 2005) we have used the food neophobia (Pliner & Hobden, 1992) and variety-seeking tendency (van Trijp & Steenkamp, 1992) traits to explore consumer reactions to fruit with novel traits such as flavour and appearance. This motivated the inclusion of these scales in the current study and we expected that higher levels of food neophobia and lower levels of variety-seeking tendency would be related to the degree of liking/disliking for fruit samples where novel flavours had been introduced. Contrary to novel flavours, changes in acid/sugar balance, achieved through injection of sweet/acid solutions were not thought to represent a level of novelty that would lead to different responses among groups of consumers with varying levels of food neophobia or variety-seeking tendency. Our rationale is that variation in sugar/acid balance is something consumers are likely to have experienced in fruit, for example by eating fruit of different degrees of maturity and ripeness or different cultivars (Beever & Hopkirk, 1990; Harker, Maindonald, & Jackson, 1996; Stec, Hodgson, MacRae, & Triggs, 1989).

In deciding which flavour/taste injections to use we were guided by methodological considerations. It was important to establish that the existing flavour/taste profile of kiwifruit could be systematically manipulated and that novel flavours could be introduced. An additional consideration was ability to vary novel flavour intensity to represent market place positions for new cultivars as, for example, "kiwifruit that tastes like pineapple" or "kiwifruit with a hint of pineapple flavour".

2. Methodology

2.1. Samples

The model system consisted of pieces of kiwifruit tissue with systematically altered flavour/taste profiles. Nine samples were included in the study, of which eight were created by injecting a small volume of flavour/tastant solution directly into pieces of tissue from *A. chinensis* 'Hort16A' (i.e., ZESPRI® GOLD Kiwifruit). The ninth sample was a control sample – *A. chinensis* 'Hort16A' tissue that was not injected with a flavour/taste solution.

2.1.1. Fruit used for injection

To ensure that the fruit tissue was of good eating quality, each piece of fruit was screened and selected for inclusion in the study if it matched specified requirements for dry matter (DM) and firmness. These indices are routinely used by post harvest scientists to assess eating quality of kiwifruit (Beever & Hopkirk, 1990; Harker et al., 2009).

Fruit was sorted for DM content using a near-infra red (NIR) sensor to be in the range 17–18.4% DM. The NIR measurements, which do not damage the fruit, were made on each fruit at opposite flat sides along the equatorial plane. Spectral data from 306–1129 nm were recorded at 3.2 nm wavelength intervals (256 data points per spectrum) and input to a proprietary NIR prediction model to estimate DM. Fruit that matched the DM criteria were subsequently tested by a non-destructive acoustic firmness system (AFS from AWETA, Nootdorp, The Netherlands) (de Kelelaere et al., 2006), selecting those that were within the range optimal eating firmness.

To minimise fruit-to-fruit variation in the tissue, fruit for the study was sourced from a single grower. It was harvested at commercial maturity, colour conditioned for 5 days at 5 °C and subsequently stored at 1 °C. Following ~12 weeks of storage, the fruit were taken from cool store and kept at 20 °C for four days prior to presentation to trained panellists or consumers.

2.1.2. Flavour solutions injected into kiwifruit tissue

Table 1 details the eight flavour/tastant treatments, which encompassed two tastants and three flavours, alone or in combination. The treatments were designed to: manipulate the sweet/acid balance of the control sample (treatment 2 and 5); increase the intensity of "GOLD kiwifruit" flavour (treatments 3 and 4); or introduce novel flavours (treatments 6–9). The sweet/acid balance of kiwifruit is known to significantly impact consumer acceptability (Marsh et al., 2006) and the intensity of gold flavour is likely to do the same (e.g., Jaeger et al., 2003b). We studied two flavours, attributed by the compounds linalool and allyl hexanoate. Linalool, which smells 'fragrant' and 'floral', is present in the flowers of kiwifruit (Matich et al., 2003), and although it has not been documented as a significant contributor to the flavour of kiwifruit, it is a potential target for development of new flavours. Allyl hexanoate, which smells of 'pineapple', was chosen because it, to our knowledge, has not been identified in the *Actinidia* genus, and hence represents a novel target. We considered that pineapple would be an appropriate flavour note to pursue given the already existing fruity and tropical notes in gold-fleshed kiwifruit (Jaeger et al., 2003b). A preliminary understanding of consumer responses to intensity variation in novel flavours was sought and, for this reason, two concentrations for each of the two novel flavours were used. Certified food grade chemicals were acquired from Sigma