What Constitutes Eating Quality to a New York Consumer and How Do We Measure Quality Objectively?

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Consumers do not always agree what is acceptable quality and instruments do not necessarily measure the same combination of properties that humans integrate into their assessment of acceptability. To ensure that new apple varieties developed from the Geneva breeding program have consistently high quality for defined groups of consumers, we are measuring quality through both direct measurements with instruments and by consumer sensory testing.

The terms quality and consumer are very complex and may be defined differently by various individuals. Consumers do not always agree what is acceptable quality (Abbott et al., 2004) and instruments do not necessarily measure the same combination of properties that humans integrate into their assessment of acceptability. Two apples can have the same instrumental values for firmness; yet can be perceived quite differently by consumers. Certain components of eating quality are more important to some individuals than others. Nevertheless, many consumers list flesh browning, bruising, large core, and thick skin as negatives. Harker et al., (2003) defined quality as "all those characteristics of a food (not just the sensory characteristics) that lead a consumer to be satisfied with the product."

Apple Consumer Characteristics

Depending on your operation you may have several categories of consumers. Consumer apple preferences are influenced by gender, race, age, income level, type of apple preferred and the memory of the last apple eaten. Asian and Hispanic consumers purchase more apples than other ethnic classes, with 'Fuji' the apple preferred by Asians. Stemilt's use of the name 'Piñata' for the apple originally called 'Pinova' was a good marketing idea as this name is appealing to Hispanic consumers, an increasing population.

In New York State 16.7% of the population is below the poverty level and 19% of these households often buy no produce at all. Low-income consumers place more emphasis on cost, convenience, accessibility and sustenance. Often without transportation, these consumers must rely on local stores where produce is often suboptimal, and they must carry groceries home (apples are bulky and will bruise). Low-income consumers can purchase less healthy foods for less money. Each additional 100 grams of fat and sweets was associated with a reduction in costs, while adding 100 g of fruits or a vegetable was associated with an increased cost (Drewnowski et al., 2004).

Memory of past experience influences consumer perception, but exaggerate the extremes both extremely good and extremely bad. Also taste sensitivity changes with age so that a consumer may never again experience that perfect apple they ate in 2005 (Harker et al., 2002a). A bad experience will cause consumers to stop buying apples for a while, change varieties or switch to a different fruit. US consumers also tend to retain a preference for the apples that they were given as children.

Consumer Demographics

The "typical" apple buyer is categorized as middle to upper class 35- to 54-year-old woman with a college degree, two children and a traditional family. Yet traditional families make up only 25% of all families (Progressive Grocer, 2005). An "opportunity consumer" is a single male who is poor or just getting by. He has no children. Apples are convenient, portable and do not need to be prepared. Surveys show that men eat more apples than women.

Apple consumers can be divided into three categories: the balanced buyer (29%) who balances price, appearance and other factors, the perfect produce buyers (55%) and the safety seekers (16%) who are concerned about pesticides and residues. Price, quality, certification and pesticide issues impact each group differently (reviewed in Harker et al., 2003). A survey of 1,783 apple consumers, funded by Washington State growers found 27% were disappointed, 21% were stressed Moms, 21% were "hard core" apple eaters, 16% were experimenters and 15% were worried.

A study by Daillant-Spinnler et al. (1996) found that consumers use terms such as mealy, mushy or bruised to describe apples of poor quality while they use terms such as crisp, firm, juicy, blemish-free, consistent color (and quality), flavor (specific to the type of apple), price and promotion, organic, packing and region produced to describe desirable apple attributes. They found consumers can be categorized into two preference groups: Sweet (and hard) apples and acidic (and

juicy) apples, but clearly there are other combinations that exist and that are preferred.

Organic produce is purchased by families and individuals. Fresh cut apples are known by 69% of consumers who like the convenience but want the variety to be on the label since the cut apples may not be the type their children like. Variety also has an effect on the consistency (variability) of quality in fresh cut.

In Europe scab-resistant apples are being developed and promoted. There is a "flavor group concept" in Switzerland where apples are characterized as to type (sweet versus acidic, etc.) rather than by name. They are marketing to both target audiences (those interested in organic) and to flavor groups. In France a new scab-resistant apple, 'Ariane' is part of a club (cooperative) effort with the breeder, nurserymen, grower and retailer under the "Les Naturiane" label. The industry recognizes that scab-resistant apple varieties need to have quality in addition to their disease resistance. Scab-resistant selections with commercial quality are available for testing from the Cornell apple breeding program.

Although apples are used in baking, most consumers do not know which varieties are best for cooking and many choose the wrong type. Poor results with the wrong variety lowers repeat purchase. In addition, food editors try to list a "common" variety available throughout the country, so 'Granny Smith' is almost universally listed in recipes. Regional varieties suited to baking should be stressed.

Apple Quality Evaluation

Although the consumer ultimately defines quality it is also a function of the genetics of the variety and rootstock, and the environment. Quality is defined differently for 'Fuji' than for 'Gala'. Thus, quality is very much variety dependent. The environmental effects on quality include preharvest environment and cultural practices and post harvest storage conditions. Both the genetics of the variety and the environment combine to produce a tremendous diversity of traits including diverse colors, diverse surface patterns (stripes, blushes, russetting and dots), diverse flavors, textures and sugar/acid ratios. There are also diverse shapes and many different resistance genes available for use in breeding. Many attributes can be changed in breeding: Flavor, texture, firmness, crispness, juiciness, mouth feel, vitamin C and antioxidants for health. When we evaluate quality we often find flavor that is too mild or too intense, with 'just right" being elusive. Large population numbers are needed to get the perfect combinations.

Desirable attributes include consistent quality, no bruises, good tasting, crisp, and flavorful. Roger Harker stated that "No matter how healthy an apple is consumers are reluctant to re-purchase fruit unless it tastes good." However, there are problems in defining, measuring and surveying consumers about quality. It is also difficult to set up trials where fruits are of the same maturity. Ideally, sensory tests should be conducted on the same apple used for analytical measurements. Each cultivar needs to be considered in relation to its specific niche and which group of consumers will respond positively to its attributes (Harker et al., 2003). There is also a strong influence of "cultivar of choice" on consumer expectations of quality (Jaeger et al., 2001).

Brix And Acid (Sweet and Sour): Apples need to have a balance of sugar and acid. Sweetness is measured as the soluble solid content (SSC) of the fruit, also called degrees Brix. A refractometer is used to measure of total sugars (SSC). Harker et al., (2002c) found that sweet taste is difficult to predict using any objective method, but degrees Brix was best. Apples need to differ by more than 1° Brix for trained panelists to detect a difference in taste. To ensure quality, Harker (2002c) suggested a minimum SSC for apples should be between 12 and 14%. Some of our advanced breeding selections average 20 to 25° Brix.

Total acidity is a measure of the percent malic acid (the primary acid in apples) and is obtained by titration of apple juice with sodium hydroxide. Titratable acidity (TA) was the best predictor of acid taste. Differences of 0.08% TA were required before the average trained panelist could detect a difference in acid taste (Harker et al., 2002c). However TA and consumer acceptability is cultivar specific. At Geneva we follow loss of acidity in storage and have found there is a lot of variation. For example, 'Fuji' has low acidity and loses what little it does have in storage, while other cultivars maintain their acidity through storage. Perception of acidity can differ among people due to ratios of sugar and acid. 'Honeycrisp' has mild flavor but surprisingly high acidity.

Flavor: Flavor is an elusive and complex trait that is difficult to characterize. Flavor is composed of sweetness, sourness, bitterness, saltiness and aroma. More research is needed on fruit flavor components, how they are produced and how we perceive them (Baldwin, 2003). Flavor is determined and influenced by genetics, the environment and cultural practices. Harvest maturity and postharvest handling also have a strong effect. In apple there are 200 to 3000 different volatiles and 15 to 40 of these aroma compounds contribute to "varietal flavor" with no one compound responsible for the characteristic flavor of a variety (Cunningham et al., 1985). The perception of flavor is also complicated due to nerve endings in the back of the nose that are able to detect aromas in parts per billion (Baldwin, 2002).

There are chemical and sensory measurements of flavor and these may or may not relate with each other. Flavor is best assessed by trained sensory panelists (Harker et al., 2002a). The types of flavors that exist in apple are diverse: 'Gala' descriptors were developed and included mushroom, nail polish remover, fruity, earthy, and musty. We use a wine wheel of descriptors to describe flavors and we taste many flavors not associated with apples: some are pleasant: berry, grape, floral and others are not; tin can, lemon.

Consumer acceptance of 'Gala' and 'Elstar' in Switzerland seemed less dependant on firmness, soluble solids content and acidity but dependent on aroma quality and juiciness (Hoehn et al., 2003). The authors suggested that aroma should be considered in storage protocols. Some volatiles are lost rapidly, especially in controlled atmosphere storage, such as with 'Pacific Rose' (Tough et al., 2001). In the future it would be great to have markers for important enzymes in flavor pathways. Research on flavor would benefit from an integrated approach with sensory experts, flavor chemists, geneticists and molecular biologists.

Firmness And Texture: Human perception of fruit texture is determined by the way that the flesh breaks down during chewing. There are three components of texture: 1) The mechanical properties of the tissue, 2) the juiciness of the flesh and 3) the mouth feel or how the apple breaks down in the mouth (Harker et al., 2002b).

Penetrometers are better for prediction of sensory attributes at harvest like crispness and fondant (the force required to crush a piece of unpeeled apple between the tongue and palate), while compression is better for prediction of characteristics developing dur-

ing storage such as mealiness and loss of juiciness (Mehinagic et al., 2004).

Trained sensory panels are only able to detect differences in firmness when the firmness of two apples differs by more than 1.2 pounds. Harker et al. (2002b) found at 13 pounds pressure that most consumers consider an apple to be mediocre and only slightly liked, but when firmness approaches 15 pounds the score is "moderately liked" to "liked very much."

Crispness accounted for 90% of the variation in liking the texture. Juiciness, aroma, sweetness and sourness were all important to flavor but their relative importance varied from year to year (Hampson et al., 2000).

Sensory Testing: A large number (50 to 100) panelists are needed and will be affected by income, ethnic and geographical background. It is almost impossible for untrained panelists to isolate the influence of firmness and juiciness from aroma and flavor when making their evaluations (Tough et al., 2001). There are many different views on the number of panelists needed, whether fruits should be whole or cut, peeled or un-peeled, whether sensory tests and laboratory analyses should be on the same fruit. The order of samples can affect results and the type of testing also can influence the outcome. It is a very complex system.

Mealiness is difficult to define as a sensory characteristic. Sensory profiling uses terms such as softness, dryness, granularity and flouriness to describe mealiness. People can detect differences in degrees of mealiness for apples but the effects on acceptability are varied (Gomez et al., 1998). Mealiness is unpleasant to most consumers but considered pleasant by about 20% of elderly consumers. European studies revealed differences in descriptions of mealiness across cultures.

No instrumental measurement was a satisfactory predictor of sensory acceptability of fresh cut apples (Abbott et al., 2004). Naturally, non-browning flesh would be a great benefit. Sufficient acidity must be present to prevent microbial contamination in fresh-cut products.

When comparing consumer perception with instrumental measurements of quality, Hoehn et al., (2003) found that for 'Golden Delicious' to be judged to have acceptable quality, it should attain a minimum of 12°Brix for soluble solids, a minimum acidity of 0.32 mg/ml (malic acid) and minimum firmness of 10 pounds. 'Elstar' firmness should exceed 10 pounds; Brix should be above 12 and acidity more than 0.4 mg/ml but less than 0.6 mg/ml. 'Gala' should attain at least 12.6 pounds. It is difficult for consumers to differentiate firmness and crispness.

Quality Evaluation in New Selections from the Breeding Program

We need to ensure that new apple varieties developed from the Geneva breeding program have consistency of quality. Fruits need to have a distinctive appearance for marketing and superior quality for consumer satisfaction. In the future we hope to cooperatively test consumer reaction for new apples with customers, packers, retailers and wholesalers. Different niches will have different varietal preferences. On-farm plantings are being established on diverse sites and with diverse marketing strategies. We have documented improved quality in our selections and an integrated approach to testing will benefit the industry as a whole.

McDonalds became the largest US purchaser of apples (55 million pounds/year) with their introduction of "Apple Dippers" in Happy Meals. These peeled fresh cut apples come with a caramel dipping sauce. Our program at Cornell has developed non-browning selections suited to this use.

Another product targeted to children are "Grapples": 'Fuji' apples infused with grape flavor since many children like the flavor of grape. We prefer to enhance flavors naturally in apples by breeding. There are some intensely flavored apples we feel would be well received by children who love intense flavors and high acidity. Ideas for kid-friendly products continue to be developed. We also have a wonderful opportunity to tie-in with education programs on apples being taught at the elementary school level. We need our youngest consumers to know about apples and be in the habit of eating them. They are the consumers of the future.

Conclusion

There are many different health-related reasons to promote apple consumption. They are a naturally healthy, low fat, high fiber product. What could be better? Gold's Gym partnered with the Washington State Apple Association in their "three-a-day" apple diet promotion. Members were told to eat one apple before each meal and this provide to be effective in weight loss. Since then several womens' magazines have recommended this diet practice to promote weight loss and good nutrition.

"The apple industry needs to have a steady stream of new varieties with different mixes of attributes in the development pipeline," (Desmond O'Rourke's 2005 world apple review). New York has this pipeline. A better understanding of consumer perceptions of apple quality is important in developing new cultivars and in marketing the ones we have. Recent research information on quality indicates that minimum quality standards would ensure that consumers are getting consistent quality. We will continue to test consumer reactions to our new selections and use what we have learned to develop apples that are pleasing to a variety of consumers and provide consistent quality throughout the season.

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