

DESCRIPTIVE ANALYSIS OF BLACK WALNUT CULTIVARS AND RELATIONSHIP  
BETWEEN CONSUMER ACCEPTANCE AND DESCRIPTIVE ANALYSIS OF BLACK  
WALNUTS IN A SUGAR COOKIE BASE

by

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## Abstract

Researchers evaluated the flavor characteristics of seven black walnut (*Juglans nigra* L.) cultivars: Brown Nugget, Davidson, Emma K, Football, Sparks 127, Sparrow, and Tomboy using descriptive sensory analysis. Seven trained panelists developed a lexicon for the black walnuts and scored the intensities of the samples for 22 flavor and taste attributes. Results showed that the 7 samples differed significantly ( $P \leq 0.05$ ) on 13 of the attributes. For the majority of the attributes, only Emma K differed from the rest of the cultivars by being characterized with lower scores for black walnut ID, overall nutty, nutty-grain-like, nutty-buttery, floral/fruity, oily, and overall sweet. It also was higher in acrid, burnt, fruity-dark, musty/earthy, rancid, and bitter attributes. Researchers then incorporated the black walnut cultivars into a simple cookie recipe and evaluated the samples for differences in flavor attributes using the same trained panelists. Nine of the 25 attributes differed significantly across cultivars: black walnut ID, overall nutty, nutty-buttery, brown, toasted, acrid, rancid, overall sweet, and sweet ( $P \leq 0.05$ ). Lower mean scores in black walnut ID, overall nutty, and sweet and higher mean scores in rancid and acrid characterized the Emma K cookie. A PCA biplot revealed that cookies with Football, Sparks 127, and Sparrow walnuts related with one another and the attributes nutty-woody, leavening, and piney. A consumer acceptance test for six of the cookies (Tomboy cultivar was excluded) was also performed. There were four significant clusters of consumers that differed in their acceptance of the cookie samples. Cluster 1 preferred Football, clusters 2 and 3 each showed no overall preference, and cluster 4 preferred Emma K suggesting a set of niche consumers for black walnut cookies.

Results presented in this paper can assist black walnut growers in determining which cultivars to plant and harvest. By knowing which cultivars have the most desirable flavor characteristics, growers can focus time and resources on select cultivars, therefore resulting in higher quality black walnuts as products to be sold to consumers in various formats. By consciously choosing which cultivars to harvest, black walnut growers can meet market demand and increase profit.

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# Chapter 1 - Literature Review

## Nut Consumption Trends

Snack and baking varieties of nuts netted almost \$5 billion in sales in 2010. Almonds and pistachios are gaining more acceptance in the marketplace in part from marketing efforts by companies, Blue Diamond Growers and Paramount Farms/Roll International, respectively (Mintel 2011). However, nut consumption is not evenly distributed amongst consumers because of dependence on consumer gender and age. Tables 1-1 and 1-2 list the top 13 nuts consumed and are further categorized by gender (Table 1-1) and age (Table 1-2). According to Mintel (2011), peanuts (a legume often grouped with nuts) are heavily favored by males while females prefer walnuts and almonds. Older adults report having a higher rate of nut consumption within a limited range of nuts; however, younger adults report consuming a wider range of nut types (Mintel 2011).

**Table 1-1.** Percentage of nut consumption by nut type and gender, September 2010<sup>†</sup>

	All	Male	Female
Peanuts*	87	92	82
Almonds	76	71	81
Cashews	70	72	69
Walnuts	54	49	58
Pecans	54	54	53
Sunflower Seeds**	40	39	41
Pistachios	39	41	37
Macadamia nuts	31	32	30
Brazil nuts	24	27	20
Hazelnuts/filberts	24	27	21
Pine nuts	21	21	21
Chestnuts	14	19	10
Hickory nuts	11	15	7

<sup>†</sup>Adapted from the 2011 Mintel report, Nuts and Dried Fruit – US

\*Legume, often grouped with nuts

\*\*Seed, often grouped with nuts

**Table 1-2.** Percentage of nut consumption by nut type and age, September 2010<sup>†</sup>

	All	18-24	25-34	35-44	45-54	55-64	65+
Peanuts*	87	91	93	95	86	79	80
Almonds	76	80	80	75	73	74	72
Cashews	70	77	71	71	67	71	68
Walnuts	54	57	63	48	48	53	57
Pecans	54	62	61	51	48	44	59
Sunflower Seeds**	40	54	56	47	44	25	17
Pistachios	39	50	54	43	39	33	20
Macadamia nuts	31	37	45	35	29	23	20
Brazil nuts	24	24	33	21	22	19	22
Hazelnuts/filberts	24	24	31	27	22	17	21
Pine nuts	21	24	38	24	14	14	11
Chestnuts	14	24	33	16	10	4	3
Hickory nuts	11	15	25	12	8	4	3

<sup>†</sup> Adapted from the 2011 Mintel report, Nuts and Dried Fruit – US

\*Legume, often grouped with nuts

\*\*Seed, often grouped with nuts

Nut consumption methods also vary by age and gender as well as by nut type. Handfuls of peanuts, almonds, and cashews are most likely to be eaten as a snack whereas other nuts are more likely to be eaten alone or as part of a meal (Table 1-3). Young adults (age 18-24) are more likely to eat nuts as a component of a meal or snack (e.g. trail mix). Females, more than males, may add nuts to prepared meals such as baked goods/desserts, salads, trail mix, and entrees. Overall, snacking on nuts is more popular than adding nuts to foods (Mintel 2011).

**Table 1-3.** Percentage of how nuts are consumed by nut type, September 2010<sup>†</sup>

	Ate Summary	Alone/By Handful	Part of Meal/Snack	Did Not Eat in Last Month
Peanuts*	87	58	29	21
Almonds	76	43	33	31
Cashews	70	46	24	34
Walnuts	54	24	29	50
Pecans	54	25	28	50
Sunflower Seeds**	40	24	16	62
Pistachios	39	27	12	63
Macadamia nuts	31	15	16	71
Brazil nuts	24	11	12	78
Hazelnuts/filberts	24	11	16	76
Pine nuts	21	7	14	81
Chestnuts	14	7	8	87
Hickory nuts	11	5	6	90

<sup>†</sup>Adapted from the 2011 Mintel report, Nuts and Dried Fruit – US

\*Legume, often grouped with nuts

\*\*Seed, often grouped with nuts

## Health Benefits of Nuts

Nuts have been part of the human diet for centuries and have turned up in everything from snacks to salads and desserts to entrees (King *et al.* 2008). However, nuts are not always a preferred food choice for everyone. A report by What We Eat in America/National Health and Nutrition Examination Survey (WWEIA/NHANES 2001-2004) found only 34% of individuals surveyed consume nuts as either snacks, peanut butter, or as recipe ingredients (King *et al.* 2008). This can be partly explained because nuts are a high calorie, high fat food; these traits do not resonate well with diet and health conscious consumers. While nuts are high in fat and calories, the fat consists mostly of heart-healthy monounsaturated fat. Nuts are also a good source of polyunsaturated fat, fiber, linoleic acid, magnesium, copper, and vitamin E (King *et al.* 2008; Fitschen *et al.* 2011).

In 2003, the Food and Drug Administration (FDA) approved a qualified health claim for nuts and cardiovascular disease and stated, “Scientific evidence suggests but does not prove that eating 1.5 oz (42 g) per day of most nuts, as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease” (King *et al.* 2008). Walnuts in particular have been studied for their protective cardiovascular properties (Tapsell 2010; Fitschen *et al.* 2011; Vinson and Cai 2012). Unlike most nuts, walnuts have a higher percentage of polyunsaturated fat (49% by weight) than of monounsaturated fat. Black walnuts contain 35.1 g per 100 g nutmeat of polyunsaturated fat and 15 g per 100 g nutmeat of monounsaturated fat (Michler *et al.* 2007). Walnuts also contain 6% by weight of omega-3 fat in the form of  $\alpha$ -linolenic acid, arginine (amino acid), melatonin,  $\gamma$ -tocopherol (vitamin E), and polyphenolics. These compounds help counter chronic diseases including diabetes, heart disease, and vascular function as well as provide antioxidants (Tapsell 2010). Along with these beneficial micronutrients walnuts have a satiating effect (due to the high fat and fiber content) and can help improve plasma lipid levels by decreasing total cholesterol and low-density lipoprotein (LDL or “bad” cholesterol) levels (Fitschen *et al.* 2011).

### ***Health Benefits of Black Walnuts***

Most research attributes health benefits to English or Persian walnuts (*Juglans regia L.*) because few studies have been conducted with black walnuts (*Juglans nigra L.*). Black and English walnuts differ in their fatty acid, antioxidant, and amino acid contents, and black walnuts contain less linoleic and  $\alpha$  linolenic acid than their English counterparts. According to Fitschen *et al.* (2011), based on the black walnuts’ rich color and flavor, they may contain a significant amount of antioxidant compounds that may prove beneficial to the cardiovascular system. This research compared the blood lipid levels, incorporation of polyunsaturated fat into red blood cell membranes, and endothelial function as influenced by English and black walnut consumption in human subjects and found that English walnuts decreased total cholesterol, decreased LDL, and increased HDL (high-density lipoproteins) in subjects. However, black walnuts decreased all three cholesterol levels in men but increased all cholesterol levels in women, suggesting a gender effect (Fitschen *et al.* 2011).

Linoleic acid content in red blood cells significantly increased after consumption of either black or English walnuts, thus increasing total polyunsaturated fat content in the subjects’ blood.

Endothelial function was maintained after consumption of English walnuts with no change in vasodilation. Vasodilation decreased after the consumption of black walnuts, thereby negatively affecting the endothelial function in subjects (Fitschen *et al.* 2011). Overall, black walnuts improved the fatty acid composition of red blood cell membranes, but their effect on lipoprotein levels and endothelial function warrant additional study, therefore Fitschen *et al.* (2011) concluded that additional research is needed to ascertain the cardiovascular benefits derived from black walnuts.

### ***Food Industry and Nuts***

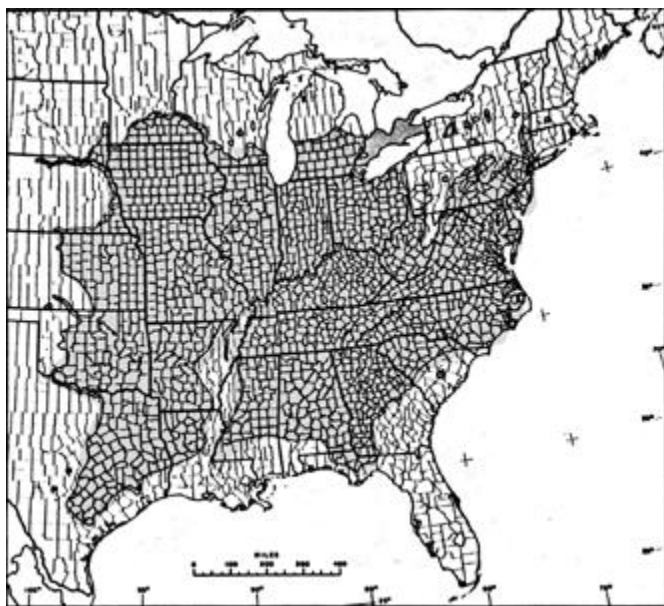
The food industry has noticed the many healthful aspects of nuts and now promotes nuts in food retail and restaurants. Diamond Foods, Incorporated has been experiencing double-digit growth in sales since 2002 and the creation of new flavor combinations and convenient packaging for their array of ready-to-eat nuts is to appease increased consumer demand (Klink 2006). Walnuts are the most popular nut used as an ingredient in foods and are used by top United States (US) food companies in baked goods, cereals, candies, ice cream and other food products (Klink 2006).

An example of the incorporation of walnuts into a readily available food product is McDonald's use of walnuts in their walnut and apple salad. Based on a traditional Waldorf salad, McDonald's version combines walnuts with apple slices, grapes, and vanilla yogurt to give the salad a more "balanced nutrient profile" (Zind 2006). Panera Bread uses walnuts in some baked goods and artisan breads. While most walnuts are sold to food companies in a chopped, diced, or cut form, walnut meal (walnuts ground into a flour-like product) is particularly popular in the European market for baked goods (Zind 2006).

### **Native Range of Black Walnut**

Black walnut (*Juglans nigra L.*), also known as eastern black walnut or American walnut, is a hardwood tree species that belongs to the walnut family, Juglandaceae. Its native habitat (Fig. 1-1) extends along the east coast from northern Florida to the New England states and southern Ontario, Canada then west towards Nebraska and Kansas as well as extending south into Texas (Reid 1990; Williams 1990; Michler *et al.* 2007). Along the western edge of its range in Kansas, black walnut abounds greatly, making up 50% of the basal area in several hectares (Williams 1990). The relative abundance of black walnut in Kansas results from various plant

and animal (including human) interactions. Two systems responsible for the majority of black walnut trees in Kansas are the osage-orange (*Maclura pomifera*) and black walnut consociation and natural stands expanding from abandoned farmstead plantings (Grey and Naughton 1971).



**Figure 1-1.** Native range of black walnut in North America (Reid 1990)

Black walnut does propagate in pure stands; however, it more often grows in mixed forest groves. It typically grows in association with the following five mesophytic forest covers: sugar maple, yellow poplar, yellow poplar-white oak-northern red oak, beech-sugar maple, and silver maple-American elm (Williams 1990; Michler *et al.* 2007). Black walnut trees grow best in moist, well-drained alluvial soils and are intolerant of shade; therefore they must be the dominant or co-dominant tree in mixed stands to survive. They can attain heights of 30-38 m, diameters of 76-120 cm (measured in diameter at breast height [d.b.h.]), and can live longer than 100 years (Williams 1990; Michler *et al.* 2007).

### **Black Walnut Cultivars**

‘Thomas’ was the first black walnut cultivar named in the US in 1881, and currently over 750 black walnut cultivars have been named. The majority of the more common black walnut cultivars (Table 1-4) were selected by amateur growers and breeders based on nut quality characteristics, mostly percent edible kernel (Reid 1990; Reid *et al.* 2004). Wild black walnuts



(trees without any genetic improvement) average 17% edible kernel, Thomas averages 24% edible kernel, and newer cultivars average over 35% edible kernel (Reid *et al.* 2004; Michler *et al.* 2007). Despite great improvement in kernel production, black walnut orchards established for commercial nut production have not been implemented and small-scale hobbyists are tasked with black walnut propagation (Reid 1990; Reid *et al.* 2004).

**Table 1-4.** Black walnut cultivars.

Beck	Drake	Kwik Krop	Schessler	Surprise
Brown Nugget	Elmer Myers	McGinnis	Scrimger	Ten Eyck
Christianson	Emma K	Mintle	Sparks 127	Thatcher
Clermont	Football	Rowher	Sparks 129	Thomas
Cranz	Grundy	Rupert	Sparks 147	Thomas/Myers
Daniel	Hay	Sarcoxie	Sparrow	Tomboy
Davidson	Knuvean	Sauber	Stambaugh	Victoria
Dot	Krouse			

### **Growth Habits of Black Walnut Trees**

There are three methods for growing black walnut trees: 1) planting grafted trees, 2) planting seedling trees then grafting onto desired cultivars two to three years later, or 3) directly planting the nuts for cultivation. The easiest method for starting an orchard and bearing nuts the soonest requires planting grafted trees, while planting seedlings requires low start-up costs. Growing black walnut trees from nuts is also an inexpensive alternative; however, walnut seed is susceptible to rodent predation (Reid *et al.* 2009).

### ***Leafing and Flowering***

Black walnut trees are among the latest trees to begin leafing and flowering which protects immature leaves and flowers from damaging late spring frosts (Reid *et al.* 2004). Black walnut trees are heterodichogamous, meaning they have both male and female flowers located separately on their branches (Reid *et al.* 2009; Coggeshall 2011). Protogyny (female flowers appearing first) and protandry (male flowers appearing first) are characteristic of black walnut

trees, with the former being more common (Williams 1990). While black walnuts can self-pollinate, cross-pollination increases nut production (Reid *et al.* 2009).

### ***Branching and Nut Yield***

Some black walnut cultivars display a branching habit known as lateral bearing or spur-type growth. These spur branches are short, compact branches that grow along the primary limbs and measure approximately 20.3-30.5 cm (8-12 in) in length. The spur branches drastically increase the nut-bearing capacity of the tree, and cultivars with spur-growth habits are the best nut-yielding cultivars (Reid *et al.* 2004; Reid *et al.* 2009). Research by Coggeshall (2011) notes that spur-growth black walnut cultivars are more precocious (producing fruit or nuts at an early age) and productive than non-spur-growth cultivars.



**Figure 1-2.** Spur growth branch (Thomas and Shumann 1993)

## ***Orchard Layout***

When planting black walnut trees adequate tree spacing is important because the trees do not grow well in shade (Williams 1990). Spacing between trees is recommended at 8-9 m (25-30 ft) allowing the trees to develop a full canopy and optimize nut production. Wider planting distances between trees is acceptable and allows the grower to plant other crops between the trees increasing orchard profitability (Reid *et al.* 2009). Typical crops planted among black walnut trees include wheat, milo, soybeans, and/or fescue (Thomas and Schumann 1993).

## **Black Walnut Pests and Diseases**

A few pests and diseases can affect the overall health of the black walnut tree and hinder nut production, but overall they are a hardy tree. Two common defoliating insects are the fall webworm (*Hyphantria cunea*) and the walnut caterpillar (*Datana integerrima*). These insects eat the leaves beginning in midsummer and continue until September. Other harmful insects include the walnut curculio (*Conotrachelus retentus*) which causes “June-drop” of walnuts and the ambrosia beetle (*Xylosandrus germanus*) which may introduce a fungal infection resulting in dieback of the black walnut tree (Williams 1990).

Walnut anthracnose (i.e. leaf blotch) is one of the more destructive diseases of black walnut trees. Caused by the fungus, *Gnomonia leptostyla*, anthracnose attacks the leaves, nuts, and sometimes the tree shoots causing small black spots to appear on infected areas and stimulating growth of these dead areas. This disease can become epidemic during wet weather conditions and can defoliate an entire tree by late summer (Berry 1981). Premature defoliation slows the tree’s growth, decreases nut quality, and increases alternate bearing in the tree. Anthracnose can be effectively controlled by fungicidal sprays; however no complete resistance to the disease exists (Berry 1981; Reid *et al.* 2004).

## **Harvesting Black Walnut Nuts**

Harvesting black walnuts generally occurs after the first frost around September to October and before squirrels prey on them (Williams 1990; Das *et al.* 2001). Smooth, green husks enclose the walnuts and can be rubbed off after turning black with time. After this hulling process, the in-shell nuts are rinsed and dried in a cool environment to prevent rancidity development (Thomas and Schumann 1993; Das *et al.* 2001). Prompt harvest is also critical in order to ensure that optimum nut quality characteristics are maintained. The longer the husk

remains on the nut, the kernels will turn darker in color and attain a bitter flavor from the decomposing husk (Thomas and Schumann 1993; Reid *et al.* 2009). Harvesting is also the most costly and time-consuming process of growing black walnut trees. Due to these hindrances, ease of shelling remains one of the most important nut quality traits desired in a cultivar (Reid *et al.* 2004; Reid *et al.* 2009).

### **Processing Black Walnut Nuts**

Currently, only one commercial processor of black walnut exists, Hammons Products Company located in Stockton, Missouri (Coggeshall 2011). The company has approximately 250 hulling and buying stations located within the US. Hammons packages the nuts for sale to bakeries, candy manufacturers, and food retail outlets, including their online shopping website for individual customers. Both shelled and whole nuts are used in their processing (Thomas and Schumann 1993).

Approximately 11,340 tons of hulled black walnuts are purchased at buying stations. However, the current supply of black walnuts does not meet demand, partly due to walnuts processed by Hammons coming mostly from wild trees. Wild black walnut trees generally produce fewer nuts per tree and the nuts tend to have a small kernel size relative to the shell and darker-colored kernels, indicative of a lower quality walnut (Brawner and Warmund 2008).

### **Economic Value of Black Walnut**

Commercial shelling operations only recover 6-10% of usable nutmeat. With English (Persian) walnuts, over 40% of usable nutmeat is attained. Of the edible nutmeat extracted from the shells, 60% of the kernels are packaged for retail sale, 30% are used in ice cream manufacturing, and 10% are used in commercial baking and candy-making ventures (Reid 1990). Black walnut contains a stronger and richer flavor than the English walnut (Thomas and Schumann 1993).

The black walnut crop increases in value because fine furniture and cabinet-making industries prize its wood and black walnut shell has various industrial uses (i.e., metal cleaning and polishing, particularly jet engines, ships, electronic circuit boards, and automobile gear systems). The nut shell is also found in oil well drilling processes, paints, dynamite filler, and as an abrasive agent in soaps, cosmetics, and dental cleansers (Thomas and Schumann 1993). Use

of black walnut products extend back into history, with uses ranging from emetics and laxatives to relieving toothaches and dermatomycosis (Das *et al.* 2001).

## **Sensory Profiling of Nuts**

### ***Other Nuts***

Sensory testing for nuts ranges from informal tastings and evaluations to very detailed and comprehensive lexicons detailing multiple aspects of several cultivars of a particular nut. Table 1-5 displays a selection of sensory attributes and definitions used in past literature and represents a sample of the type of language used for profiling nuts. For complete lists of the attributes, see the original papers.

**Table 1-5.** Sensory attributes and definitions from selected literature.

Attribute	Nut Type	Definition	Source
Acrid	black walnut	Sharp/acrid, charred flavor associated with a food over baked or excessively browned in oil.	Warmund <i>et al.</i> (2009a) Lee <i>et al.</i> (2011)
Almond nut meat	almond	Aromatics associated with the meat of almonds.	Civille <i>et al.</i> (2010)
Astringency	English walnut	Not available (N/A)	Ingels <i>et al.</i> (1990) Sinesio and Moneta (1997)
Bitter	English and black walnut	Fundamental taste described as harsh. Taste is simulated by solutions of caffeine or quinine.	Warmund <i>et al.</i> (2009a) Warmund <i>et al.</i> (2009b) Lee <i>et al.</i> (2011)
Bitter taste	English walnut	N/A	Guerrero <i>et al.</i> (2000) Sinesio <i>et al.</i> (2001)
Bitterness	English walnut	N/A	Sinesio and Moneta (1997)
Black walnut	black walnut	Intensity of sweet, musty/earthy, oily, brown, buttery, woody, piney, astringent, bitter, and slightly acrid flavors.	Warmund <i>et al.</i> (2009a) Lee <i>et al.</i> (2011)
Brown	black walnut	Rich, full aromatic with a degree of darkness generally associated with canned pinto beans.	Warmund <i>et al.</i> (2009a) Lee <i>et al.</i> (2011)
Brown fruit	almond	Aromatics associated with the general category of brown fruit, such as raisins, prunes, and figs.	Civille <i>et al.</i> (2010)
Buttery	black walnut	Aromatics commonly associated with natural, fresh, slightly salted butter.	Warmund <i>et al.</i> (2009a) Lee <i>et al.</i> (2011)

Attribute	Nut Type	Definition	Source
Coconut/lactone	almond	Aromatics associated with shredded or dried coconut and coconut milk, including lactones.	Civille <i>et al.</i> (2010)
Cooked (almond)	almond	Aromatics associated with nuts, beans, or legumes that have been gently heated or boiled.	Civille <i>et al.</i> (2010)
Dark roast	peanut	N/A	Isleib <i>et al.</i> (2006)
Dark roast (almond)	almond	Aroma compounds associated with cocoa beans and/or nuts that are dark-roasted but not burnt.	Civille <i>et al.</i> (2010)
Dark roasted peanut	peanut	The aromatic associated with dark-roasted peanuts (4+ on USDA color chips) and having very browned or toasted character.	Johnsen <i>et al.</i> (1988) Ng and Dunford (2009)
Firmness	English walnut	N/A	Ingels <i>et al.</i> (1990)
Fishy	peanut	The aromatic associated with trimethylamine, cod liver oil, or old fish.	Johnsen <i>et al.</i> (1988) Ng and Dunford (2009)
Flavor intensity	English walnut	N/A	Sinesio and Moneta (1997) Guerrero <i>et al.</i> (2000) Sinesio <i>et al.</i> (2001)
Floral flavor	English walnut	N/A	Sinesio and Moneta (1997)
Flour flavor	English walnut	N/A	Guerrero <i>et al.</i> (2000) Sinesio <i>et al.</i> (2001)
Fruity	English and black walnut	Aromatic of fermented fruit or non-citrus fruits.	Warmund <i>et al.</i> (2009b)

Attribute	Nut Type	Definition	Source
Musty	English and black walnut	Aromatic of a damp basement or damp soil (wet) or dust (dry).	Warmund <i>et al.</i> (2009b)
Musty/earthy	black walnut	Humus-like aromatics that may or may not include damp soil, decaying vegetation, or cellar-like characteristics.	Warmund <i>et al.</i> (2009a) Lee <i>et al.</i> (2011)
Nutty	peanut	N/A	Isleib <i>et al.</i> (2006)
Nutty	English and black walnut	Intensity of nut flavor, including raw nutty.	Warmund <i>et al.</i> (2009b)
Overall flavor	pistachio	N/A	Tsantili <i>et al.</i> (2010)
Overall nutty	black walnut	Intensity of all nutty characteristics including sweet, oily, light brown, slightly musty and/or buttery, earthy, woody, astringent, and bitter flavors.	Warmund <i>et al.</i> (2009a) Lee <i>et al.</i> (2011)
Over-roast	peanut	N/A	Isleib <i>et al.</i> (2006)
Painty/rancid	English and black walnut	Aromatic of oxidized oil, linseed oil, oil-based paint.	Warmund <i>et al.</i> (2009b)
Piney	black walnut	A slight resinous aromatic associated with fresh green pine needles.	Warmund <i>et al.</i> (2009a) Lee <i>et al.</i> (2011)
Rancid	black walnut	Aromatic commonly associated with oxidized fat and oils.	Warmund <i>et al.</i> (2009a) Lee <i>et al.</i> (2011)
Rancid flavor	English walnut	N/A	Guerrero <i>et al.</i> (2000) Sinesio <i>et al.</i> (2001)
Raw (almond)	almond	Aromatics associated with uncooked beans or legumes.	Civille <i>et al.</i> (2010)



Attribute	Nut Type	Definition	Source
Raw bean/peanutty	peanut	The aromatic associated with light-roast peanuts (about 1-2 on USDA color chips) and having legume-like character (specify beans or pea if possible).	Johnsen <i>et al.</i> (1988) Ng and Dunford (2009)
Raw/beany	peanut	N/A	Isleib <i>et al.</i> (2006)
Red fruit	almond	Total aromatics associated with red berries, including the synthesized, raw, and cooked notes of berries, such as strawberries, raspberries, and cherries.	Civille <i>et al.</i> (2010)
Roasted (almond)	almond	Aromatics associated with almonds that have been roasted.	Civille <i>et al.</i> (2010)
Roasted peanut	peanut	N/A	Isleib <i>et al.</i> (2006)
Roasted peanut	peanut	N/A	Isleib <i>et al.</i> (2006)
Roasted peanutty	peanut	The aromatic associated with medium-roast peanuts (about 3-4 on USDA color chips) and having fragrant character such as methyl pyrazine.	Johnsen <i>et al.</i> (1988) Ng and Dunford (2009)
Skunky/mercaptan	peanut	The aromatic associated with sulfur compounds, such as mercaptan, which exhibit skunk-like character.	Johnsen <i>et al.</i> (1988) Ng and Dunford (2009)
Stale/cardboardy	English and black walnut	Aromatic of wet cardboard and associated with slightly oxidized oils.	Warmund <i>et al.</i> (2009b)
Sweet aromatics	almond	Aromatics associated with products that smell sweet, such as honey, maple syrup, brown sugar, and vanilla	Civille <i>et al.</i> (2010)

Attribute	Nut Type	Definition	Source
Sweet taste	English walnut	N/A	Guerrero <i>et al.</i> (2000) Sinesio <i>et al.</i> (2001)
Sweetness	English walnut	N/A	Ingels <i>et al.</i> (1990) Sinesio and Moneta (1997)
Under-roast	peanut	N/A	Isleib <i>et al.</i> (2006)
Walnut	almond	Aromatics associated with walnuts.	Civille <i>et al.</i> (2010)
Walnut flavor	English walnut	N/A	Ingels <i>et al.</i> (1990)
Wood/hull/skins	peanut	N/A	Isleib <i>et al.</i> (2006)
Woody	almond	Aromatics associated with the general category of wood.	Civille <i>et al.</i> (2010)
Woody	black walnut	Sweet, brown, musty, dark, dry aromatics associated with the bark of a tree.	Warmund <i>et al.</i> (2009a)
Woody odor	English walnut	N/A	Guerrero <i>et al.</i> (2000) Sinesio <i>et al.</i> (2001)
Woody/hulls/skins	peanut	The aromatics associated with base peanut character (absence of fragrant top notes) and related to dry wood, peanut hulls, and skins.	Johnsen <i>et al.</i> (1988) Ng and Dunford (2009)
Woody/hulls/skins	English and black walnut	Aromatic associated with the outer protective coating of the nut, a dry wood note.	Warmund <i>et al.</i> (2009b)

### ***Descriptive Analysis***

Descriptive analysis on specific nuts varies with some species of nuts receiving more attention than others. The analysis methods also vary from broad and sometimes ambiguous scales to very detailed and precise measurement tools. A recent study on pistachios (*Pistachia vera* L.) utilized sensory analysis to differentiate cultivars using an untrained panel for evaluation on appearance characteristics and overall flavor. The scale used was a basic five-point scale with 1=unacceptable, 2=poor, 3=fair, 4=good, and 5=excellent (Tsantili *et al.* 2010).

Several descriptive sensory studies focus on peanut flavor characteristics. Johnsen *et al.* (1988) developed a lexicon for peanut flavor, while Isleib *et al.* (2006) compared sensory aspects between normal- and high-oleic peanuts, and Ng and Dunford (2009) studied flavor attributes for peanut cultivars grown in the southwestern US. Peanuts, while classified as a legume, are the most commonly consumed nut, justifying the greater amount of research focusing on peanuts' sensory properties (Mintel 2011).

One comprehensive work (Civille *et al.* 2011) on a particular nut's sensory profile used almond cultivars. The authors developed a 78-term lexicon covering appearance, aroma, flavor, and texture attributes of the seven most popular almond cultivars. The study exemplifies good execution and provides ideal detail quality desirable for characterizing any nut species.

### ***Consumer Studies***

Few studies evaluate consumer liking and preference on nuts and nut-related products. Australian consumers evaluated macadamia nuts (*Macadamia spp.*) for liking of appearance, flavor, texture, and aftertaste using a continuous line scale. This data was then correlated with descriptive analysis to determine the sensory drivers of consumer acceptance of Macadamia nuts (O'Riordan *et al.* 2005). Sacchetti *et al.* (2009) evaluated roasted chestnut (*Castanea sativa* Mill.) samples from fresh and frozen nuts for expectation and consumer liking in two tests where processing information either was or was not provided.

Consumer studies with nut-based products also have been conducted. One study evaluated consumer acceptability and consumption intent for bread samples enriched with nut pastes from four different nut sources: peanut, almond, hazelnut, and walnut (Oliete *et al.* 2008), while another paper reported consumer acceptability of a snack product with a peanut-based meat analogue (Rehrah *et al.* 2009). Both papers include acceptable methods and appropriate

hedonic scales, but fewer than 100 consumers were recruited resulting in the statistics to be somewhat unreliable.

The aforementioned descriptive and consumer studies represent a small selection of the research being carried out on nuts and nut-related products but does not cover this topic's full scope of literature.

### ***English Walnuts***

Despite English (Persian) walnuts being well-known, the amount of research profiling its sensory characteristics is still minimal. Additionally, the majority of the work has been conducted in Europe with varying degrees of panel training (Ingels *et al.* 1990; Sinesio and Moneta 1997; Guerrero *et al.* 2000; Sinesio *et al.* 2001).

Ingels *et al.* (1990) used a semi-trained panel to determine flavor differences among eight English walnut cultivars utilizing the duo-trio and paired test methods. This study did not prioritize establishing a walnut flavor lexicon, but attributes (i.e., sweet, astringent, overall walnut flavor, and firmness) were used to evaluate differences among the cultivars in the paired tests.

Trained panelists assessed cultivar and geographical effect on sensory attributes of walnuts in research by Sinesio and Moneta (1997). The panel generated 15 terms covering external shell and kernel appearance, color, visual, manual and oral texture, and taste/flavor to describe the 18 samples. Sinesio *et al.* (2001) also used trained panelists for their assessment of cultivar and geographic effect on sensory attributes. The study used three separate panels in different countries (Spain, France, and Italy) to determine significant attributes common to 13 different walnut samples. As in Sinesio and Moneta's (1997) study, descriptors were included for shell, kernel, flavor, and texture characteristics (Sinesio *et al.* 2001).

Guerrero *et al.* (2000) used trained and untrained panels to evaluate six walnut samples (differing by cultivar, geographic origin, and post-harvest treatment). Both panels generated terms for the final lexicon of 18 attributes covering visual, olfactory, flavor, and oral texture. While the untrained panel did not add new terms to the lexicon, their inclusion demonstrated the lexicon's simplicity and ease of use. Researchers found only 10 attributes (i.e., sweetness, skin color, kernel veins, brightness, color uniformity, roughness, bitterness, astringency, sourness of the skin, and flour flavor) were necessary to classify the samples (Guerrero *et al.* 2000).

## ***Black Walnuts***

Like English walnuts, sensory research on black walnuts is sparse, and few cultivars have undergone descriptive and/or analytical analyses. Consumer data is almost non-existent with only one study on a black walnut food product having been conducted.

### ***Husk Characteristics on Kernel Quality***

As stated previously, the husk surrounding the black walnut shell can adversely affect the flavor of the black walnut kernels. Light-colored kernels tending to have milder flavor are viewed more favorably than dark-colored kernels which tend to have an increased bitterness. If the husk remains on the shell for an extended time period post-harvest, juices from the decomposing husk can seep into the shell, darkening the kernels and imparting a more pronounced bitter flavor (Thomas and Shumann 1993; Reid *et al.* 2009).

For two consecutive years black walnuts were collected by Brawner and Warmund (2008) to study the effect of husk softening on kernel characteristics for three black walnut cultivars: Emma K, Kwik Krop, and Sparrow. Black walnuts from each cultivar were harvested weekly for five consecutive weeks with the third week denoted as the “usual” date of harvest. The authors used a standard denting method (grasping the walnut and depressing the husk with the thumb to leave an imprint) and a durometer to measure husk softness and related harvest dates with their effect on percent kernel, husk, and kernel colors (Brawner and Warmund 2008).

The percentage of husks that dented generally increased with successive harvest dates for all three cultivars. Denting determines when the black walnuts are ready to be harvested. Optimum harvest occurs when 5-50% of the walnut husks remain dented after lifting the thumb. Additionally, percent kernel increased with successive harvest dates with the greatest percent kernel retrieved occurring at or near 100% denting (Brawner and Warmund 2008).

Researchers measured husk and kernel colors ( $L^*$ , chroma, and hue angle) with a handheld spectrophotometer and sorted kernels into light, medium, and dark categories. Hue angle values for husks generally decreased (became more yellow-green) with later harvest dates and kernel color darkened with later harvest dates. Researchers determined that light-colored kernels had LCH sums ( $L^* + \text{chroma} + \text{hue angle}$ )  $\geq 150$ , medium-colored had LCH sums from 149-126, and dark-colored had LCH sums  $\leq 125$  (Brawner and Warmund 2008).

Warmund (2008) conducted a follow-up study researching delayed husk hulling and its effect on kernel color. Emma K, Kwik Krop, and Sparrow black walnut cultivars were harvested weekly over a consecutive five-week period. Each week individual cultivar nuts were randomly assigned to either an immediate or a two-week delayed hulling (removing the outer husk) treatment. Kernel color ( $L^*$ , chroma, and hue angle) was measured with a handheld spectrophotometer and overall indicated decreased color (i.e., dark colored walnuts) for all three cultivars resulting in dark-colored walnuts (Warmund 2008). These two studies indicate a trade-off between high percent kernel and light-colored kernels.

### ***Descriptive Analysis of Black Walnuts***

Very little formal work on describing the sensory attributes of black walnuts has been completed; however, annual informal tastings and evaluation of black walnut kernels have been conducted by the University of Missouri and various nut grower associations in Missouri, Nebraska, and Iowa to assist producers in determining which cultivars to plant and grow (Warmund *et al.* 2009b). Warmund *et al.* (2009b) took the initial step to standardize sensory analysis of black walnut cultivars by conducting descriptive analysis on both black and English (Persian) walnuts. The authors evaluated the aroma, flavor, and texture of kernels from six black walnut cultivars (Emma K, Football, Jackson, Kwik Krop, Sparks 127, and Sparrow), one wild black walnut species, and two English walnut cultivars (Tulare and Chandler) by using descriptive sensory analysis. Analysis used only kernels classified as medium-colored (LCH sum values 126-149). Research compiled 22 sensory attributes describing the samples (one aroma, 11 flavor, and 10 textural terms). Results indicated that 20 of the 22 attributes applied to both English and black walnuts; however, English walnuts were less aromatic than black walnuts. Black walnuts were distinguished from English cultivars by their fruity, musty, and sweeter characteristics. Research indicated few sensory differences among black walnut cultivars and the wild species, while overall aroma, fruity, woody, musty, and sweet notes varied within the six improved black walnut cultivars (Warmund *et al.* 2009b).

A second descriptive analysis study (Warmund *et al.* 2009a) compared flavor attributes of light-, medium-, and dark-colored kernels of black walnut cultivars Emma K, Kwik Krop, and Sparks 127; the study also included one wild black walnut species. The trained panel generated 18 flavor descriptors and evaluated samples of each color classification for each cultivar. Results indicated that kernel color affected six attributes (burnt, musty/dusty, oily, woody,

astringent, and sour) with brown as the only varying attribute in the wild species samples. Additionally, color and flavor varied more in the Emma K and Sparks 127 cultivars than in the Kwik Krop and wild (Warmund *et al.* 2009a).

### ***Volatile Compounds and Sensory***

Lee *et al.* (2011) expanded previous research (Warmund *et al.* 2009a) by investigating the volatile compounds associated with light-, medium-, and dark-colored black walnuts and their influence on the walnuts' sensory profiles. The same three cultivars, Emma K, Kwik Krop, and Sparks 127 and one wild species were used as in Warmund *et al.* (2009a). Lee *et al.* (2011) found 34 aromatic compounds in the black walnut cultivars using solid-phase microextraction-gas chromatography-mass spectrometry. In comparison, English walnuts contain 110 aromatic compounds, thus, illustrating the similarities between black and English walnuts, key differences still exist (Warmund *et al.* 2009b; Lee *et al.* 2011).

Among the 34 compounds, 14 esters were present contributing the floral and fruity aromas that distinguish black walnuts from English walnuts. Two furan compounds supplied the overall nutty aroma in the samples. Aldehydes (two) and alcohols (five) were related with rancid and acrid notes. Hexanal was related with musty/earthy, rancid and acrid notes and was the differentiating factor of dark-colored kernels from medium- and light-colored kernels. Light-colored kernels held a higher total concentration of aromatic compounds than all other medium- and dark-colored sample cultivars (Lee *et al.* 2011).

### ***Black Walnut Syrup***

Matta *et al.* (2005) conducted descriptive and consumer sensory analysis of black walnut syrup. As research indicates, this study alone evaluates the sensory properties of a black walnut food product. For the descriptive portion, Matta *et al.* (2005) developed a 15-term lexicon for three black walnut syrup samples (50%:50% walnut syrup/cane sugar, 85%:15% walnut syrup/cane sugar, and 100% pure walnut syrup). Researchers also developed lexicons for commercial maple-flavored table syrup and two pure maple syrup samples and compared attributes among all samples. The authors found that the pure maple and walnut syrups were more complex in attributes and contained similar sensory profiles, while the table syrup was a simple product described with only four attributes (Matta *et al.* 2005).

Researchers conducted two consumer tests, completed in consecutive years, to compare degree of liking for the pure black walnut, pure maple, and table syrup samples. They evaluated the samples for overall liking, sweetness, and aftertaste using a 9-point hedonic scale, where 1=dislike extremely and 9=like extremely. In both consumer tests, table syrup was liked best among the three samples. The pure maple and black walnut samples did not differ significantly from each other in degree of liking, suggesting a niche market of syrup users (Matta *et al.* 2005).

### **Research Objectives**

To date, adequate research evaluating the sensory aspects of various black walnut cultivars remains absent. Therefore information presented in the current study may prove useful to walnut growers wishing to establish optimum black walnut orchards. Because black walnut consumption occurs mainly as a dessert ingredient or confectionary item, data collection on changes in black walnut sensory attributes when incorporated into specific food items proves relevant. Only one consumer study exists evaluating acceptance of a black walnut food product. Therefore, this paper aimed to determine: 1) differences in flavor attributes among black walnut cultivars using descriptive sensory analysis; 2) differences in flavor attributes among black walnut cultivars in a cookie base using descriptive sensory analysis; and 3) consumer liking and flavor intensity of black walnut cookies. Additionally, to better understand consumer acceptance of black walnut cultivars the researcher correlated the consumer acceptance data with the descriptive data on the black walnut cookies.



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## **Chapter 2 - Materials and Methods**

### **Section 1 – Descriptive Analysis of Flavor Characteristics among Black Walnut Cultivars**

#### ***Samples***

I obtained seven black walnut cultivars (~9.1 kg per cultivar, in shell) from a walnut orchard in Joplin, MO. The cultivars included: Brown Nugget, Davidson, Emma K, Football, Sparks 127, Sparrow, and Tomboy. The black walnuts were transported to the Sensory Analysis Center (Manhattan, KS) on November 4, 2011. The black walnuts dried in their shells for 5 days at room temperature ( $23\text{C} \pm 1\text{C}$ ). Walnut shelling was completed over 13 days using a Duke Pecan Walnut Cracker (Duke Pecan Company, West Point, MS) and Channel Lock model number 436, 15.24 cm cutting pliers (Channel Lock Inc., Meadville, PA) to remove the nutmeat from the shells. Samples were transferred to 3.8 L glass jars and kept under frozen conditions ( $-26\text{C} \pm 1\text{C}$ ) to maintain freshness and delay oil oxidation in the nuts (Reid 2011).

#### ***Sample Preparation***

After shelling, the nuts were removed from the freezer and chopped with an OXO Good Grips® manual hand chopper (OXO, New York, NY). Three depressions of the chopping plunger chopped the nuts. The black walnuts were returned to their respective glass jars and taken to the Experimental Milling Lab in Shellenberger Hall at Kansas State University. To obtain approximately equal-sized pieces of nutmeat, the black walnuts were passed through a set of sieving frames (30.48 cm square frames with stainless steel wiring and square holes) to sort the nuts (Grain Science and Industry, Kansas State University, Manhattan, KS). A cleaner frame (i.e., sieve) was set on top of a number-four frame with a tray frame underneath. The black walnuts were dispensed on top of the cleaner frame, and all three frames were shaken gently to sieve the nuts. Black walnut pieces used for evaluation remained in between the cleaner and number-four frame, while the nut pieces collected by the cleaner frame were too small for evaluation and placed in separate glass jars. Nut pieces remaining on the cleaner frame's top were re-chopped and sieved again. The black walnuts were placed back in their respective glass jars and stored under frozen conditions ( $-26\text{C} \pm 1\text{C}$ ) until evaluation.

### ***Panelists***

Seven panelists (six female, one male) from the Sensory Analysis Center at Kansas State University in Manhattan, KS were selected for descriptive evaluation of the black walnuts. All panelists completed 120 h of general training in descriptive analysis methodology, and each panelist had over 2,000 h of testing experience with a wide variety of food items. Three panelists had prior experience on evaluating nut-related samples.

### ***Orientation and Lexicon Development***

The researcher used six, 90 min sessions to orient panelists to all seven samples and develop the ballot and lexicon for evaluation. Panelists were provided with an initial lexicon adapted from two previous studies on black walnut syrup and nutty attributes, respectively (Matta *et al.* 2005; Miller *et al.* 2013). Panelists tasted the samples one at a time then wrote down all perceived flavor attributes associated with that sample. After tasting, panelists engaged in open discussion to refine terminology and add/delete terms from the lexicon as necessary. The attributes were grouped in order of dominance with the most dominant flavors appearing at the beginning of the lexicon and the lesser dominant terms appearing toward the end. The same attribute grouping style was applied to the ballot so that the listing of attributes matched between lexicon and ballot. Panelists also discussed appropriate serving size and evaluation procedures and practiced balloting several samples to ensure consistency in evaluation techniques. Open discussion clarified any confusion in intensity scoring. All samples were at room temperature ( $23^{\circ}\text{C} \pm 1^{\circ}\text{C}$ ) for tasting.

Orientation sessions also were used to refine definitions and references for the attributes. Panelists were provided with all references listed in the lexicon and tasted them to ensure suitability for evaluation against the black walnuts. In some instances, the definition and/or reference was changed to better reflect the character of the black walnut samples. Panel members changed the ‘black walnut’ attribute to ‘black walnut ID’ and altered the definition to include sweet, musty/dusty, floral/fruity, and fruity-dark attributes. Additionally, the reference used for ‘black walnut ID’ was changed from a flavor extract to ground pieces of various black walnut cultivars. The final lexicon included 22 flavor attributes including astringent and three basic tastes (bitter, sour, and sweet). Table 2-1 lists the attributes, definitions, and references used for testing.

**Table 2-1.** Flavor attributes, definitions, and references for descriptive analysis of black walnuts<sup>†</sup>

Attribute	Definition	References
Black Walnut ID	Aromatics associated with black walnuts including musty/earthy, piney, woody, brown, sweet, buttery, oily, astringent, and slightly acrid aromatics; other aromatics may include musty/dusty, floral/fruity, and/or fruity-dark.	Ground black walnut pieces = 12.0 <u>Preparation:</u> Measure out 1 tbsp each of various cultivars into a food processor and blend for 30 s. Serve in 1 fl oz cups.
Overall Nutty	Measurement reflecting the total of nutty characteristics and the degree to which these characteristics fit together. Nutty characteristics are: sweet, oily, light brown, slightly musty and/or buttery, earthy, woody, astringent, bitter, etc. (e.g., nuts, wheat germ, certain whole grains).	Gold Medal whole wheat flour = 4.5 Kretschmer Wheat Germ = 7.5 Mixture of Diamond slivered almonds and Kroger chopped hazelnuts = 7.5 <u>Preparation:</u> Puree the almonds and hazelnuts separately in blenders for 45 s on high speed. Combine equal amounts of the chopped nuts. Serve in 1 fl oz cups. Diamond shelled walnuts = 8.0 Diamond pecan halves = 9.0
Nutty-Woody	Nutty aromatic characterized by the presence of woodiness, increased musty/dustiness, brown, astringent, and bitter.	Diamond pecan halves = 7.5 Diamond shelled walnuts = 7.5
Nutty-Grain-like	Nutty aromatic characterized by the presence of a grainy aromatic, increased musty/dustiness, and brown.	Gold Medal whole wheat flour = 4.5 Kretschmer Wheat Germ = 7.5
Nutty-Buttery	Nutty aromatic characterized by a buttery impression, and/or increased fatty aromatics and musty/earthy character.	HyVee dry roasted and salted Macadamia nuts = 5.0

Attribute	Definition	References
Brown	Rich, full aromatic impression always characterized with some degree of darkness generally associated with certain attributes (e.g., toasted, nutty, sweet).	<p>Bush's Best pinto beans (canned) = 5.0  <u>Preparation:</u> Drain beans and rinse with de-ionized water. Serve in 1 fl oz cups.</p> <p>Kretschmer Wheat Germ = 7.5  Sethness AP 100 Caramel Color (full strength) = 13.0 (aroma)  <u>Preparation:</u> Place 1/2 tsp caramel color in a medium snifter. Cover.</p>
Caramelized	Round, full-bodied, medium brown aromatic	<p>C&amp;H golden brown sugar = 7.5 (aroma)  C&amp;H golden brown sugar = 9.0 (flavor)</p>
Acrid	Sharp/acrid, charred flavor note associated with something over-baked or excessively browned in oil.	Alf's Natural Nutrition puffed red wheat cereal = 3.0
Burnt	Dark, brown, somewhat sharp, over-baked grain aromatic.	Alf's Natural Nutrition puffed red wheat cereal = 4.0
Floral/Fruity	Sweet, light, aromatics impression associated with flowers and fruits.	<p>Welch's white grape juice = 5.0  <u>Preparation:</u> Dilute 1 part juice with 1 part de-ionized water.</p>

Attribute	Definition	References
Fruity-dark	Sweet, brown, honey/caramel-like aromatics commonly associated with dark fruits such as raisins and prunes that have been cooked.	<p>1/4 c Sun Maid raisins, 1/3 c Ocean Spray dried cranberries, 1/4 c Sun Maid prunes, and 3/4 c water = 5.0 (flavor), 7.0 (aroma)</p> <p><u>Preparation:</u> Mix raisins, dried cranberries, and prunes (chopped). Add 3/4 c de-ionized water and cook in a microwave oven on high power for 2 min. Pour juice into 1 fl oz c. Put 1 tsp of cooked fruit with at least 1 piece of the chopped cooked prunes in a medium snifter. Cover.</p>
Piney	Slight resinous aromatic associated with fresh green pine needles.	Kroger pine nuts = 6.0
Musty/Dusty	Dry, dirt-like aromatic associated with dry, brown soil.	<p>Potato peel = 5.0 (aroma)</p> <p><u>Preparation:</u> Place 0.5 g potato peel in a medium snifter. Cover.</p>
Musty/Earthy	Humus-like aromatics that may or may not include damp soil, decaying vegetation, or cellar-like characteristics.	<p>Sliced button mushroom = 8.5 (aroma)</p> <p><u>Preparation:</u> Place 3 slices of mushroom in a medium snifter. Cover.</p>



Attribute	Definition	References
Woody	Sweet, brown, musty, dark, dry aromatics associated with the bark of a tree.	Diamond shelled walnuts = 4.0 Sigma-Aldrich Cedarwood oil, Virginia = 6.5 (aroma) <u>Preparation:</u> Place 1 drop oil on a cotton ball in a medium snifter. Cover.
Overall Sweet	Aromatic associated with the impression of sweet substances.	Post Shredded Wheat cereal = 1.5 General Mills Wheaties cereal = 3.0 Lorna Doone Cookie = 4.5
Oily	Light aromatics associated with vegetable oil such as corn or soybean oil.	Kroger slivered almonds = 4.0 HyVee dry roasted and salted Macadamia nuts = 9.0
Rancid	Aromatic commonly associated with oxidized fat and oils.	Wesson vegetable oil = 2.5 <u>Preparation:</u> Measure 1/3 c oil in liquid measuring cup. Cook in a microwave oven on high power for 2.5 min. Let cool and pour into 1 fl oz cups.
Astringent	Feeling of a puckering or a tingling sensation on the surface and/or edge of the tongue and mouth.	0.030% Alum solution = 1.5 0.050% Alum solution = 2.5 0.075% Alum solution = 3.5
Bitter	Fundamental taste factor of which caffeine is typical.	0.010% Caffeine solution = 2.0 0.020% Caffeine solution = 3.5 0.035% Caffeine solution = 5.0

Attribute	Definition	References
Sour	Fundamental taste factor of which citric acid is typical.	0.015% Citric acid solution = 1.5 0.025% Citric acid solution = 2.5
Sweet	Fundamental taste factor of which sucrose is typical.	1.0% Sucrose solution = 1.0

†0-15-point numeric scale with 0.5 increments was used to rate the intensities of the samples and references.

### ***Test Design and Sample Evaluation***

Based on previous research using a method for taste-testing experimentation (Ferris 1957) this study constructed its test designs from a series of modified William's Latin Squares (Hunter 1996). Kuehl (2000) provides a succinct definition of the Latin Square design:

The Latin square arrangement derives from an arrangement of the Latin letters A, B, C, ... into a square array such that each letter appears once in each column and once in each row of the square. In applications to experiments, the rows and columns of the array are identified with the two blocking criteria and the Latin letters are identified with the treatments.

Table 2-2 illustrates an example of a Latin Square design. This study modified the Latin Squares to adjust for first-order residual effects, meaning that order of treatments within the Latin Square also are randomized ensuring each sample was seen in each position (1,2,3,...,7) exactly once when viewed either by columns or rows.

**Table 2-2.** Example of a Latin Square design

Blocking factor 2	Blocking factor 1			
	1	2	3	4
1	A	B	C	D
2	B	C	D	A
3	C	D	A	B
4	D	A	B	C

Table 2-3 shows an example of this modified Latin Square. This design provided a complete Latin Square meaning that seven panelists and seven samples were chosen for evaluation, thus creating a perfect square. The researcher completed computation of the Latin Squares for all descriptive evaluation phases in SAS® statistical software (version 9.2, SAS Institute Inc., Cary, NC). The SAS® code for the modified Latin Square designs can be found in Appendix A.

**Table 2-3.** Example of a modified Latin Square design

	Blocking factor 1			
Blocking factor 2	1	2	3	4
1	A	B	C	D
2	B	C	D	A
3	D	A	B	C
4	C	D	A	B

Panelists evaluated the seven black walnuts in triple replicate for each cultivar. One replication on the black walnut samples was completed in 1 day during 105 min evaluation sessions, for 3 day duration. Appendix B illustrates the complete test design for the black walnut evaluation.

The black walnuts were removed from the freezer the afternoon prior to testing and allowed to thaw at room temperature ( $23\text{C} \pm 1\text{C}$ ) prior to evaluation. The morning of evaluation each panelist was served 12 g of each cultivar in a plastic 96 mL cup with plastic lid (Solo Cup Company, Lake Forest, IL). The cups were labeled with a three-digit blinding code. Panelists sat at a round table under ambient lighting and temperature conditions. Panelists scored the samples individually on paper ballots with erasable red pencils. Researchers used a hybrid method based on the Flavor Profile Method (Keane 1992), and panelists evaluated attribute intensities by scoring a ballot (Appendix C) containing a 0-15-point numerical scale with 0.5 increments, where 0.0 = none/not present and 15.0 = highest possible intensity. A tray with references for the flavor attributes was provided for each panelist along with definition/reference sheets (Appendix D). Panelists took either two similarly-sized larger or three similarly-sized smaller pieces of black walnut (as determined during orientation to ensure approximately equal sampling amounts) into their mouths and chewed until well masticated before scoring the intensities of attributes. Panelists were encouraged to expectorate; however, panelists were instructed to swallow at least one bite of each sample. Reverse osmosis, de-ionized water, baby carrots, 1.27 cm Mozzarella cheese cubes (low moisture, part skim; Kroger Company, Cincinnati, OH), and 0.32 cm skinless cucumber slices were used as palate cleansers, and soft-bristled toothbrushes (Kroger Company, Cincinnati, OH) were provided to reduce tooth-packing

build-up from the samples. Sample evaluation took ~10 min, and a 5 min rest period was instilled in between samples to reduce flavor carryover.

### *Statistical Analysis*

I performed analysis of variance (ANOVA) to test the significance of each flavor attribute across cultivars at the 5% level of significance. Using Fisher's protected Least Significant Difference (LSD) post-hoc means separation was also analyzed at the 5% level of significance. Statistical analyses were performed with SAS® statistical software (SAS® version 9.2, SAS Institute Inc., Cary, NC) (Appendix A) using PROC MIXED.

The researcher conducted principal components analysis (PCA) using the covariance matrix to evaluate the relationship(s) among attributes and cultivars. A PCA biplot visually depicts the spatial arrangement of the attributes and samples in order to draw conclusions on which attribute(s) describe particular sample(s). The researcher used the Unscrambler software (The Unscrambler X version 10.1, Camo Software AS, Oslo, Norway) to perform the analysis.

## **Section 2 – Descriptive Analysis of Flavor Characteristics of Black Walnut Cultivars in a Sugar Cookie Base**

### ***Samples***

Samples were the same seven black walnut cultivars used in the black walnut kernel evaluation: Brown Nugget, Davidson, Emma K, Football, Sparks 127, Sparrow, and Tomboy. The black walnuts had been previously shelled, chopped, and sieved according to the methods detailed in Section One. The samples were stored in 128 oz sized glass jars in a walk-in freezer ( $-26^{\circ}\text{C} \pm 1^{\circ}\text{C}$ ) to maintain freshness and delay oxidation of the natural oils until the samples were incorporated into the sugar cookies (Reid 2011).

### ***Cookie Preparation and Baking Method***

I selected a basic sugar cookie recipe from the American Association of Cereal Chemists (AACC) as a food carrier for the black walnuts (AACC International Method 10-53.01). Because certain supplies were not readily available researchers made some modifications to streamline preparation and baking processes. Rubber dough guides (Regency Evendough Bands, Regency Wraps Inc., Dallas, TX) placed on the ends of 26.5 cm wooden rolling pins, measuring 9.5 mm thick, were used in place of the 7.0 mm metal gauge strips to ensure even thickness of the cookie dough. Cookie cutters, 63.5 mm diameter, replaced the 60 mm cookie cutters specified in the original AACC method. I imposed these modifications due to local availability of supplies. Appendix E contains both the original and modified recipe and preparation procedures.

Black walnuts were removed from the freezer the day before preparing the cookies and allowed to thaw at room temperature ( $23^{\circ}\text{C} \pm 1^{\circ}\text{C}$ ). Ingredients were weighed out using a digital scale (model SI-4001, Denver Instrument, Bohemia, NY) then mixed according to the AACC procedures in a 575 watt KitchenAid stand mixer with 6 qt bowl and paddle attachment (KitchenAid Professional 600, model KP26M1XWH, Whirlpool Corporation, Benton Harbor, MI). For each cultivar, researchers added 90 g (40% by flour weight) of black walnut kernels to the cookie recipe and incorporated the kernels along with the flour into the dough. The dough was rolled out on a lightly-floured countertop with a wooden rolling pin and rubber dough guides placed on the ends of the rolling pin. In order to streamline the process, one mass of dough was

rolled out rather than eight divided portions as stated in the original AACC procedures. A metal cookie cutter measuring 63.5 mm in diameter was used to cut out the cookies from the dough. The cookies were scored into one-eighths using the edge of a metal spatula to ensure a controlled bite amount for panelists evaluating the samples. Each batch of cookie dough yielded approximately 11 cookies.

The cookies were baked in an electric oven (model RB160PXYB, Whirlpool Corporation, Benton Harbor, MI) for 11 min on a lightly greased metal baking sheet, rotating the baking sheet halfway through the baking time ensuring even browning of the cookies. Cookies cooled on the baking sheet for 5 min before being removed to a metal baking rack to cool completely. Once cooled, the cookies were placed in gallon-sized re-sealable plastic bags (Ziploc® brand freezer bags with Smart Zip® seal, S.C. Johnson & Son Inc., Racine, WI) and labeled with the date, cultivar name, and batch number. Black walnut cookies were stored under frozen conditions ( $-26\text{C} \pm 1\text{C}$ ) for one week prior to evaluation.

### ***Panelists***

The researcher used seven (six female, one male) highly trained descriptive analysis panelists from the Sensory Analysis Center (Manhattan, KS) for evaluation of the black walnut cookies. The panelists had 120 h of general descriptive analysis training, over 2,000 h of evaluation experience with a wide array of food products, and had previously evaluated black walnut kernel samples (Section 1 – Changes in Sensory Characteristics among Black Walnut Cultivars). Three panelists also had prior experience on evaluating nut-related samples.

### ***Orientation and Lexicon Development***

Two, 90 min orientation sessions were held to familiarize the panelists with the samples and to refine the lexicon and ballot used for evaluation. During these sessions, panelists tasted the samples and used the lexicon from the black walnut kernel testing to determine applicable attributes for the black walnut cookies. The panelists engaged in open discussion to add or delete any terms from the lexicon and tested the references for the attributes to determine appropriateness. The final lexicon contained 25 attributes with the basic tastes, bitter, salty, sour, sweet, as well as astringent. Table 2-4 lists the attributes, definitions, and references used for evaluation.

The order of attributes listed on the ballot was determined during orientation. Panelists listed the more prominent attributes toward the beginning of the ballot and grouped similar terms together, i.e., overall sweet, brown sweet, and sweet were listed together on the ballot providing smooth evaluation flow. Sample amounts for evaluation purposes and a standard evaluation protocol were also established. Panelists practiced balloting a few samples to ensure consistent evaluation procedures. All samples were served at room temperature ( $23\text{C} \pm 1\text{C}$ ) for tasting.



**Table 2-4.** Flavor attributes, definitions, and references for descriptive analysis of black walnut cookies<sup>†</sup>

Attribute	Definition	References
Black Walnut ID	Aromatics associated with black walnuts including musty/earthy, piney, woody, brown, sweet, buttery, oily, astringent, and slightly acrid aromatics; other aromatics may include musty/dusty, floral/fruity, and/or fruity-dark.	Ground black walnut pieces = 12.0 <u>Preparation:</u> Measure out 1 tbsp each of various cultivars into a food processor and blend for 30 s. Serve in 1 fl oz cups.
Overall Nutty	Measurement reflecting the total of nutty characteristics and the degree to which these characteristics fit together. Nutty characteristics are: sweet, oily, light brown, slightly musty and/or buttery, earthy, woody, astringent, bitter, etc. (e.g., nuts, wheat germ, certain whole grains).	Gold Medal whole wheat flour = 4.5 Kretschmer Wheat Germ = 7.5 Mixture of Diamond slivered almonds and Kroger chopped hazelnuts = 7.5 <u>Preparation:</u> Puree the almonds and hazelnuts separately in blenders for 45 s on high speed. Combine equal amounts of the chopped nuts. Serve in 1 fl oz cups. Diamond shelled walnuts = 8.0 Diamond pecan halves = 9.0
Nutty-Woody	Nutty aromatic characterized by the presence of woodiness, increased musty/dustiness, brown, astringent, and bitter.	Diamond pecan halves = 7.5 Diamond shelled walnuts = 7.5
Nutty-Grain-like	Nutty aromatic characterized by the presence of a grainy aromatic, increased musty/dustiness, and brown.	Gold Medal whole wheat flour = 4.5 Kretschmer Wheat Germ = 7.5
Nutty-Buttery	Nutty aromatic characterized by a buttery impression, and/or increased fatty aromatics and musty/earthy character.	HyVee dry roasted and salted Macadamia nuts = 5.0

Attribute	Definition	References
Brown	Rich, full aromatic impression always characterized with some degree of darkness generally associated with certain attributes (e.g., toasted, nutty, sweet).	Bush's Best pinto beans (canned) = 5.0 <u>Preparation:</u> Drain beans and rinse with de-ionized water. Serve in 1 fl oz cups. Kretschmer Wheat Germ = 7.5 Sethness AP 100 Caramel Color (full strength) = 13.0 (aroma) <u>Preparation:</u> Place ½ tsp caramel color in a medium snifter. Cover.
Flour-like	General term used to describe the light dusty/musty aromatics associated with wheat.	Gold Medal all-purpose flour = 5.0
Leavening	Aromatics associated with baking soda and/or baking powder in baked flour products.	Pancake = 7.0 <u>Preparation:</u> Mix 1 c all-purpose flour, 1 tsp baking soda, 1/8 tsp salt, and 3/4 c water in a bowl. Cook on a skillet over medium to medium-high heat. Do not let either side brown. Cut edges off pancake and discard. Cut the remaining pancake into cubes and serve in 3.25 fl oz cups.
Toasted	Brown, baked aromatic that may occur with grain products.	General Mills Cheerios cereal = 7.0
Acrid	Sharp/acrid, charred flavor note associated with something over-baked or excessively browned in oil.	Alf's Natural Nutrition puffed red wheat cereal = 3.0

Attribute	Definition	References
Floral/Fruity	Sweet, light, aromatics impression associated with flowers and fruits.	Welch's white grape juice = 5.0 <u>Preparation:</u> Dilute 1 part juice with 1 part de-ionized water.
Fruity-dark	Sweet, brown, honey/caramel-like aromatics commonly associated with dark fruits such as raisins and prunes that have been cooked.	1/4 c Sun Maid raisins, 1/3 c Ocean Spray dried cranberries, 1/4 c Sun Maid prunes, and 3/4 c water = 5.0 (flavor), 7.0 (aroma)  <u>Preparation:</u> Mix raisins, dried cranberries, and prunes (chopped). Add 3/4 c de-ionized water and cook in a microwave oven on high power for 2 min. Pour juice into 1 fl oz cups. Put 1 tsp of cooked fruit with at least 1 piece of the chopped cooked prunes in a medium snifter. Cover.
Piney	Slight resinous aromatic associated with fresh green pine needles.	Kroger pine nuts = 6.0
Musty/Dusty	Dry, dirt-like aromatic associated with dry, brown soil.	Potato peel = 5.0 (aroma) <u>Preparation:</u> Place 0.5 g potato peel in a medium snifter. Cover.
Musty/Earthy	Humus-like aromatics that may or may not include damp soil, decaying vegetation, or cellar-like characteristics.	Sliced button mushroom = 8.5 (aroma) <u>Preparation:</u> Place 3 slices of mushroom in a medium snifter. Cover.

Attribute	Definition	References
Woody	Sweet, brown, musty, dark, dry aromatics associated with the bark of a tree.	Diamond shelled walnuts = 4.0 Sigma-Aldrich Cedarwood oil, Virginia = 6.5 (aroma) <u>Preparation:</u> Place 1 drop oil on a cotton ball in a medium snifter. Cover.
Rancid	Aromatic commonly associated with oxidized fat and oils.	Wesson vegetable oil = 2.5 <u>Preparation:</u> Measure 1/3 c oil in a liquid measuring cup. Cook in a microwave oven on high power for 2.5 min. Let cool and pour into 1 fl oz cups.
Vanilla/Vanillin	Aromatics associated with natural or non-natural vanillin which may or may not include brown, bean-like aromatics.	McCormick vanilla extract in 2% liquid milk = 4.0 <u>Preparation:</u> Mix 1/8 tsp vanilla extract in 1/2 c 2% liquid milk. Serve in 1 fl oz cups.
Overall Sweet	Aromatic associated with the impression of sweet substances.	Post Shredded Wheat cereal = 1.5 General Mills Wheaties cereal = 3.0 Lorna Doone Cookie = 4.5
Brown Sweet	Sweet, round, light brown aromatics which may also include the character notes identified as vanillin and caramelized.	Pepperidge Farm Bordeaux cookies = 7.5
Astringent	Feeling of a puckering or a tingling sensation on the surface and/or edge of the tongue and mouth.	0.030% Alum solution = 1.5 0.050% Alum solution = 2.5 0.075% Alum solution = 3.5

<b>Attribute</b>	<b>Definition</b>	<b>References</b>
Bitter	Fundamental taste factor of which caffeine is typical.	0.010% Caffeine solution = 2.0 0.020% Caffeine solution = 3.5 0.035% Caffeine solution = 5.0
Salty	Fundamental taste factor of which sodium chloride is typical.	0.20% Sodium chloride solution = 2.5 0.25% Sodium chloride solution = 3.5
Sour	Fundamental taste factor of which citric acid is typical.	0.015% Citric acid solution = 1.5 0.025% Citric acid solution = 2.5
Sweet	Fundamental taste factor of which sucrose is typical.	1.0% Sucrose solution = 1.0

\*0-15-point numeric scale with 0.5 increments was used to rate the intensities of the samples and references.

### ***Test Design and Sample Evaluation***

I used a series of modified William's Latin Squares (Hunter 1996) to create the test designs for evaluating the black walnut cookies. The series of modified Latin Squares used in this study were based on a design implemented for taste-testing experiments (Ferris 1957). The Latin Squares were complete, meaning that seven panelists were used to compliment the seven cultivars used for testing, thus creating a perfect square. I adjusted the Latin Square design for first-order bias and randomized treatment order within the Latin Square ensuring each sample was seen in each serving position (1, 2, 3,..., 7) exactly once when viewed by either columns or rows. Appendix B illustrates the test designs used for the black walnut cookie evaluations. The researcher completed construction of the Latin Squares for all descriptive evaluation phases in SAS® statistical software (version 9.2, SAS Institute Inc., Cary, NC). Appendix A provides the SAS® codes for the modified Latin Square designs.

Panelists evaluated samples in triple replicate for each of the seven black walnut cultivars. Due to the product's complexity and panelist concerns of fatigue, one replication was completed over a period of 2 days. Five samples were seen each day during 105 min evaluation sessions for a total of 3 days. The final six samples were evaluated during a 120 min session with an extended 10 min break halfway through the session on the fourth and final day.

The cookies were removed from the freezer 3 h prior to testing and cut into 1/8 wedges using a serrated knife following the score lines indented in the cookies before baking. This time allowed the cookies to reach room temperature conditions prior to evaluation ( $23\text{C} \pm 1\text{C}$ ). Two, 63.5 mm diameter cookies were served to each panelist (total of 16 wedges) in 236.6 mL Styrofoam bowls with plastic lids (Dart Container Corporation, Mason, MI) labeled with three-digit blinding codes. Panelists sat at a round table under ambient lighting and temperature conditions. Panelists scored the samples individually on paper ballots with erasable red pencils. A hybrid method based on the Flavor Profile Method (Keane 1992) was used, and intensities of the attributes were scored on a 0-15-point numerical scale with 0.5 increments where 0.0 = none/not present and 15.0 = highest possible intensity. Appendix C includes the ballot used by panelists for evaluation. A tray with references for the flavor attributes and definition/reference sheets (Appendix D) was provided to each panelist. Panelists were instructed to take one wedge into their mouths and chew until the point of swallowing before scoring attributes on the ballot.

Panelists were instructed to swallow at least one bite of each sample; however, expectoration was also encouraged. Reverse osmosis, de-ionized water, baby carrots, 1.27 cm Mozzarella cheese cubes (low moisture, part skim; Kroger Company, Cincinnati, OH), and 0.32 cm skinless cucumber slices were used as palate cleansers. Sample evaluation took ~15 min, and a 5 min rest period was instilled between samples to reduce flavor carryover effects.

### ***Statistical Analysis***

The researcher performed analysis of variance (ANOVA) to test the significance of each flavor attribute across the black walnut cookie samples at the 5% level of significance. Using Fisher's protected Least Significant Difference (LSD) post-hoc means separation was also analyzed at the 5% level of significance. Statistical analyses were performed with SAS® statistical software (version 9.2, SAS Institute Inc., Cary, NC) using PROC MIXED. Appendix A contains the SAS® codes.

Principal components analysis (PCA) using the covariance matrix was conducted to evaluate the relationship(s) among the attributes and black walnut cookies. A PCA biplot visually depicts the spatial arrangement of the attributes and samples in order to draw conclusions on which attribute(s) describe particular sample(s). The author performed analysis using the Unscrambler software (The Unscrambler X version 10.1, Camo Software AS, Oslo, Norway).

### **Section 3 – Consumer Hedonic and Intensity Ratings of Black Walnut Cultivars in a Sugar Cookie Base**

#### ***Samples***

I incorporated six black walnut cultivars (Brown Nugget, Davidson, Emma K, Football, Sparks 127, and Sparrow) into a plain sugar cookie formula in order to gauge consumer liking and intensity scores of the cultivars. The black walnuts were the same cultivars used previously in the black walnut cookie descriptive testing. The cultivar Tomboy was omitted from this study due to inadequate sample amount. As with the black walnut cookie descriptive phase, the black walnut kernels were kept in 3.8 L glass jars and stored under frozen conditions ( $-26\text{C} \pm 1\text{C}$ ) until they were incorporated into the sugar cookies to maintain freshness and delay oil oxidation in the black walnuts (Reid 2011).

#### ***Cookie Preparation and Baking Method***

The same preparation and baking procedures used for the sugar cookies in the descriptive analysis were employed for the consumer evaluation cookies (Section 2 – Changes in Sensory Characteristics of Black Walnut Cultivars in a Sugar Cookie Base, Cookie Preparation and Baking Method). One aspect differed in the procedure in that the cookies were scored in half instead of eighths prior to baking. Appendix E includes the original and modified cookie formulations. For each cultivar, I prepared six batches of cookies, baked them over a one week period, and kept them frozen ( $-26\text{C} \pm 1\text{C}$ ) in gallon-sized re-sealable plastic bags (Ziploc® brand freezer bags with Smart Zip® seal, S.C. Johnson & Son Inc., Racine, WI) until use. All cookies were removed from the freezer one day prior to the first day of testing and allowed to thaw at room temperature ( $23\text{C} \pm 1\text{C}$ ). The cookies were kept at room temperature throughout the two days of testing.

#### ***Consumers***

From the greater Kansas City area 101 consumers were recruited to participate in the black walnut cookie consumer evaluation. Consumers recruited for this study represented the demographic for black walnut consumers and were selected based on the eligibility requirements



set by the screener (Appendix F). All consumers were screened by telephone, and a follow-up e-mail was sent to each consumer to confirm their session day and time slot.

### ***Test Design and Sample Evaluation***

The researcher used a series of William's Latin Square designs (Hunter 1996) with six samples and six consumers in each design to generate the rotation order of the samples for a possible 120 consumers. Appendix A illustrates the SAS® codes used to create the Latin Square designs, while Appendix B shows the complete rotation orders for the samples.

The black walnut cookies were cut in half approximately 10 min before each session of consumer testing. Each consumer was served one half of a cookie on a 15.24 cm white Styrofoam plate (Pactive Corporation, Lake Forest, IL) with a random three-digit blinding code label attached to the edge of the plate. Hourly sessions were held over 2 days (12 sessions on day one and 11 sessions on day two) to accommodate all consumers. Consumers signed consent forms (Appendix G) stating that they were willing participants in this study and could withdraw at any time without penalty. A copy of the moderator's guide used during the consumer tests is provided in Appendix H detailing pertinent information and other directions related to the format of the testing sessions. Each session lasted ~30 min during which each consumer was instructed to taste the sample in front of them and rate their degree of liking and flavor intensity on the provided ballot (Appendix I). Unsalted Saltine crackers and reverse osmosis, de-ionized water were used as palate cleansers in between samples. Each consumer was served all six samples in a monadic fashion by the pre-determined rotation order. At the session's end, consumers were compensated for their time with a monetary payment.

### ***Statistical Analysis***

To test the significance of each hedonic and intensity questions across panelists at the 5% level of significance, I performed analysis of variance (ANOVA). Post-hoc means separation was analyzed using Fisher's protected Least Significant Difference (LSD) at the 5% level of significance to determine differences among cultivars. To determine if notable groups of consumers were affecting the data, a cluster analysis using Ward's minimum variance procedure was performed. I conducted ANOVA at the 5% significance level for each of the individual clusters as well as an ANOVA for all clusters combined to determine significances both within and across clusters. Analyses were carried out with SAS® statistical software (version 9.2, SAS

Institute Inc., Cary, NC) (Appendix A) using PROC MIXED. This statistical technique of testing treatment effects on the whole data set then clustering consumers based on liking trends and finally testing treatment effects within each of the clusters has been recommended to improve interpretation of hedonic-scaled consumer data (Schilling and Coggins 2007).

I constructed an external preference map using partial least squares (PLS) regression to determine relationships between the descriptive flavor attributes and consumer acceptability of the cookies across the clusters. The PLS procedure was carried out in the Unscrambler statistical software (The Unscrambler X version 10.1, Camo Software AS, Oslo, Norway) for this study.

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## **Chapter 3 - Descriptive Analysis of Flavor Characteristics among Black Walnut Cultivars**

### **Abstract**

Seven black walnut cultivars, Brown Nugget, Davidson, Emma K, Football, Sparks 127, Sparrow, and Tomboy, were evaluated by descriptive sensory analysis. Seven trained panelists developed a lexicon for the black walnuts and scored the intensities of the samples for 22 flavor attributes. Results showed that the seven samples differed significantly ( $P \leq 0.05$ ) on 13 of the attributes. For the majority of the attributes, only Emma K differed from the rest of the cultivars by being characterized with lower scores for black walnut ID, overall nutty, nutty-grain-like, nutty-buttery, floral/fruity, oily, and overall sweet. That sample also was higher in acrid, burnt, fruity-dark, musty/earthy, rancid, and bitter attributes. The remaining six cultivars showed few differences in individual attribute ratings, but did show differences when mapped using multivariate techniques indicating as many as four clusters of black walnut cultivars based on flavor. Future studies should include descriptive analysis of other black walnut cultivars, both wild and commercial, that could be grown and harvested for production.

## Introduction

Black walnut (*Juglans nigra* L.), also known as eastern black walnut or American walnut, is a hardwood tree species native to central and eastern United States (US) and Ontario, Canada (Reid 1990; Williams 1990; Michler *et al.* 2007). Black walnut is a high value crop with its timber, walnut shell, and walnut kernels providing various applications in industry. As a food product, black walnut produces a highly aromatic and flavorful nut popular with consumers (Michler *et al.* 2007).

Over 750 cultivars of black walnut are in existence; however, little formal research on sensory attribute descriptors of black walnut has been completed. For the past several years, informal tastings and evaluations of black walnut kernels have been conducted annually by the University of Missouri (in conjunction with various nut grower associations in Missouri, Nebraska, and Iowa) to assist producers in determining which cultivars to plant and grow (Warmund *et al.* 2009b).

To bring some standardization to the industry, Warmund *et al.* (2009b) used descriptive analysis to describe and compare sensory characteristics of black and English (Persian) walnuts (*Juglans regia* L.). The study evaluated the aroma, flavor, and texture of kernels from six black walnut cultivars, one wild black walnut species, and two English walnut cultivars. Twenty-two sensory attributes were compiled including one aroma, 11 flavor, and 10 textural terms. The results indicated that 20 of the 22 attributes were applicable to both English and black walnuts; however, English walnuts were less aromatic than black walnuts. Black walnuts were distinguished from English cultivars by their fruity, musty, and sweeter characteristics. Overall aroma, fruity, woody, musty, and sweet notes varied within the six improved black walnut cultivars suggesting some degrees of difference by cultivar (Warmund *et al.* 2009b).

In addition to cultivar effect on flavor attributes, kernel color also can affect the sensory attributes of black walnuts. Warmund *et al.* (2009a) investigated this relationship with light-, medium-, and dark-colored kernels of three cultivars and one wild species. Eighteen flavor descriptors were generated by a trained descriptive panel, and samples of each color classification for each walnut cultivar were evaluated. “Brown” flavor was the only attribute varying in the wild species sample, whereas, six (burnt, musty/dusty, oily, woody, astringent, and sour) of the 18 attributes were affected by kernel color for the other three cultivars. Additionally,

Emma K and Sparks 127 cultivars were more variable in color and flavor than the Kwik Krop and wild samples (Warmund *et al.* 2009a).

Lee *et al.* (2011) expanded the research of Warmund *et al.* (2009a) by investigating the volatile compounds associated with the light-, medium-, and dark-colored black walnut kernels and their influence on the walnuts' sensory profiles. Those researchers found 34 aromatic compounds present in the black walnut cultivars using solid-phase microextraction-gas chromatography-mass spectrometry and discovered total concentration of aromatic compounds was higher in light-colored kernels for all cultivars than in the medium- or dark-colored samples.

Profiling the sensory characteristics of different cultivars of a specific nut variety has been done to compile lexicons for specific nuts in order to better understand differences in variety, processing, or other variables (Sinesio and Moneta 1997; Guerrero *et al.* 2000; Sinesio *et al.* 2001; Ng and Dunford 2009; Civille *et al.* 2010) and recently a lexicon for general nutty characteristics was published (Miller *et al.* 2013). Although research on evaluating the sensory aspects of various black walnut cultivars is growing, additional information could prove useful to walnut growers who wish to establish optimum black walnut orchards. Therefore, the objectives of this paper were to 1) develop a lexicon to describe various black walnut cultivars and 2) determine differences in flavor attributes among black walnut cultivars using descriptive sensory analysis.

## **Materials and Methods**

### ***Samples and Sample Preparation***

Seven black walnut cultivars grown in 2011 were obtained from a nut orchard in Joplin, Missouri. The cultivars included: Brown Nugget, Davidson, Emma K, Football, Sparks 127, Sparrow, and Tomboy. The black walnuts were transported to the Sensory Analysis Center (Manhattan, KS) and allowed to dry in their shells for 5 days at ambient temperature ( $23\text{C} \pm 1\text{C}$ ). Shelling the walnuts was completed with a Duke Pecan Walnut Cracker (Duke Pecan Company, West Point, MS) and Channel Lock model number 436, 15.24 cm cutting pliers (Channel Lock Inc., Meadville, PA) was used to remove nutmeat from the shells. Samples were then transferred to 3.8 L glass jars and stored under frozen conditions ( $-26\text{C} \pm 1\text{C}$ ) to maintain freshness and delay oxidation of the oils in the nuts (Reid 2011).

Once all the black walnuts were shelled the nuts were removed from the freezer and chopped with a manual hand chopper (OXO, New York, NY) by depressing the chopping plunger three times. The black walnuts were returned to their respective glass jars. In order to obtain approximately equal-sized pieces of nutmeat for evaluation, the black walnuts were passed through a set of sieving frames to sort the nuts. The sieving frames were 30.48 cm square frames with stainless steel wiring and square holes (Grain Science and Industry, Kansas State University, Manhattan, KS). A cleaner frame (that is, sieve) was set on top of a number-four frame with a tray frame underneath, then the black walnuts were dispensed on top of the cleaner frame and all three frames were shaken gently to sieve the nuts. Black walnut pieces remaining in between the cleaner and number-four frame were used for evaluation while the pieces that fell into the cleaner frame were considered too small for evaluation. Nut pieces that remained on top of the cleaner frame were re-chopped and sieved again. The selected black walnut pieces were placed back in their respective glass jars and kept under frozen conditions ( $-26\text{C} \pm 1\text{C}$ ) until evaluation.

### ***Descriptive Analysis***

Seven panelists (6 female, 1 male) employed at the Sensory Analysis Center at Kansas State University (Manhattan, KS) were selected for descriptive evaluation of the black walnut cultivars. All panelists had completed 120 h of general training in descriptive analysis methodology, and each panelist had over 2,000 h of testing experience with a wide variety of food items. Three panelists had prior experience evaluating nuts and nut-related samples.

### ***Lexicon Development and Orientation***

Six, 90 min sessions were used to orient the panelists to all seven samples and develop the ballot and lexicon for evaluation. Panelists were provided with an initial lexicon adapted from 2 previous studies on black walnut syrup and nut-related attributes, respectively (Matta *et al.* 2005; Miller *et al.* 2013). Panelists were instructed to taste the samples one at a time and write down all flavor attributes perceived with that sample. The panelists then engaged in open discussion to refine their terminology and add or delete terms from the lexicon as deemed necessary. The attributes were then grouped in order of dominance with the most dominant flavors appearing at the lexicon's beginning and the less dominant flavors toward the end. The same grouping style of attributes was applied to the ballot allowing the listing of attributes to

stay consistent between the lexicon and ballot. The panelists also discussed appropriate serving size and evaluation techniques and practiced evaluating several samples to ensure consistent evaluation techniques. Open discussion was used to clarify any confusion in intensity scoring. All samples were evaluated at room temperature ( $23^{\circ}\text{C} \pm 1^{\circ}\text{C}$ ). Suwonsichon *et al.* (2012), Adhikari *et al.* (2011), Elía (2011), Koppel *et al.* (2011), and Limpawattana and Shewfelt (2010) used similar lexicon development procedures.

Orientation sessions were used to clarify definitions and references for the attributes. Panelists were provided with all references listed in the lexicon and asked to taste them to ensure that they were suitable for evaluation against the black walnuts. In some instances the definition and/or reference was changed to better reflect the character of the black walnut samples. The attribute, 'black walnut' was changed to 'black walnut ID' and its definition was altered to include supplementary attributes (i.e., sweet, musty/dusty, floral/fruity, and fruity-dark). Additionally, the reference used for 'black walnut ID' was changed from a flavor extract to ground pieces of various black walnut cultivars. The final lexicon included 22 flavor attributes including astringent and three basic tastes bitter, sour, and sweet. Table 3-1 lists the attributes, definitions, and references used for testing.



**Table 3-1.** Flavor attributes, definitions, and references for descriptive analysis of black walnuts<sup>†</sup>

Attribute	Definition	References
Black Walnut ID	Aromatics associated with black walnuts including musty/earthy, piney, woody, brown, sweet, buttery, oily, astringent, and slightly acrid aromatics; other aromatics may include musty/dusty, floral/fruity, and/or fruity-dark.	Ground black walnut pieces = 12.0 <u>Preparation:</u> Measure out 1 tbsp each of various cultivars into a food processor and blend for 30 s. Serve in 1 fl oz cups.
Overall Nutty	Measurement that reflects the total of nutty characteristics and the degree to which these characteristics fit together. Nutty characteristics are: sweet, oily, light brown, slightly musty and/or buttery, earthy, woody, astringent, bitter, etc. (e.g., nuts, wheat germ, certain whole grains).	Gold Medal whole wheat flour = 4.5 Kretschmer Wheat Germ = 7.5 Mixture of Diamond slivered almonds and Kroger chopped hazelnuts = 7.5 <u>Preparation:</u> Puree the almonds and hazelnuts separately in blenders for 45 s on high speed. Combine equal amounts of the chopped nuts. Serve in 1 fl oz cups. Diamond shelled walnuts = 8.0 Diamond pecan halves = 9.0
Nutty-Woody	Nutty aromatic characterized by the presence of woodiness, increased musty/dustiness, brown, astringent, and bitter.	Diamond pecan halves = 7.5 Diamond shelled walnuts = 7.5
Nutty-Grain-like	Nutty aromatic characterized by the presence of a grainy aromatic, increased musty/dustiness, and brown.	Gold Medal whole wheat flour = 4.5 Kretschmer Wheat Germ = 7.5
Nutty-Buttery	Nutty aromatic characterized by a buttery impression, and/or increased fatty aromatics and musty/earthy character.	HyVee dry roasted and salted Macadamia nuts = 5.0

Attribute	Definition	References
Brown	Rich, full aromatic impression always characterized with some degree of darkness generally associated with attributes (e.g., toasted, nutty, sweet).	<p>Bush's Best pinto beans (canned) = 5.0  <u>Preparation:</u> Drain beans and rinse with de-ionized water. Serve in 1 fl oz cups.</p> <p>Kretschmer Wheat Germ = 7.5  Sethness AP 100 Caramel Color (full strength) = 13.0 (aroma)  <u>Preparation:</u> Place 1/2 tsp caramel color in a medium snifter. Cover.</p>
Caramelized	Round, full-bodied, medium brown aromatic	<p>C&amp;H golden brown sugar = 7.5 (aroma)  C&amp;H golden brown sugar = 9.0 (flavor)</p>
Acrid	Sharp/acrid, charred flavor note associated with something over-baked or excessively browned in oil.	Alf's Natural Nutrition puffed red wheat cereal = 3.0
Burnt	Dark, brown, somewhat sharp, over-baked grain aromatic.	Alf's Natural Nutrition puffed red wheat cereal = 4.0
Floral/Fruity	Sweet, light, aromatics impression associated with flowers and fruits.	<p>Welch's white grape juice = 5.0  <u>Preparation:</u> Dilute 1 part juice with 1 part de-ionized water.</p>

Attribute	Definition	References
Fruity-dark	Sweet, brown, honey/caramel-like aromatics commonly associated with dark fruits such as raisins and prunes that have been cooked.	<p>1/4 c Sun Maid raisins, 1/3 c Ocean Spray dried cranberries, 1/4 c Sun Maid prunes, and 3/4 c water = 5.0 (flavor), 7.0 (aroma)</p> <p><u>Preparation:</u> Mix raisins, dried cranberries, and prunes (chopped). Add 3/4 c de-ionized water and cook in a microwave oven on high power for 2 min. Pour juice into 1 fl oz cups. Put 1 tsp of cooked fruit with at least 1 piece of the chopped cooked prunes in a medium snifter. Cover.</p>
Piney	Slight resinous aromatic associated with fresh green pine needles.	Kroger pine nuts = 6.0
Musty/Dusty	Dry, dirt-like aromatic associated with dry, brown soil.	<p>Potato peel = 5.0 (aroma)</p> <p><u>Preparation:</u> Place 0.5 g potato peel in a medium snifter. Cover.</p>
Musty/Earthy	Humus-like aromatics that may or may not include damp soil, decaying vegetation, or cellar-like characteristics.	<p>Sliced button mushroom = 8.5 (aroma)</p> <p><u>Preparation:</u> Place 3 slices of mushroom in a medium snifter. Cover.</p>
Woody	Sweet, brown, musty, dark, dry aromatics associated with the bark of a tree.	<p>Diamond shelled walnuts = 4.0</p> <p>Sigma-Aldrich Cedarwood oil, Virginia = 6.5 (aroma)</p> <p><u>Preparation:</u> Place 1 drop oil on a cotton ball in a medium snifter. Cover.</p>

Attribute	Definition	References
Overall Sweet	Aromatic associated with the impression of sweet substances.	Post Shredded Wheat cereal = 1.5 General Mills Wheaties cereal = 3.0 Lorna Doone Cookie = 4.5
Oily	Light aromatics associated with vegetable oil such as corn or soybean oil.	Kroger slivered almonds = 4.0 HyVee dry roasted and salted Macadamia nuts = 9.0
Rancid	Aromatic commonly associated with oxidized fat and oils.	Wesson vegetable oil = 2.5 <u>Preparation:</u> Measure 1/3 c oil in a liquid measuring cup. Cook in a microwave oven on high power for 2.5 min. Let cool and pour into 1 fl oz cups.
Astringent	Feeling of a puckering or a tingling sensation on the surface and/or edge of the tongue and mouth.	0.030% Alum solution = 1.5 0.050% Alum solution = 2.5 0.075% Alum solution = 3.5
Bitter	Fundamental taste factor of which caffeine is typical.	0.010% Caffeine solution = 2.0 0.020% Caffeine solution = 3.5 0.035% Caffeine solution = 5.0
Sour	Fundamental taste factor of which citric acid is typical.	0.015% Citric acid solution = 1.5 0.025% Citric acid solution = 2.5
Sweet	Fundamental taste factor of which sucrose is typical.	1.0% Sucrose solution = 1.0

<sup>†</sup>0-15-point numeric scale with 0.5 increments was used to rate the intensities of the samples and references.

### ***Test Design and Sample Evaluation***

A series of modified William's Latin Square designs (Hunter 1996) were used to construct the test designs of this study. Computation of the Latin Squares for descriptive evaluation was completed with SAS® statistical software, version 9.2 (SAS Institute Inc., Cary, NC). The black walnuts were removed from the freezer the afternoon prior to each testing day and allowed to thaw at room temperature ( $23^{\circ}\text{C} \pm 1^{\circ}\text{C}$ ). The morning of evaluation, 12 g of each cultivar was served in a plastic 96 mL cup with plastic lid (Solo Cup Company, Lake Forest, IL) to each panelist. The cups were labeled with a random three-digit code. Panelists sat at a round table under ambient lighting and temperature ( $23^{\circ}\text{C} \pm 1^{\circ}\text{C}$ ) conditions. Panelists scored the samples individually using a 0-15 point scale with 0.5 increments where 0 = none/not present and 15.0 = highest possible intensity. References for the flavor attributes were provided for each panelist along with definition/reference sheets. Panelists took either two similarly-sized larger or three similarly-sized smaller pieces of black walnut (as determined during orientation to ensure approximately equal sampling amounts) into their mouths and chewed until well-masticated before scoring the intensities of attributes.

Although expectoration was encouraged, panelists were instructed to swallow at least one bite of each sample. Reverse osmosis, de-ionized water, baby carrots, 1.27 cm Mozzarella cheese cubes (low moisture, part skim; Kroger Company, Cincinnati, OH), and 0.32 cm skinless cucumber slices were used as palate cleansers. Panelists also used a soft-bristled toothbrush (Kroger Company, Cincinnati, OH) to lightly brush the tops of molar teeth to reduce sample build-up in the teeth. Panelists evaluated the black walnuts in triple replicate for each of the seven cultivars. One replication was completed in 1 day during a 105 min evaluation session, for a total of 3 days of testing. Sample evaluation took approximately 10 min, and a 5 min rest period was used in addition to rinse agents to reduce flavor carryover.

### ***Statistical Analysis***

An analysis of variance (ANOVA) was conducted to test for differences in the flavor attributes across cultivars at the 5% level of significance. Cultivar, panelist, and replication were used as sources of variation with panelist and replication as random effects. Using Fisher's protected Least Significant Difference (LSD) at the 5% level of significance, post-hoc means separation was analyzed to determine which cultivars were significantly different. Statistical

analyses were performed with SAS® statistical software version 9.2 (SAS Institute Inc., Cary, NC) using PROC MIXED. Principal components analysis (PCA) using the covariance matrix was performed to visually depict the relationship(s) among attributes and cultivars. PCA was performed using Unscrambler version 10.1 (Camo Software AS, Oslo, Norway).

## **Results and Discussion**

Mean intensity scores for the 22 attributes by cultivar are listed in Table 3-2. Compared with prior research on flavor attributes of English walnuts (Sinesio and Moneta 1997; Guerrero *et al.* 2000; Sinesio *et al.* 2001) the attributes developed in the present study contain more detailed descriptions. Attributes in those other studies are few and somewhat elementary (astringent, bitter, floral, flour, rancid, sweet, and woody), while the attributes we developed specify more intricate flavors (nutty-buttery, nutty-grain-like, brown, toasted, fruity-dark, piney, musty/dusty, etc.). It is interesting to note that research on English walnut flavors does not include a ‘walnut’ flavor in the lexicons, while our study does include a ‘black walnut ID’ attribute. The research attained from the current study represents more detailed methods on characterizing flavors of black walnut cultivars.

Lexicons developed for other nut species do provide more precise descriptors. For example Ng and Dunford (2009) used three attributes characterizing the degree of roasting in peanuts as well as attributes for earthy, grainy, green and off-notes such as cardboard, painty, burnt, fishy, and skunky/mercaptan. Civile *et al.* (2010) break down several of multi-dimensional descriptors of almonds into single-note descriptors (e.g., fruity, red fruit, and brown fruit). The authors of the current study used this same technique when defining the nutty attributes found in the black walnuts (i.e., overall nutty, nutty-buttery, nutty-grain-like, and nutty-woody). Overall, the lexicon developed in the current study is more similar to the lexicons used by Ng and Dunford (2009) and Civile *et al.* (2010) in terms of a greater number of and more detailed attributes used for evaluation. This lexicon further expands upon the literature for profiling the flavor attributes of black walnuts.

**Table 3-2.** Mean intensity scores and separation of flavor attributes for seven black walnut cultivars<sup>†</sup>

Attribute	Cultivar						
	Brown Nugget	Davidson	Emma K	Football	Sparks 127	Sparrow	Tomboy
Black Walnut ID	11.05 <sup>a</sup>	11.12 <sup>a</sup>	8.57 <sup>b</sup>	11.14 <sup>a</sup>	10.88 <sup>a</sup>	11.26 <sup>a</sup>	11.38 <sup>a</sup>
Overall Nutty	7.21 <sup>a</sup>	7.41 <sup>a</sup>	0.98 <sup>b</sup>	7.24 <sup>a</sup>	7.10 <sup>a</sup>	7.31 <sup>a</sup>	7.46 <sup>a</sup>
Nutty-Woody	6.14	6.07	5.86	6.33	6.24	6.14	6.17
Nutty-Grain-like	4.81 <sup>a</sup>	4.90 <sup>a</sup>	4.14 <sup>b</sup>	4.71 <sup>a</sup>	4.81 <sup>a</sup>	4.74 <sup>a</sup>	4.79 <sup>a</sup>
Nutty-Buttery	3.52 <sup>a</sup>	3.57 <sup>a</sup>	2.26 <sup>b</sup>	3.38 <sup>a</sup>	3.32 <sup>a</sup>	3.31 <sup>a</sup>	3.38 <sup>a</sup>
Brown	4.19	4.12	4.69	4.26	4.17	4.29	4.10
Caramelized	1.83	1.86	1.50	1.81	1.91	1.79	1.71
Acrid	0.38 <sup>b</sup>	0.48 <sup>b</sup>	1.88 <sup>a</sup>	0.67 <sup>b</sup>	0.64 <sup>b</sup>	0.57 <sup>b</sup>	0.43 <sup>b</sup>
Burnt	0.10 <sup>b</sup>	0.00 <sup>b</sup>	0.38 <sup>a</sup>	0.17 <sup>b</sup>	0.07 <sup>b</sup>	0.17 <sup>b</sup>	0.10 <sup>b</sup>
Floral/Fruity	1.60 <sup>a</sup>	1.69 <sup>a</sup>	0.93 <sup>b</sup>	1.60 <sup>a</sup>	1.48 <sup>a</sup>	1.62 <sup>a</sup>	1.69 <sup>a</sup>
Fruity-dark	0.41 <sup>b</sup>	0.33 <sup>b</sup>	1.12 <sup>a</sup>	0.55 <sup>b</sup>	0.38 <sup>b</sup>	0.43 <sup>b</sup>	0.21 <sup>b</sup>
Piney	2.31	2.50	2.12	2.50	2.58	2.74	2.50
Musty/Dusty	2.52	2.45	2.43	2.52	2.52	2.50	2.64
Musty/Earthy	1.76 <sup>bc</sup>	1.85 <sup>bc</sup>	2.71 <sup>a</sup>	2.12 <sup>b</sup>	1.69 <sup>c</sup>	1.98 <sup>bc</sup>	1.76 <sup>bc</sup>

Attribute	Cultivar						
	Brown Nugget	Davidson	Emma K	Football	Sparks 127	Sparrow	Tomboy
Woody	3.41	3.52	3.52	3.55	3.57	3.43	3.43
Overall Sweet	2.64 <sup>a</sup>	2.52 <sup>a</sup>	2.21 <sup>b</sup>	2.62 <sup>a</sup>	2.43 <sup>ab</sup>	2.50 <sup>a</sup>	2.64 <sup>a</sup>
Oily	3.52 <sup>a</sup>	3.62 <sup>a</sup>	2.98 <sup>b</sup>	3.69 <sup>a</sup>	3.50 <sup>a</sup>	3.57 <sup>a</sup>	3.48 <sup>a</sup>
Rancid	0.05 <sup>b</sup>	0.10 <sup>b</sup>	1.05 <sup>a</sup>	0.10 <sup>b</sup>	0.05 <sup>b</sup>	0.00 <sup>b</sup>	0.05 <sup>b</sup>
Astringent	2.95	2.79	2.93	2.79	2.71	2.79	2.76
Bitter	3.24 <sup>bc</sup>	3.00 <sup>c</sup>	3.76 <sup>a</sup>	3.38 <sup>b</sup>	3.17 <sup>bc</sup>	3.38 <sup>b</sup>	3.24 <sup>bc</sup>
Sour	2.43	2.24	2.39	2.36	2.21	2.43	2.21
Sweet	1.00	0.91	0.74	0.83	0.76	0.79	0.88

<sup>†</sup> Means with different superscripts within a row are significantly different ( $P \leq 0.05$ ) according to Fisher's protected least significant difference (LSD) test.



## *Flavor*

Thirteen flavor attributes differed significantly ( $P \leq 0.05$ ) across cultivars. They included black walnut ID, overall nutty, nutty-grain-like, nutty-buttery, acrid, burnt, floral/fruity, fruity-dark, musty/earthy, overall sweet, oily, rancid, and bitter. Although significant differences were found for over half the attributes on the ballot, the majority of the ranges for the attributes were fairly small. Most differences were for Emma K compared to other samples (Table 3-2). For example, of the attributes differing significantly, the cultivars differed by less than 0.5 for overall sweet (greatest difference of 0.43) and burnt (greatest difference of 0.38). There were several attributes that differed by more than 1.00 as well, with black walnut ID having the greatest difference of 2.81 among cultivars.

The flavor of cultivars in this study that had been in prior research is similar to those other published reports (Warmund *et al.* 2009a; Warmund *et al.* 2009b; Lee *et al.* 2011). Warmund *et al.* (2009b) noted that when compared with English (Persian) walnuts, black walnuts were characterized by fruity and musty flavors (Emma K and Sparrow cultivars with higher fruity ratings; Sparks 127 and Sparrow with higher musty intensities). In a subsequent study on light-, medium-, and dark-colored black walnut kernels, researchers noted that wild samples had a significantly higher rating for floral/fruity than the improved cultivars Emma K, Kwik Krop, and Sparks 127 (Warmund and others 2009a). This flavor variation may be due to natural annual variation in crop production because the samples were collected from the same location and both studies contained wild and improved cultivars. In the current study, Emma K had the lowest rating for floral/fruity but the highest rating for fruity-dark (significantly different at  $P \leq 0.05$ ). Additionally, Emma K scored highest for musty/earthy while Sparks 127 and Sparrow, though not significantly different from each other, had lower scores and were significantly different from Emma K.

Warmund *et al.* (2009a) and Warmund *et al.* (2009b) noted that the black walnut samples were sweeter than the English walnut samples and that wild samples were the sweetest over all black walnut samples, including improved cultivars. In the current study, intensity scores for sweet were much lower than those reported by Warmund *et al.* (2009b), but overall sweetness was comparable to those from Warmund *et al.* (2009a). The differences may be attributed to

unavoidable annual variations in harvesting agricultural products or differences in the evaluation of sweetness.

### ***Cultivar Effect***

During shelling and chopping of the black walnuts it was observed that the Emma K sample was much darker in color and more wrinkled and shriveled in appearance than the lighter, plumper and smoother exteriors of the other cultivars. When compared with the study's other cultivars, Emma K usually differed significantly ( $P \leq 0.05$ ) from the other samples. Emma K was characterized by lower ratings for black walnut ID, overall nutty, nutty-grain-like, nutty-buttery, floral/fruity, oily, and overall sweet and was higher in acrid, burnt, fruity-dark, musty/earthy, rancid, and bitter notes. Miller *et al.* (2013) demonstrated that there is a synergy/suppression effect with overall nutty and its four sub-components (nutty-beany, nutty-buttery, nutty-grain-like, and nutty-woody). If there is disparity among the four sub-components then they may suppress the overall nutty attribute. Therefore, Emma K's lower overall nutty score may be caused by its lower nutty-buttery and nutty-grain-like scores.

The PCA biplot helps to illustrate this point (Fig. 3-1). The PCA illustrates that Emma K relates with the flavor attributes rancid, acrid, fruity-dark, brown, musty/dusty, burnt, and bitter. It is the only sample displayed on the left-hand side of the biplot while the other six samples (Brown Nugget, Davidson, Football, Sparks 127, Sparrow, and Tomboy) are on the right-hand side closer to the sweet- and nutty-related attributes. Miller *et al.* (2013) found that walnuts were typically characterized by nutty-beany, nutty-buttery, and nutty-woody attributes reinforcing the PCA results.



**Figure 3-1.** Principal components analysis (PCA) biplot showcasing principle components 1 and 2 for the 7 black walnut cultivars and the 22 descriptive flavor attributes.

By looking at the “map” of cultivars it is possible to examine the multivariate differences that can be noted among products. Although there were few differences in single attributes among the samples other than Emma K, the multivariate map shows a more disparate picture. Football and Sparrow appear to be similar to one another as they are grouped together in the PCA biplot, while Brown Nugget, Davidson, and Sparks 127 also are grouped closely to one another, suggesting shared traits among these three cultivars. Tomboy falls by itself in the component space, but it is positioned closer to the attributes (i.e., musty/earthy, overall sweet, nut-related attributes, etc.) than the remaining cultivars. Despite the ANOVA statistics showing few to no significant differences in flavor attributes among these six cultivars, there are differences among these cultivars that become apparent when all attributes are evaluated simultaneously.

Compared with Emma K, the other cultivars were 2.31 to 2.81 points higher in black walnut ID (significant at  $P \leq 0.05$ ). Similar trends in an earlier study by Warmund *et al.* (2009a) indicated that dark-colored Emma K kernels were scored significantly lower in the attribute black walnut when compared to light-, medium-, and dark-colored kernels from Kwik Krop, Sparks 127, and wild black walnuts. Additionally, burnt notes were lower across the lighter-colored kernels (Emma K, Kwik Krop, Sparks 127, and wild) when compared with the same cultivar’s dark-colored kernels (Warmund *et al.* 2009a). This was also noted in the present study where Brown Nugget, Davidson, Football, Sparks 127, Sparrow, and Tomboy were significantly lower in burnt flavor intensities when compared with the darker-colored Emma K sample.

Rancid notes have been reported previously in trace amounts in medium-colored Emma K samples (Warmund *et al.* 2009b) and in greater degree in dark-colored samples (Warmund *et al.* 2009a). Rancidity is affected partially by harvest date and storage conditions. Exact harvest dates and conditions are unknown in this study because cultivar samples were donated by a third party. Storage conditions were the same for all samples, indicating that the rancid notes may have been present in the Emma K kernels prior to evaluation.

Unfavorable weather conditions could have adversely affected Emma K more than other samples, thus contributing to the differences in appearance and attribute ratings. Research indicates that nut quality parameters (for example, kernel size and kernel color) can be affected by water stress in walnut trees (Cohen *et al.* 1997). Another explanation could be delayed harvest dates or delayed hulling. Past research indicates that these two factors can contribute to

darker-colored kernels, and Emma K kernels are particularly sensitive to color changes caused by delayed hulling (Brawner and Warmund 2008; Warmund 2008). Warmund *et al.* (2009b) reported that color and flavor varied more in Emma K than the other cultivars evaluated by the authors indicating that Emma K may be more sensitive to weather conditions and harvesting practices. Whether these observed attribute traits are characteristic of the Emma K cultivar or can be attributed to poor climatic and/or harvesting conditions is unclear, thus more research is needed to validate these findings.

## **Conclusions**

Overall, the seven black walnut cultivars evaluated in this study differed significantly across 13 descriptive flavor attributes, and the Emma K cultivar most often differed from the other cultivars (Brown Nugget, Davidson, Football, Sparks 127, Sparrow, and Tomboy). The remaining six cultivars evaluated in this study appear to provide similar flavors and could provide equivalency for black walnut growers if the data are found to be consistent in other harvest years and conditions. Distinguished by their black walnut ID, overall nutty, floral/fruity, and overall sweet notes these cultivars had low ratings for rancid, astringent, and bitter. Future research should focus on descriptive analysis for other black walnut cultivars commonly harvested for commercial production. The re-evaluation of the Emma K cultivar is recommended to determine if the aforementioned attributes are characteristic of that cultivar or were due to suboptimal growing conditions.

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## **Chapter 4 - Descriptive Analysis and Consumer Acceptance of Black Walnut Cultivars in a Sugar Cookie Base**

### **Abstract**

Researchers incorporated seven black walnut cultivars (Brown Nugget, Davidson, Emma K, Football, Sparks 127, Sparrow, and Tomboy) into sugar cookies to characterize their flavor attributes by trained assessors and acceptance by consumers. Nine of the 25 attributes differed significantly across cultivars: black walnut ID, overall nutty, nutty-buttery, brown, toasted, acrid, rancid, overall sweet, and sweet ( $P \leq 0.05$ ). Lower mean scores in black walnut ID, overall nutty, and sweet and higher mean scores in rancid and acrid characterized the Emma K cultivar. The remaining six samples were more similar to one another in flavor characteristics. Four clusters of consumers who differed in their acceptance of the cookie samples were found. Cluster 1 preferred Football, clusters 2 and 3 each showed no overall preference, and cluster 4 preferred Emma K suggesting a set of niche consumers for black walnuts used in cookies.

## Introduction

Black walnut (*Juglans nigra* L.) is a hardwood tree species valued for its fine wood and distinctively-flavored nuts. Known as eastern black walnut or American walnut, the species is native to North America extending from Ontario, Canada to northern Florida in the United States (US) then west towards Nebraska, Kansas, and Texas (Reid 1990; Williams 1990; Michler *et al.* 2007). To date, over 750 black walnut cultivars have been described. Cultivars for propagation are selected on the basis of nut quality characteristics, most notably percent edible kernel (Reid 1990; Michler *et al.* 2004). In addition to producing edible nuts and timber for furniture and cabinet-making, the black walnut shell has many uses as well; therefore increasing the value of the crop. The shell is found in oil well drilling processes, paints, as filler in dynamite, and as an abrasive agent in soaps, cosmetics, and dental cleansers (Thomas and Shumann 1993).

In commercial shelling operations, only 6-10% of usable nutmeat is recovered compared with over 40% recovered nutmeat in English (Persian) walnuts (*Juglans regia* L.). Of the edible nutmeat extracted from the shells, 60% of the kernels are packaged for retail sale, 30% are used in ice cream manufacturing, and 10% are used in commercial baking and candy-making ventures (Reid 1990). The black walnut is much stronger and richer in flavor than that of the English walnut (Thomas and Schumann 1993).

Little formal research on characterizing the sensory attributes of black walnuts has been completed. Warmund *et al.* (2009a) investigated the sensory attributes between black and English walnuts using descriptive sensory analysis. Black walnuts were distinguished from English cultivars by their fruity, musty, and sweeter characteristics. Overall aroma, fruity, woody, musty, and sweet notes varied among the black walnut cultivars studied. A second descriptive analysis study compared flavor attributes of light-, medium-, and dark-colored kernels of the black walnut cultivars Emma K, Kwik Krop, and Sparks 127 plus one wild species (Warmund *et al.* 2009b). Kernel color affected six of the attributes: burnt, musty/dusty, oily, woody, astringent, and sour. Additionally, the Emma K and Sparks 127 cultivars varied more in color and flavor than the Kwik Krop and wild sample.

Because of their strong flavor, black walnuts are consumed more frequently as an ingredient in ice cream and baked goods and confectionary items; however, only one research paper was found investigating the sensory characteristics of a black walnut food product. Matta,

*et al.* (2005) compared black walnut syrup, maple syrup, and maple-flavored table syrup using both descriptive and consumer sensory analysis. Research indicated that the pure maple and walnut syrups contained more complex attributes and had somewhat similar sensory profiles, while deeming the table syrup a simple product. However, results of the consumer analysis indicated the table syrup was liked best among the samples perhaps because it was more familiar to the products most consumers purchase.

Black walnut cultivars differ from one another based on tree and nut quality characteristics that may affect their performance and acceptance in food products. Thus, understanding how black walnut sensory attributes may change when incorporated into a specific food item becomes vital to producers. Therefore, the objectives of this paper were to 1) determine differences in flavor attributes among black walnut cultivars in a cookie base using descriptive sensory analysis, 2) determine consumer acceptance and flavor intensity of black walnut cookies, and 3) correlate the descriptive data with the consumer acceptance data on the black walnut cookies to better understand consumer acceptance of black walnut cultivars.

## **Materials and Methods**

### ***Black Walnut Samples and Preparation***

Researchers procured seven black walnut cultivars (Brown Nugget, Davidson, Emma K, Football, Sparks 127, Sparrow, and Tomboy) from a nut orchard in Joplin, MO. The nuts were transported to the Sensory Analysis Center (Manhattan, KS), were dried for 5 days, shelled, chopped and sieved to control piece size, and stored frozen ( $-26\text{C} \pm 1\text{C}$ ) until used for testing (~3 months).

### ***Cookie Preparation and Baking Method***

A basic sugar cookie recipe from the American Association of Cereal Chemists (AACC) was selected as a food carrier for the black walnuts (AACC International Method 10-53.01). Researchers implemented some modifications to the procedures because certain supplies were not readily available. Rubber dough guides (Regency Evendough Bands, Regency Wraps Inc., Dallas, TX) placed on the ends of 26.5 cm long wooden rolling pins measuring 9.5 mm thick were used in place of the 7.0 mm metal gauge strips to ensure even thickness of the cookie dough. Researchers replaced the 60 mm cookie cutters specified in the original AACC method

with 63.5 mm diameter cookie cutters. The modifications imposed were due to local availability of the supplies. The original and modified recipes and preparation procedures can be found in Appendix E.

Black walnuts were removed from the freezer the day before preparing the cookies and allowed to thaw at room temperature ( $23\text{C} \pm 1\text{C}$ ). Ingredients were weighed out using a digital scale (model SI-4001, Denver Instrument, Bohemia, NY) then mixed according to the AACC procedures in a 575 W KitchenAid stand mixer with 6 qt bowl and paddle attachment (KitchenAid Professional 600, model KP26M1XWH, Whirlpool Corporation, Benton Harbor, MI). Researchers added 90 g (40% by flour weight) of one of the seven black walnut cultivars to the recipe and incorporated the nuts into the dough with the flour. The dough was rolled out on a lightly-floured countertop with a wooden rolling pin and rubber dough guides placed on the ends of the rolling pin. A single mass of the dough was rolled out rather than dividing it into eight portions as stated in the original AACC procedures in order to streamline the process. A metal cookie cutter measuring 63.5 mm in diameter was used to cut out the cookies from the dough. In order to ensure a controlled bite amount for the panelists when evaluating the samples, researchers scored the cookies into one-eighths (for descriptive testing) or one half (for consumer testing) using the edge of a metal spatula. Each batch of cookie dough yielded approximately 11 cookies.

Researchers baked the cookies in an electric oven (model RB160PXYB, Whirlpool Corporation, Benton Harbor, MI) for 11 min on a lightly greased metal baking sheet, rotating the baking sheet halfway through the baking time to ensure even baking of the cookies. Cookies were allowed to cool on the baking sheet for 5 min before being moved to a metal baking rack to cool completely. Once cooled, the cookies were placed in gallon-sized, re-sealable plastic bags (Ziploc® brand freezer bags with the Smart Zip® seal, S.C. Johnson & Son Inc., Racine, WI) and labeled with the date, cultivar name, and batch number. Black walnut cookies were stored under frozen conditions ( $-26\text{C} \pm 1\text{C}$ ) for one week prior to evaluation.

### ***Descriptive Analysis***

Seven (six female, one male) highly trained descriptive analysis panelists from the Sensory Analysis Center (Manhattan, KS) evaluated the flavor attributes of the black walnut cookies. The panelists had 120 h of general descriptive analysis training, over 2,000 h of

evaluation experience with a wide array of food products, and had previously evaluated raw black walnut samples (Miller and Chambers, in review). Three panelists also had prior experience evaluating nut-related samples.

### ***Orientation and Lexicon Development***

Two, 90 min orientation sessions were held to familiarize the panelists with the samples and to refine the lexicon and ballot that would be used for evaluation. During these sessions, the panelists tasted the samples and used a lexicon from prior black walnut testing to determine appropriate attributes for the black walnut cookies. The panelists engaged in open discussion to add or delete terms from the lexicon and also tasted the references to determine their appropriateness. The final lexicon contained 25 flavor attributes including the basic tastes bitter, salty, sour, sweet, as well as the feeling factor astringent. Table 4-1 provides attribute definitions and references unique to this study. Adhikari *et al.* (2011), Elía (2011), Koppel *et al.* (2011), Talavera-Bianchi *et al.* (2011), and Vásquez-Araújo *et al.* (2011) used similar lexicon development techniques as those presented in this study.

During orientation, panelists determined the order of the attributes listed on the ballot. Panelists listed the more prominent attributes toward the ballot's beginning and grouped similar terms together, (i.e., overall sweet, brown sweet, and sweet). Sample amount for evaluation purposes and standard evaluation protocols were also established. Panelists practiced balloting a couple of the samples to ensure consistent evaluation procedures were used. All samples were served at room temperature ( $23\text{C} \pm 1\text{C}$ ).

**Table 4-1.** Flavor attributes, definitions, and references used for descriptive analysis of black walnut cookies<sup>†</sup>

Attribute	Definition	References
Flour-like	General term used to describe the light dusty/musty aromatics associated with wheat.	Gold Medal all-purpose flour = 5.0
Leavening	Aromatics associated with baking soda and/or baking powder in baked flour products.	Pancake = 7.0 <u>Preparation:</u> Mix 1 c all-purpose flour, 1 tsp baking soda, 1/8 tsp salt, and 3/4 c water in a bowl. Cook on a skillet over medium to medium-high heat. Do not let either side brown. Cut edges off pancake and discard. Cut the remaining pancake into cubes and serve in 3.25 fl oz cups.
Toasted	Brown, baked aromatic that may occur with grain products.	General Mills Cheerios cereal = 7.0
Vanilla/Vanillin	Aromatics associated with natural or non-natural vanillin which may or may not include brown, bean-like aromatics.	McCormick vanilla extract in 2% liquid milk = 4.0 <u>Preparation:</u> Mix 1/8 tsp vanilla extract in 1/2 c 2% liquid milk. Serve in 1 fl oz cups.
Brown Sweet	Sweet, round, light brown aromatics which may also include the character notes identified as vanillin and caramelized.	Pepperidge Farm Bordeaux cookies = 7.5
Salty	Fundamental taste factor of which sodium chloride is typical.	0.20% Sodium chloride solution = 2.5 0.25% Sodium chloride solution = 3.5

<sup>†</sup> 0-15-point numeric scale with 0.5 increments was used to rate the intensities of the samples and references. Additional attributes (black walnut ID, overall nutty, nutty-buttery, nutty-grain-like, nutty-woody, brown, acrid, floral/fruity, fruity-dark, piney, musty/dusty, musty/earthy, woody, rancid, overall sweet, sweet, astringent, bitter, and sour) used in the evaluation are provided in Miller and Chambers (in review).

### ***Test Design and Sample Evaluation***

Researchers used a series of modified William's Latin Squares (Hunter 1996) to create the test design for evaluating the black walnut cookies. The Latin Square design was adjusted for first-order bias and treatment order by randomizing the design to ensure each sample was seen in each serving position (1, 2, 3,..., 7) exactly once when viewed by columns or rows. Construction of the Latin Square design was computed in SAS® statistical software (version 9.2, SAS Institute Inc., Cary, NC).

The cookies were removed from the freezer 3 h prior to testing to allow tempering to room temperature ( $23\text{C} \pm 1\text{C}$ ). They were cut into one-eighth ( $1/8$ ) wedges using a serrated knife following the score lines indented in the cookies before baking. Two cookies were served to each panelist (total of 16 wedges) in 236.6 mL Styrofoam bowls with plastic lids (Dart Container Corporation, Mason, MI) labeled with three-digit blinding codes. Panelists sat at a round table under ambient lighting and temperature ( $23\text{C} \pm 1\text{C}$ ) conditions. Panelists scored the samples using a 0-15 numerical scale with 0.5 increments where 0 = none/not present and 15.0 = highest possible intensity. Researchers provided each panelist with a tray of references for the flavor attributes and the previously established lexicon. Panelists were instructed to take one wedge into their mouths and chew until the point of swallowing before scoring attributes on the ballot. Expectoration was encouraged; however, panelists were required to swallow at least one bite per sample. Reverse osmosis, de-ionized water, baby carrots, 1.27 cm Mozzarella cheese cubes (low moisture, part skim, Kroger Company, Cincinnati, OH), and 0.32 cm skinless cucumber slices were used as palate cleansers. Sample evaluation took approximately 15 min, and a 5 min rest period was observed in between samples to reduce flavor carryover effects. Samples were evaluated in three replications on different for each of the seven cultivars of black walnut cookies.

### ***Consumer Acceptability***

Researchers recruited 101 consumers from the greater Kansas City, KS (USA) area to participate in a consumer acceptance study of the black walnut cookies. The Tomboy cultivar was excluded in the consumer evaluation because an insufficient amount of nutmeat was available. The remaining six cultivars were used for consumer testing (Brown Nugget, Davidson, Emma K, Football, Sparks 127, and Sparrow). The consumers recruited for this study

represented the demographic for black walnut consumers and were selected based on eligibility requirements set by the study's screener. Consumers were required to be 18 years of age and older with an approximately 50/50 male to female split. They could not have any known food allergies or work in a sensitive job area (advertising firm, market research firm, or food manufacturer), consume nuts at least once every two to three months, be acceptors of both black walnuts and cookies, and not have participated in a consumer research study within the past three months. All consumers were screened by telephone and a follow-up e-mail was sent to each consumer to confirm their participation at a specified time.

### ***Test Design and Sample Evaluation***

Researchers used a series of six by six William's Latin Square designs (Hunter 1996) to generate the rotation order of the samples for a possible 102 consumers. The SAS® statistical software (version 9.2, SAS Institute Inc., Cary, NC) to generate the Latin Squares.

The black walnut cookies were cut in half using a serrated knife approximately 10 min before each session of consumer testing. Each consumer was served one half cookie on a 15.24 cm white Styrofoam plate (Pactive Corporation, Lake Forest, IL) with a random three-digit blinding code label attached to the plate's edge. Each session lasted approximately 30 min during which each consumer was instructed to taste the sample in front of them and rate their degree of liking using 9-point rating scales where 1=dislike extremely and 9=like extremely, and flavor intensity using a scale from 1=not at all flavorful to 9=extremely flavorful. Consumers evaluated the samples for overall acceptability, overall liking of flavor, overall flavor intensity, liking of black walnut flavor, and black walnut flavor intensity. Unsalted top crackers (Nabisco Premium saltine crackers unsalted tops, Kraft Foods Inc., Northfield, IL) and bottled water were used as palate cleansers in between samples. Each consumer was served the six samples in a sequential monadic design according to the pre-determined rotation order. Consumers were paid for their participation.

## ***Statistical Analyses***

### ***Descriptive Analysis***

Researchers performed analysis of variance (ANOVA) to test the significance of each of the 25 flavor attributes across the black walnut cookie samples at the 5% level of significance.



Using Fisher's protected Least Significant Difference (LSD), post-hoc means separation was also analyzed at the 5% level of significance to determine which samples were significantly different for each attribute. Statistical analyses were performed with SAS® statistical software (version 9.2, SAS Institute Inc., Cary, NC) using PROC MIXED.

Principal components analysis (PCA) using the covariance matrix was conducted to evaluate the relationships among the flavor attributes and black walnut cookies. Analysis was performed using the Unscrambler software (The Unscrambler X version 10.1, Camo Software AS, Oslo, Norway).

### ***Consumer Acceptability***

An analysis of variance (ANOVA) was performed to test for differences among cookies based on the hedonic and intensity questions at the 5% level of significance. Post-hoc means separation also was analyzed using Fisher's protected Least Significant Difference (LSD) at the 5% level of significance to determine which samples were significantly different.

As suggested by Yenket *et al.* (2011b), cluster analysis using Ward's minimum variance procedure was performed to determine if different groups of consumers based on their measurements of the different samples. External preference mapping was conducted using guidelines suggested by Yenket *et al.* (2011a). ANOVA was executed for each individual cluster as well as an ANOVA for all clusters combined to determine significances ( $P \leq 0.05$ ) in products. Researchers carried out analyses with SAS® statistical software (version 9.2, SAS Institute Inc., Cary, NC) using PROC MIXED. Scientists recommend this statistical technique (i.e., testing treatment effects on the whole data set then clustering consumers based on liking trends and finally testing treatment effects within each of the clusters) to improve interpretation of hedonic-scaled consumer data (Schilling and Coggins 2007). Cluster analyses have been used in other recent studies to group or sort consumers (Heenan *et al.* 2010; Chrea *et al.* 2011; Fernández-Vázquez *et al.* 2011).

An external preference map using partial least squares regression (PLS) was performed to determine relationships between the descriptive flavor attributes and consumer acceptability of the cookies across the clusters. Researchers conducted this analysis using The Unscrambler statistical software (The Unscrambler X version 10.1, Camo Software AS, Oslo, Norway).

## Results and Discussion

### *Descriptive Analysis*

Nine of the 25 walnut cookie flavor attributes were significantly different ( $P \leq 0.05$ ) across cultivars: black walnut ID, overall nutty, nutty-buttery, brown, toasted, acrid, rancid, overall sweet, and sweet (Table 4-2). In the cookies, Emma K was significantly lower in black walnut ID and overall nutty when compared with the other six cultivars. This same trend has been seen previously in descriptive studies evaluating the walnut kernels themselves (Warmund *et al.* 2009b; Miller and Chambers, in review). Emma K also was significantly lower in overall sweet and sweet taste and higher in rancid and acrid ( $P \leq 0.05$ ).

Cookies containing Brown Nugget rated highest in the flavor attributes brown and toasted; Davidson, Sparks 127, and Sparrow reported significantly lower scores in brown, while Davidson and Tomboy scored significantly lower in toasted ( $P \leq 0.05$ ). Cookies with Davidson scored significantly higher in nutty-buttery, while Football and Emma K scored lowest for that attribute ( $P \leq 0.05$ ). Miller *et al.* (2013) noted that if the four sub-groups of the overall nutty flavor (nutty-beany, nutty-buttery, nutty-grain-like, and nutty-woody) are in discord with one another then they may negatively affect the perception of the overall nutty attribute. This could explain why Emma K, with its lower nutty-buttery rating, also scored lowest in overall nutty.

**Table 4-2.** Mean intensity scores<sup>†</sup> and separation of flavor attributes for black walnut cookies.\*

Attribute	Cultivar						
	Brown Nugget	Davidson	Emma K	Football	Sparks 127	Sparrow	Tomboy
Black Walnut ID	7.14 <sup>a</sup>	7.21 <sup>a</sup>	6.50 <sup>b</sup>	7.31 <sup>a</sup>	7.24 <sup>a</sup>	7.19 <sup>a</sup>	7.57 <sup>a</sup>
Overall Nutty	6.10 <sup>a</sup>	6.02 <sup>a</sup>	5.45 <sup>b</sup>	6.29 <sup>a</sup>	6.14 <sup>a</sup>	6.19 <sup>a</sup>	6.40 <sup>a</sup>
Nutty-Woody	3.98	3.95	3.90	3.98	3.86	4.10	3.88
Nutty-Grain-like	4.19	4.43	4.00	4.26	4.29	4.19	4.50
Nutty-Buttery	2.93 <sup>abc</sup>	3.10 <sup>a</sup>	2.50 <sup>d</sup>	2.71 <sup>cd</sup>	3.00 <sup>ab</sup>	2.74 <sup>bcd</sup>	2.81 <sup>bc</sup>
Brown	4.26 <sup>a</sup>	3.67 <sup>c</sup>	4.17 <sup>ab</sup>	3.81 <sup>bc</sup>	3.74 <sup>c</sup>	3.62 <sup>c</sup>	3.98 <sup>abc</sup>
Flour-like	3.98	4.05	3.93	3.93	4.00	3.93	3.86
Leavening	2.83	2.93	2.98	2.88	2.95	3.02	3.07
Toasted	3.71 <sup>a</sup>	3.17 <sup>c</sup>	3.57 <sup>ab</sup>	3.21 <sup>bc</sup>	3.52 <sup>abc</sup>	3.60 <sup>ab</sup>	3.14 <sup>c</sup>
Acrid	0.29 <sup>ab</sup>	0.05 <sup>b</sup>	0.60 <sup>a</sup>	0.14 <sup>b</sup>	0.12 <sup>b</sup>	0.31 <sup>ab</sup>	0.00 <sup>b</sup>
Floral/Fruity	1.43	1.31	1.26	1.50	1.45	1.43	1.50
Fruity-dark	0.60	0.48	0.81	0.62	0.36	0.55	0.36
Piney	2.26	2.29	2.07	2.31	2.38	2.29	2.12
Musty/Dusty	2.19	2.07	1.90	2.31	2.14	2.21	2.33

Attribute	Cultivar						
	Brown Nugget	Davidson	Emma K	Football	Sparks 127	Sparrow	Tomboy
Musty/Earthy	1.83	1.95	1.88	1.55	1.45	1.57	1.60
Woody	2.86	2.83	2.67	2.71	2.81	2.79	2.88
Rancid	0.07 <sup>b</sup>	0.10 <sup>b</sup>	0.38 <sup>a</sup>	0.05 <sup>b</sup>	0.00 <sup>b</sup>	0.10 <sup>b</sup>	0.00 <sup>b</sup>
Vanilla/Vanillin	2.62	2.50	2.33	2.50	2.40	2.43	2.64
Overall Sweet	3.95 <sup>ab</sup>	3.98 <sup>ab</sup>	3.81 <sup>b</sup>	3.95 <sup>ab</sup>	4.10 <sup>a</sup>	4.02 <sup>a</sup>	4.12 <sup>a</sup>
Brown Sweet	3.10	2.83	2.76	2.98	3.05	2.88	3.14
Astringent	2.81	2.88	3.00	2.88	2.81	2.88	2.79
Bitter	3.31	3.29	3.48	3.26	3.29	3.43	3.38
Salty	2.90	2.95	3.02	2.83	2.93	2.81	2.86
Sour	2.50	2.48	2.67	2.48	2.43	2.64	2.57
Sweet	3.24 <sup>a</sup>	3.10 <sup>a</sup>	2.79 <sup>b</sup>	3.12 <sup>a</sup>	3.24 <sup>a</sup>	3.12 <sup>a</sup>	3.21 <sup>a</sup>

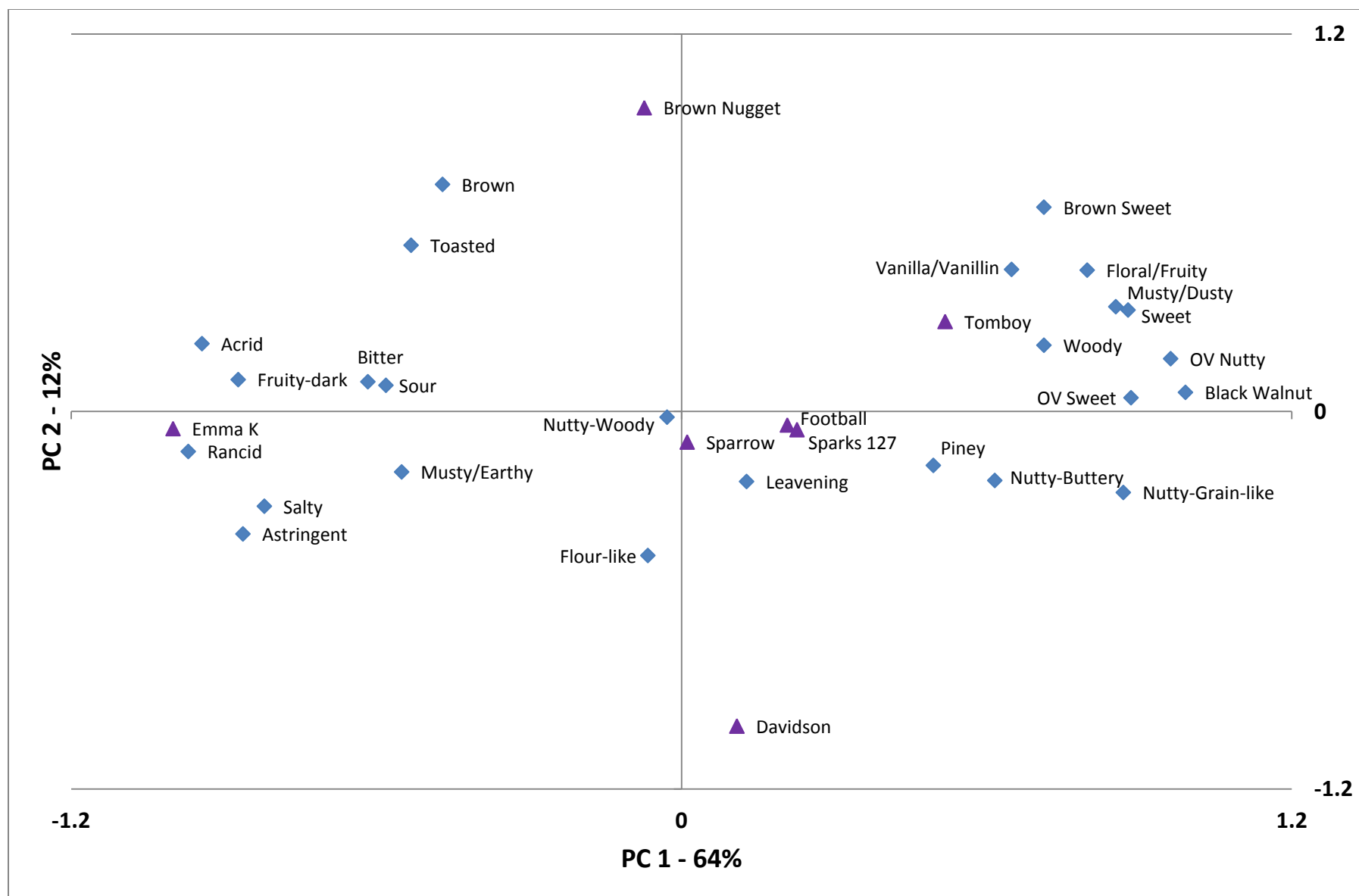
<sup>†</sup>Scores are based on a 0-15-point numeric scale with 0.5 increments.

<sup>\*</sup>Means with different superscripts within a row are significantly different ( $P \leq 0.05$ ) according to Fisher's protected least significant difference (LSD) test.

### ***Principal Component Analysis***

Based on the biplot depiction of the products and attributes (Fig. 4-1), the Emma K cookie was associated with the attributes rancid, acrid, fruity-dark, bitter, sour, musty/earthy, salty, and astringent. Researchers noted a similar result in a PCA biplot of black walnut kernels and descriptive flavor attributes (Miller and Chambers, in review). The Emma K sample related to attributes such as rancid, acrid, fruity-dark, brown, and astringent and was spatially distanced from the other black walnut kernels evaluated in the study (Miller and Chambers, in review).

The Davidson sample appears at the bottom of the PCA biplot, while the Brown Nugget sample appears at the top near the flavors brown and toasted. Brown Nugget scored highest in brown and toasted and Davidson scored significantly lower in these two attributes demonstrating congruence between the ANOVA statistics and the PCA biplot. Football, Sparks 127, and Sparrow group together in the component space near the flavors nutty-woody, leavening, and piney. While there were no significant differences in these attributes among samples, when all attributes are considered together, the biplot shows a similarity in the aforementioned attributes among these three cookies. The Tomboy cookie is also secluded by itself near such attributes as vanilla/vanillin, woody, sweet, musty/dusty, floral/fruity, and others. ANOVA statistics revealed Tomboy scored higher in overall sweet and sweet characteristics and numerically higher (not statistically significant) in woody, overall nutty, and black walnut ID characteristics.



**Figure 4-1.** Sensory map of principal components 1 and 2 for the seven black walnut cookies and the descriptive flavor attributes.

### ***Consumer Acceptability***

One hundred one (101) consumers rated the acceptability and flavor intensity of six black walnut cookies (Brown Nugget, Davidson, Emma K, Football, Sparks 127, and Sparrow). Table 4-3 shows gender and age distributions for the consumers. The majority of the participants (78%) reported eating black walnuts at least once during the time span of one to every six months, while 21% reported never having eaten black walnuts. These results are similar to a previous study evaluating black walnut consumption (Gold *et al.* 2004). According to Gold *et al.* (2004), results from their survey questionnaire of 232 participants during the 2003 Missouri Chestnut Roast festival, 58% of the participants consumed black walnuts either weekly, monthly, or at least 2-6 times a year, while only 15% had never tried black walnuts.

ANOVA results showed that only the black walnut flavor intensity differed significantly across cookies for all consumers ( $P \leq 0.05$ ). Sparrow and Football cookies were perceived to be the most intense in black walnut flavor (means scores 5.59 and 5.37, respectively), while Emma K and Sparks 127 were perceived to be the least intense (mean scores 4.74 and 4.68, respectively).

Although there was no significant difference in overall acceptability of the black walnut cookies among consumers as a whole, researchers found four significantly different clusters ( $P \leq 0.05$ ) of consumers within the pool of 101 consumers. Table 4-3 provides gender and age demographics for the clusters. Cluster 1 comprises of 29 consumers. This group had significant differences ( $P \leq 0.05$ ) in overall acceptability of the black walnut cookies. Football was the most favored cookie, while Emma K was the least favored. Clusters 2 and 3 contained 25 and 13 consumers, respectively. Both clusters showed no significant differences in overall acceptability of the cookies with mean scores of 3.3 (this group did not like any of the samples) and 6.9 (this group liked all of the samples), respectively. Cluster 4 contained 33 consumers who liked the Emma K cookies the most ( $P \leq 0.05$ ) and liked Football the least. Researchers excluded one consumer from the cluster analysis due to an incomplete ballot. Table 4-4 illustrates the mean overall acceptability scores by cluster.

By studying the results of the cluster analysis, scientists can deduce why there were no significant differences in acceptability across all consumers. Cluster 1 liked the Football sample the most and Emma K the least, while cluster 4 indicated the exact opposite results (i.e., Emma

K liked the most and Football liked the least). Additionally, clusters 2 and 3 showed no differentiation in their liking of the cookies. Analyzing all four clusters of consumers as a whole simply “averages to the middle” with results of various consumer clusters negating each other.

**Table 4-3.** Consumer demographics compiled from 101 consumers in the greater Kansas City, KS area.

Consumers	Gender %		Age %					
	Female	Male	18-24	25-35	36-45	46-55	56-65	66+
All	72	28	10	22	27	27	9	5
Cluster 1	66	34	14	10	28	41	7	0
Cluster 2	88	12	0	20	40	24	16	0
Cluster 3	38	62	8	31	15	15	15	15
Cluster 4	79	21	15	30	21	21	3	9

**Table 4-4.** Overall acceptability scores<sup>†</sup> and means separation of black walnut cookies for consumer clusters.\*

	Cultivar					
	Brown Nugget	Davidson	Emma K	Football	Sparks 127	Sparrow
Cluster 1	5.07 <sup>b</sup>	5.86 <sup>ab</sup>	3.66 <sup>c</sup>	6.24 <sup>a</sup>	5.10 <sup>b</sup>	5.52 <sup>ab</sup>
Cluster 2	3.88	2.80	3.72	3.00	3.28	3.28
Cluster 3	7.00	6.62	7.00	6.69	7.23	6.69
Cluster 4	4.97 <sup>bc</sup>	5.18 <sup>abc</sup>	5.91 <sup>a</sup>	3.94 <sup>d</sup>	5.70 <sup>ab</sup>	4.39 <sup>cd</sup>

<sup>†</sup>Scores are based on a 9-point hedonic scale.

\*Means with different superscripts within a row are significantly different ( $P \leq 0.05$ ) according to Fisher’s protected least significant difference (LSD) test.

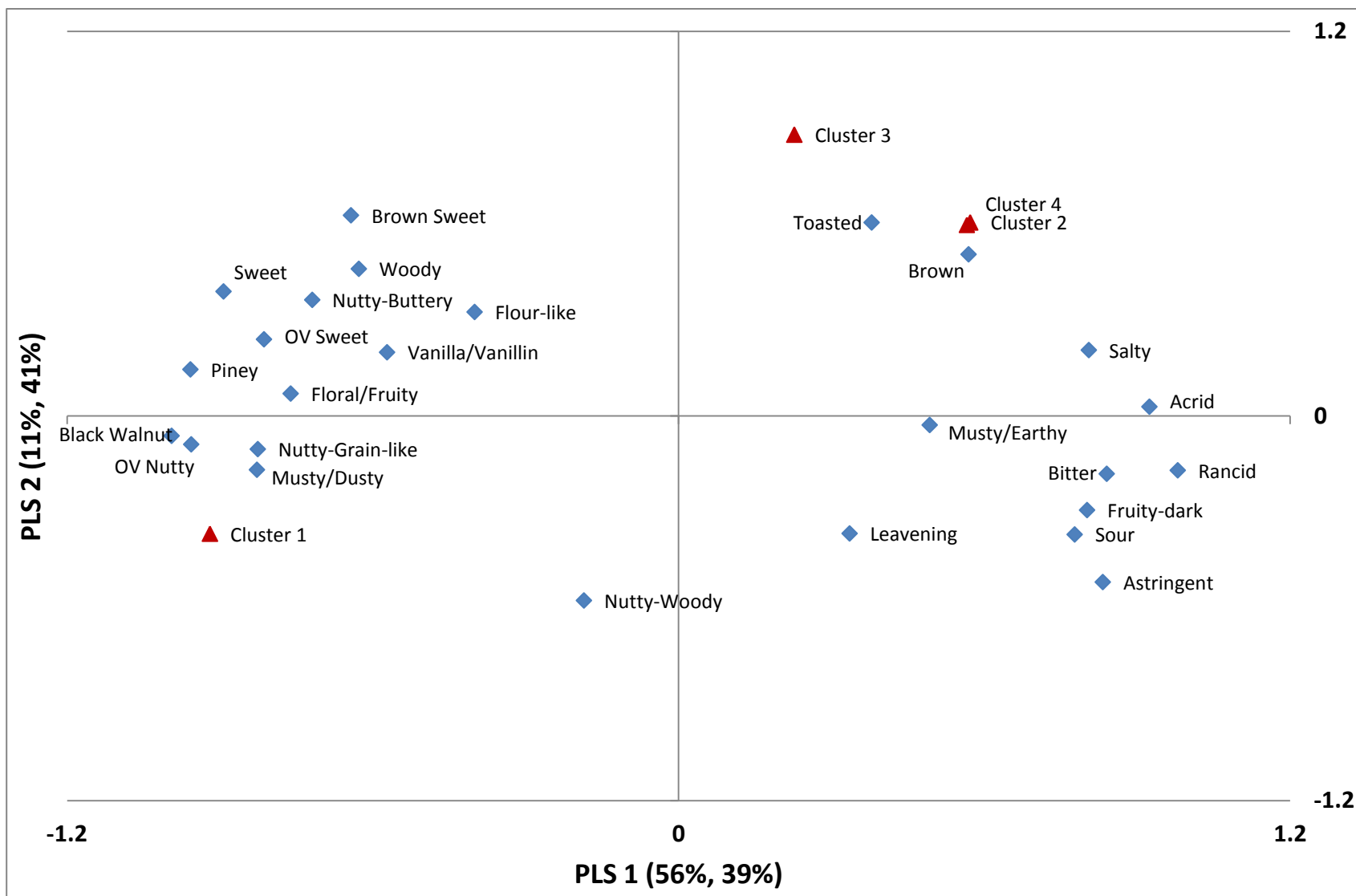


### ***Relating Consumer Acceptability with Descriptive Attributes***

An external preference map using PLS regression was performed to relate consumer acceptability with the descriptive flavor attributes of the black walnut cookies (Fig. 4-2). Sixty-seven percent (67%) of the descriptive data explained 80% of the consumer data across dimensions 1 and 2. The preference map indicates that consumers in cluster 1 (Football most preferred, Emma K least preferred) associated the cookie samples with the flavor attributes black walnut ID, overall nutty, nutty-grain-like, and musty/dusty. This is logical because Football was significantly higher in black walnut ID and overall nutty compared to Emma K. Results indicate that these two flavor attributes are the driving factors of liking for cluster 1.

Clusters 2, 3, and 4 group closer together on the map and are related with the flavor attributes toasted, brown, salty, and acrid. Cluster 4 consumers showed a preference for the Emma K sample, which was significantly higher in acrid, brown, and toasted flavors based on the descriptive results. Clusters 2 and 3 had no preference for any sample. Consumers made several comments of a salty taste and/or a strange aftertaste in some of the cookies. These comments, along with the undesirable attribute “acrid” may explain cluster 2’s overall disliking of the cookies.

It appears that there are sets of niche consumers who either generally like, dislike, or show strong preference for a particular cultivar in regards to black walnut cookies. Emma K was the most preferred cookie from the largest cluster of consumers; however, lower intensities of black walnut ID, overall nutty, and sweet notes and higher rancid and acrid notes characterize this sample. The second largest cluster of consumers (cluster 1) preferred Football the most, but cluster 4 preferred it the least. Brown Nugget may provide a suitable compromise to use in the black walnut cookies, as it generally was well liked by all consumer clusters who liked black walnut cookies, and had high scores for black walnut ID, overall nutty, nutty-buttery, overall sweet, and sweet to characterize its flavor.



**Figure 4-2.** External preference map of consumer clusters and descriptive flavor attributes for black walnut cookies. Sixty-seven percent (67%) of the descriptive data explained 80% of the consumer data across dimensions 1 and 2.

## **Conclusions**

Seven black walnut cultivars (Brown Nugget, Davidson, Emma K, Football, Sparks 127, Sparrow, and Tomboy) were incorporated into a sugar cookie and tested for differences in flavor attributes among these cultivars. Nine of the 25 flavor attributes differed significantly across samples (black walnut ID, overall nutty, nutty-buttery, toasted, brown, acrid, rancid, overall sweet, and sweet). Emma K was characterized by lower ratings of black walnut ID, overall nutty, and sweet and higher ratings of rancid. The PCA biplot further reveals that Football, Sparks 127, and Sparrow samples related with one another and the attributes nutty-woody, leavening, and piney. Brown Nugget, Davidson, and Tomboy each occupied their own space in the PCA biplot. A consumer acceptance test was performed on all cookies except for the Tomboy cultivar. Four significant clusters with differing cookie preferences emerged from the analysis. Results indicate that Brown Nugget may be an appropriate cultivar to use in black walnut cookies, as all consumer clusters received it well, and it contained acceptable flavor qualities.

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## Appendix A - SAS® Codes

### SAS® Code for Latin Square Designs

```
dm 'log;clear;output;clear;';
title 'Latin Square Design';
ods rtf;
proc plan seed=1156165;
factors rows=7 ordered cols=7 ordered / noprint;
treatments tmts=7 cyclic;
output out=g
    rows cvals=('G1' 'G2' 'G3' 'G4' 'G5' 'G6' 'G7') random
    cols cvals=('O1' 'O2' 'O3' 'O4' 'O5' 'O6' 'O7') random
    tmts nvals=(1 2 3 4 5 6 7) random;
quit;

Proc tabulate;
    class rows cols;
    var tmts;
    table rows, cols*(tmts*f=6.) / rts=8;
run;
ods rtf close;
quit;
```

### *Notes*

1. The seed number was changed for each repetition for both phases of the descriptive testing (raw black walnuts and black walnut cookies) to generate six unique Latin Square Designs.
2. The seed number was changed for each of the 20 Latin Squares used to generate the sample rotation orders for the consumer test with the black walnut cookies. This resulted in 20 different Latin Square Designs.
3. The 'rows,' 'cols,' and 'tmts' variables were changed to "6" for creating Latin Square Designs for sample rotations used in the consumer test.
4. The 'rows cvals,' 'cols cvals,' and 'tmts nvals' variables, "G7," "O7," and "7" (respectively), were deleted for the Latin Square Designs used for creating the sample rotation orders for the consumer test.



## SAS® Code for Analyzing Descriptive Test Data (Black Walnut Kernels and Black Walnut Cookies)

```
dm 'log;clear;output;clear;';
options nodate nonumber;

data (data name);
input Cultivar$ Panelist$ Rep$ atr1 atr2 atr3 atr4 atr5 atr6 atr7 atr8
      atr9 atr10 atr11 atr12 atr13 atr14 atr15 atr16 atr17 atr18 atr19 atr20
      atr21 atr22;
cards;

;

ods rtf;
proc mixed data= (data name) covtest cl;
  class rep panelist cultivar;
  model atr# = cultivar/outp = (data name);
  title '(attribute name)';
  random rep panelist;
  lsmeans cultivar/cl pdiff;
  ods output diffs=ppp lsmeans=mmm;

run;

%include 'W:\Hn\SAC\PROJECTS BY YEAR\Projects 2011\Black Walnuts-SAC-Ashley
Miller-DA and CLT-12-2011\SAS Codes\Pdmix800.sas';
  %pdmix800 (ppp,mmm,alpha=.05,sort=yes);

run;

ods rtf close;
quit;
```

### Notes

1. The number of “atr#” input variables corresponds to the number of attributes on the respective ballots (i.e. 22 attributes for raw black walnuts and 25 attributes for black walnut cookies).
2. The PROC MIXED procedure is repeated for each attribute resulting in 22 individual codes for the raw black walnut attributes and 25 individual codes for the black walnut cookie attributes.
3. “atr#” is replaced by “atr1”, “atr2”, ..., “atrXX” for each of the attributes. The “title” variable is named according to the specific attribute (i.e. atr1 is ‘Black Walnut ID’).

## SAS® Code for Analyzing Consumer Test Data

### ANOVA

```
dm'log;clear;output;clear';
options nodate nonumber;
```

```
data (data name);
input Sample$  Cons$  OALike  FlavLike  FlavInt  WalLike  WalInt;
cards;

;
```

```
ods rtf;
proc mixed data = (data name) covtest cl;
  class Sample Cons;
  model OALike = Sample/outp= (data name) ;
  title 'Overall Liking';
  random Cons
  lsmeans Sample/cl pdiff;
run;
```

```
proc mixed data = (data name) covtest cl;
  class Sample Cons;
  model FlavLike = Sample/outp= (data name) ;
  title 'Overall Flavor Liking';
  random Cons
  lsmeans Sample/cl pdiff;
run;
```

```
proc mixed data = (data name) covtest cl;
  class Sample Cons;
  model FlavInt = Sample/outp= (data name) ;
  title 'Flavor Intensity';
  random Cons
  lsmeans Sample/cl pdiff;
run;
```

```
proc mixed data = (data name) covtest cl;
  class Sample Cons;
  model WalLike = Sample/outp= (data name) ;
  title 'Walnut Flavor Liking';
  random Cons
  lsmeans Sample/cl pdiff;
run;
```

```

proc mixed data = (data name) covtest cl;
    class Sample Cons;
    model WalInt = Sample/outp= (data name) ;
    title 'Walnut Intensity';
    random Cons
    lsmeans Sample/cl pdiff;
run;

ods rtf close;
quit;

```

### *Cluster Analysis – Consumer Overall Liking Scores*

```

dm 'log;clear;output;clear;';
title 'Frag Cluster';
data consumer1;
input Consumer$ Brown_Nugget Davidson Emma_K Football Sparks_127 Sparrow;
cards;
(input raw data here)
;

ods rtf;
ods graphics on;
proc cluster data=consumer1 outtree=treew method=ward pseudo std CCC ;
id Consumer;
Var Brown_Nugget Davidson Emma_K Football Sparks_127 Sparrow;
run;
legend1 frame cframe=ligr
position=center value=(justify=center);
axis1 label=(angle=90 rotate = 0) minor=none order=(0 to 70 by 2);
axis2 minor=none order=( 1 to 28 by 1);

proc gplot;
plot _CCC_*_ncl_ /
frame cframe=ligr legend=legend1 Vaxis= axis3 haxis= axis2;
PLOT _PSF_*_NCL_ _PST2_*_NCL_ /OVERLAY
frame cframe=ligr legend=legend1 Vaxis= axis1 haxis= axis2;
run;

proc tree data=treew nclusters=4 out= result1 sort;
id Consumer;
run;

```

```
proc sort data= result1; by cluster;
run;
```

```
proc print data= result1; by cluster;
run;
```

```
ods graphics off;
ods rtf close;
quit;
```

## *ANOVA for Clusters*

### **Comparing within Individual Clusters**

```
title 'Cluster 1';
data consumer;
input Panelist$ Cultivar$ OA_Liking;
cards;
(insert raw data here)
;

ods rtf;
proc glm data=consumer;
class Panelist Cultivar;
model OA_Liking = Panelist Cultivar/ss3;
      means cultivar/lsd;
      lsmeans cultivar/pdiff lines;
run;
ods rtf close;
quit;
```

### *Notes*

1. Four separate ANOVA analyses (corresponding to each of the four clusters from the consumer data) were conducted. The title for each ANOVA was changed to reflect this (Cluster 1, Cluster 2, Cluster 3, and Cluster 4).
2. Only consumers previously grouped into a particular cluster were used in the ANOVA analysis for that respective cluster.

### **Comparing across All Clusters**

```
data consumer;
input Panelist$ Cultivar$ Cluster$ OA_Liking;
cards;
(insert raw data here)
;

ods rtf;
proc sort data=consumer; by cluster;
proc glm data=consumer;
class Panelist Cultivar Cluster;
model OA_Liking = Cultivar cluster panelist(cluster) cultivar*cluster/ss3;
      means cultivar/lsd;
      lsmeans cultivar/pdiff lines;
run;
ods rtf close;
quit;
```

## Appendix B - Test Designs for Black Walnut Descriptive Analysis

### Black Walnut Kernel Evaluation

	Session						
	1	2	3	4	5	6	7
Panelist #	Blinding Code						
58	450	743	829	630	337	961	261
63	743	829	961	261	630	337	450
49	337	630	261	829	743	450	961
8	261	450	743	337	961	829	630
45	961	337	630	743	450	261	829
62	829	961	337	450	261	630	743
61	630	261	450	961	829	743	337

Key	
Brown Nugget	261
Davidson	630
Emma K	337
Football	961
Sparks 127	450
Sparrow	743
Tomboy	829

	Session						
	1	2	3	4	5	6	7
Panelist #	Blinding Code						
58	847	166	646	435	515	970	755
63	646	847	435	515	970	755	166
49	166	755	847	646	435	515	970
8	755	970	166	847	646	435	515
45	515	435	970	755	166	847	646
62	435	646	515	970	755	166	847
61	970	515	755	166	847	646	435

Key	
Brown Nugget	970
Davidson	755
Emma K	847
Football	646
Sparks 127	435
Sparrow	515
Tomboy	166

	Session						
	1	2	3	4	5	6	7
Panelist #	Blinding Code						
58	226	581	142	817	900	627	340
63	900	142	226	340	817	581	627
49	817	226	900	627	340	142	581
8	627	817	340	142	581	900	226
45	142	627	581	900	226	340	817
62	340	900	817	581	627	226	142
61	581	340	627	226	142	817	900

Key	
Brown Nugget	142
Davidson	817
Emma K	340
Football	226
Sparks 127	581
Sparrow	900
Tomboy	627



## Black Walnut Cookie Evaluation

	Session				
	1	2	3	4	5
Panelist #	Blinding Code				
58	276	816	925	766	627
63	388	276	627	816	529
49	627	925	766	388	816
8	816	766	388	529	925
45	925	388	529	276	766
62	766	529	276	627	388
61	529	627	816	925	276

Key	
Brown Nugget	925
Davidson	276
Emma K	766
Football	816
Sparks 127	388
Sparrow	529
Tomboy	627

	Session				
	1	2	3	4	5
Panelist #	Blinding Code				
58	529	388	346	612	229
63	766	925	836	346	979
49	276	529	229	457	612
8	627	276	152	979	836
45	816	627	612	152	457
62	925	816	979	229	346
61	529	766	457	836	152

Key		
Brown Nugget	925	612
Davidson	276	229
Emma K	766	836
Football	816	979
Sparks 127	388	346
Sparrow	529	457
Tomboy	627	152

	Session				
	1	2	3	4	5
Panelist #	Blinding Code				
58	979	152	457	836	418
63	152	612	229	457	668
49	346	836	152	979	770
8	457	229	346	612	992
45	229	979	836	346	303
62	836	457	612	152	243
61	612	346	979	229	549

Key		
Brown Nugget	612	770
Davidson	229	418
Emma K	836	549
Football	979	243
Sparks 127	346	992
Sparrow	457	668
Tomboy	152	303

	Session						
	1	2	3		4	5	6
Panelist #	Blinding Code						
58	992	243	770	BREAK 10 MIN.	668	549	303
63	303	418	549		992	243	770
49	243	303	668		549	992	418
8	770	668	243		303	418	549
45	549	992	418		770	668	243
62	668	549	303		418	770	992
61	418	770	992		243	303	668

Key	
Brown Nugget	770
Davidson	418
Emma K	549
Football	243
Sparks 127	992
Sparrow	668
Tomboy	303

## Black Walnut Cookie Rotation Order for Consumer Test

Key	
Brown Nugget	185
Davidson	334
Emma K	429
Football	603
Sparks 127	812
Sparrow	960

Latin Square Design 1

	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
<b>Panelist1</b>	960	603	334	429	812	185
<b>Panelist2</b>	812	334	603	185	960	429
<b>Panelist3</b>	603	429	185	960	334	812
<b>Panelist4</b>	185	812	960	334	429	603
<b>Panelist5</b>	429	960	812	603	185	334
<b>Panelist6</b>	334	185	429	812	603	960

Latin Square Design 2

	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
<b>Panelist7</b>	812	429	960	334	603	185
<b>Panelist8</b>	429	603	334	185	812	960
<b>Panelist9</b>	185	960	812	429	334	603
<b>Panelist10</b>	334	185	603	812	960	429
<b>Panelist11</b>	603	812	185	960	429	334
<b>Panelist12</b>	960	334	429	603	185	812

Latin Square Design 3

	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
<b>Panelist13</b>	185	960	812	429	334	603
<b>Panelist14</b>	334	812	603	185	429	960
<b>Panelist15</b>	603	429	185	812	960	334
<b>Panelist16</b>	429	603	960	334	185	812
<b>Panelist17</b>	812	334	429	960	603	185
<b>Panelist18</b>	960	185	334	603	812	429

Latin Square Design 4

	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
<b>Panelist19</b>	812	960	603	334	429	185
<b>Panelist20</b>	429	812	185	603	334	960
<b>Panelist21</b>	960	185	334	429	812	603
<b>Panelist22</b>	334	429	960	185	603	812
<b>Panelist23</b>	603	334	812	960	185	429
<b>Panelist24</b>	185	603	429	812	960	334

Latin Square Design 5

	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
<b>Panelist25</b>	334	812	603	429	185	960
<b>Panelist26</b>	960	185	812	334	429	603
<b>Panelist27</b>	603	429	185	960	334	812
<b>Panelist28</b>	429	603	960	185	812	334
<b>Panelist29</b>	185	960	334	812	603	429
<b>Panelist30</b>	812	334	429	603	960	185

Latin Square Design 6

	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
<b>Panelist31</b>	812	429	960	334	185	603
<b>Panelist32</b>	334	603	429	185	812	960
<b>Panelist33</b>	185	960	603	812	334	429
<b>Panelist34</b>	960	334	812	429	603	185
<b>Panelist35</b>	603	812	185	960	429	334
<b>Panelist36</b>	429	185	334	603	960	812

Latin Square Design 7

	<b>Sample1</b>	<b>Sample2</b>	<b>Sample3</b>	<b>Sample4</b>	<b>Sample5</b>	<b>Sample6</b>
<b>Panelist37</b>	334	429	185	960	603	812
<b>Panelist38</b>	960	185	603	812	429	334
<b>Panelist39</b>	185	960	812	603	334	429
<b>Panelist40</b>	429	334	960	185	812	603
<b>Panelist41</b>	812	603	429	334	185	960
<b>Panelist42</b>	603	812	334	429	960	185

Latin Square Design 8

	<b>Sample1</b>	<b>Sample2</b>	<b>Sample3</b>	<b>Sample4</b>	<b>Sample5</b>	<b>Sample6</b>
<b>Panelist43</b>	960	185	334	812	603	429
<b>Panelist44</b>	603	429	812	334	960	185
<b>Panelist45</b>	812	960	429	185	334	603
<b>Panelist46</b>	429	334	960	603	185	812
<b>Panelist47</b>	334	603	185	429	812	960
<b>Panelist48</b>	185	812	603	960	429	334

Latin Square Design 9

	<b>Sample1</b>	<b>Sample2</b>	<b>Sample3</b>	<b>Sample4</b>	<b>Sample5</b>	<b>Sample6</b>
<b>Panelist49</b>	960	603	185	812	429	334
<b>Panelist50</b>	429	812	960	334	603	185
<b>Panelist51</b>	603	334	429	185	812	960
<b>Panelist52</b>	334	960	812	429	185	603
<b>Panelist53</b>	185	429	334	603	960	812
<b>Panelist54</b>	812	185	603	960	334	429

Latin Square Design 10

	<b>Sample1</b>	<b>Sample2</b>	<b>Sample3</b>	<b>Sample4</b>	<b>Sample5</b>	<b>Sample6</b>
<b>Panelist55</b>	812	603	185	429	960	334
<b>Panelist56</b>	429	185	334	960	603	812
<b>Panelist57</b>	334	960	603	812	429	185
<b>Panelist58</b>	603	812	429	185	334	960
<b>Panelist59</b>	960	334	812	603	185	429
<b>Panelist60</b>	185	429	960	334	812	603

Latin Square Design 11

	<b>Sample1</b>	<b>Sample2</b>	<b>Sample3</b>	<b>Sample4</b>	<b>Sample5</b>	<b>Sample6</b>
<b>Panelist61</b>	812	429	185	334	960	603
<b>Panelist62</b>	603	960	812	429	334	185
<b>Panelist63</b>	960	185	429	603	812	334
<b>Panelist64</b>	429	603	334	812	185	960
<b>Panelist65</b>	334	812	960	185	603	429
<b>Panelist66</b>	185	334	603	960	429	812

Latin Square Design 12

	<b>Sample1</b>	<b>Sample2</b>	<b>Sample3</b>	<b>Sample4</b>	<b>Sample5</b>	<b>Sample6</b>
<b>Panelist67</b>	603	429	334	185	960	812
<b>Panelist68</b>	334	960	603	812	429	185
<b>Panelist69</b>	185	334	812	429	603	960
<b>Panelist70</b>	812	603	185	960	334	429
<b>Panelist71</b>	960	185	429	603	812	334
<b>Panelist72</b>	429	812	960	334	185	603

Latin Square Design 13

	<b>Sample1</b>	<b>Sample2</b>	<b>Sample3</b>	<b>Sample4</b>	<b>Sample5</b>	<b>Sample6</b>
<b>Panelist73</b>	429	812	960	185	603	334
<b>Panelist74</b>	603	334	185	812	960	429
<b>Panelist75</b>	812	960	429	603	334	185
<b>Panelist76</b>	334	185	603	960	429	812
<b>Panelist77</b>	185	603	334	429	812	960
<b>Panelist78</b>	960	429	812	334	185	603

Latin Square Design 14

	<b>Sample1</b>	<b>Sample2</b>	<b>Sample3</b>	<b>Sample4</b>	<b>Sample5</b>	<b>Sample6</b>
<b>Panelist79</b>	603	429	812	960	334	185
<b>Panelist80</b>	334	185	429	603	960	812
<b>Panelist81</b>	960	812	185	334	603	429
<b>Panelist82</b>	429	960	334	812	185	603
<b>Panelist83</b>	812	334	603	185	429	960
<b>Panelist84</b>	185	603	960	429	812	334



Latin Square Design 15

	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
<b>Panelist85</b>	812	429	334	603	185	960
<b>Panelist86</b>	429	960	185	334	812	603
<b>Panelist87</b>	334	185	960	429	603	812
<b>Panelist88</b>	603	334	429	812	960	185
<b>Panelist89</b>	185	812	603	960	334	429
<b>Panelist90</b>	960	603	812	185	429	334

Latin Square Design 16

	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
<b>Panelist91</b>	185	429	960	603	812	334
<b>Panelist92</b>	603	334	812	960	429	185
<b>Panelist93</b>	960	185	429	812	334	603
<b>Panelist94</b>	334	812	603	185	960	429
<b>Panelist95</b>	429	960	185	334	603	812
<b>Panelist96</b>	812	603	334	429	185	960

Latin Square Design 17

	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
<b>Panelist97</b>	334	185	603	812	960	429
<b>Panelist98</b>	429	960	812	603	185	334
<b>Panelist99</b>	812	334	185	960	429	603
<b>Panelist100</b>	960	812	334	429	603	185
<b>Panelist101</b>	603	429	960	185	334	812
<b>Panelist102</b>	185	603	429	334	812	960

Latin Square Design 18

	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
<b>Panelist103</b>	429	334	960	603	812	185
<b>Panelist104</b>	960	603	185	812	334	429
<b>Panelist105</b>	603	429	812	960	185	334
<b>Panelist106</b>	812	960	334	185	429	603
<b>Panelist107</b>	334	185	603	429	960	812
<b>Panelist108</b>	185	812	429	334	603	960

Latin Square Design 19

	<b>Sample1</b>	<b>Sample2</b>	<b>Sample3</b>	<b>Sample4</b>	<b>Sample5</b>	<b>Sample6</b>
<b>Panelist109</b>	960	334	429	185	812	603
<b>Panelist110</b>	334	429	603	960	185	812
<b>Panelist111</b>	812	185	960	603	429	334
<b>Panelist112</b>	185	960	334	812	603	429
<b>Panelist113</b>	603	812	185	429	334	960
<b>Panelist114</b>	429	603	812	334	960	185

Latin Square Design 20

	<b>Sample1</b>	<b>Sample2</b>	<b>Sample3</b>	<b>Sample4</b>	<b>Sample5</b>	<b>Sample6</b>
<b>Panelist115</b>	334	429	960	812	185	603
<b>Panelist116</b>	429	812	603	334	960	185
<b>Panelist117</b>	812	334	185	429	603	960
<b>Panelist118</b>	185	960	334	603	812	429
<b>Panelist119</b>	603	185	812	960	429	334
<b>Panelist120</b>	960	603	429	185	334	812

## Appendix C - Ballots for Black Walnut Descriptive Analysis

### Black Walnut Kernel Evaluation

Panelist \_\_\_\_\_

Sample \_\_\_\_\_

Date \_\_\_\_\_

#### Flavor

Black Walnut	0	0.5	1	1.5	2	2.5	3	3.5	4	<u>4.5</u>	5	5.5	6	6.5	7	<u>7.5</u>	8	8.5	9	9.5	10	10.5	11	11.5	<u>12</u>	12.5	13	13.5	14	14.5	15
Overall Nutty	0	0.5	1	1.5	2	2.5	3	3.5	4	<u>4.5</u>	5	5.5	6	6.5	7	<u>7.5</u>	<u>8</u>	8.5	<u>9</u>	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Nutty-Woody	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	<u>7.5</u>	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Nutty-Grain-like	0	0.5	1	1.5	2	2.5	3	3.5	4	<u>4.5</u>	5	5.5	6	6.5	7	<u>7.5</u>	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Nutty-Buttery	0	0.5	1	1.5	2	2.5	3	<u>3.5</u>	4	4.5	<u>5</u>	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Brown	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	<u>5</u>	5.5	6	6.5	7	<u>7.5</u>	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	<u>13</u>	13.5	14	14.5	15
Caramelized	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	<u>7.5</u>	8	8.5	<u>9</u>	9.5	10	10.5	11	11.5	12	12.5	<u>13</u>	13.5	14	14.5	15
Acrid	0	0.5	1	1.5	2	2.5	<u>3</u>	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Burnt	0	0.5	1	1.5	2	2.5	3	3.5	<u>4</u>	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

Floral/Fruity	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	<u>5</u>	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity-dark	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	<u>5</u>	5.5	6	6.5	<u>7</u>	7.5	8	8.5	<u>9</u>	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Piney	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	<u>6</u>	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Musty/Dusty	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	<u>5</u>	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Musty/Earthy	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	<u>8.5</u>	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Woody	0	0.5	1	1.5	2	2.5	3	3.5	<u>4</u>	4.5	5	<u>5.5</u>	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Overall Sweet	0	0.5	1	<u>1.5</u>	2	2.5	<u>3</u>	3.5	4	<u>4.5</u>	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Oily	0	0.5	1	1.5	2	2.5	3	3.5	<u>4</u>	4.5	5	5.5	6	6.5	7	7.5	8	8.5	<u>9</u>	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Rancid	0	0.5	1	1.5	2	<u>2.5</u>	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Astringent	0	0.5	1	<u>1.5</u>	2	<u>2.5</u>	3	<u>3.5</u>	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Bitter	0	0.5	1	1.5	<u>2</u>	2.5	3	<u>3.5</u>	4	4.5	<u>5</u>	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Sour	0	0.5	1	<u>1.5</u>	2	<u>2.5</u>	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Sweet	0	0.5	<u>1</u>	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

## Black Walnut Cookie Evaluation

Panelist \_\_\_\_\_

Sample \_\_\_\_\_

Date \_\_\_\_\_

### Flavor

Black Walnut	0	0.5	1	1.5	2	2.5	3	3.5	4	<u>4.5</u>	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	<u>12</u>	12.5	13	13.5	14	14.5	15
Overall Nutty	0	0.5	1	1.5	2	2.5	3	3.5	4	<u>4.5</u>	5	5.5	6	6.5	7	<u>7.5</u>	<u>8</u>	8.5	<u>9</u>	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Nutty-Woody	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	<u>7.5</u>	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Nutty-Grain-like	0	0.5	1	1.5	2	2.5	3	3.5	4	<u>4.5</u>	5	5.5	6	6.5	7	<u>7.5</u>	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Nutty-Buttery	0	0.5	1	1.5	2	2.5	3	<u>3.5</u>	4	4.5	<u>5</u>	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Brown	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	<u>5</u>	5.5	6	6.5	7	<u>7.5</u>	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	<u>13</u>	13.5	14	14.5	15
Flour-like	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	<u>5</u>	5.5	6	6.5	7	7.5	8	8.5	<u>9</u>	9.5	10	10.5	11	11.5	12	12.5	<u>13</u>	13.5	14	14.5	15
Leavening	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	<u>7</u>	7.5	8	8.5	<u>9</u>	9.5	10	10.5	11	11.5	12	12.5	<u>13</u>	13.5	14	14.5	15
Toasted	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	<u>7</u>	7.5	8	8.5	<u>9</u>	9.5	10	10.5	11	11.5	12	12.5	<u>13</u>	13.5	14	14.5	15

Acrid	0	0.5	1	1.5	2	2.5	<u>3</u>	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Floral/Fruity	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	<u>5</u>	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity-dark	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	<u>5</u>	5.5	6	6.5	<u>7</u>	7.5	8	8.5	<u>9</u>	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Piney	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	<u>6</u>	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Musty/Dusty	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	<u>5</u>	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Musty/Earthy	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	<u>8.5</u>	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Woody	0	0.5	1	1.5	2	2.5	3	3.5	<u>4</u>	4.5	5	<u>5.5</u>	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Rancid	0	0.5	1	1.5	2	<u>2.5</u>	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Vanilla/Vanillin	0	0.5	1	1.5	2	2.5	3	3.5	<u>4</u>	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Astringent	0	0.5	1	<u>1.5</u>	2	<u>2.5</u>	3	<u>3.5</u>	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Bitter	0	0.5	1	1.5	<u>2</u>	2.5	3	<u>3.5</u>	4	4.5	<u>5</u>	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Salty	0	0.5	1	1.5	2	<u>2.5</u>	3	<u>3.5</u>	4	4.5	<u>5</u>	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

<b>Sour</b>	0	0.5	1	<u>1.5</u>	2	<u>2.5</u>	3	<u>3.5</u>	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
<b>Overall Sweet</b>	0	0.5	1	<u>1.5</u>	2	2.5	<u>3</u>	3.5	4	<u>4.5</u>	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
<b>Brown Sweet</b>	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	<u>7.5</u>	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
<b>Sweet</b>	0	0.5	1	1.5	<u>2</u>	2.5	3	3.5	<u>4</u>	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

## Appendix D - Definition and Reference Sheets for Black Walnut

### Descriptive Analysis

#### Black Walnut Kernel Evaluation

**Technicians:** *Serve 1 tbsp (12 grams, chopped) for evaluation.*

**Panelists:** *Use 2-3 pieces of black walnut (depending on size) for evaluation.*

#### **FLAVOR**

**Black Walnut ID:** Aromatics associated with black walnuts including musty/earthy, piney, woody, brown, sweet, buttery, oily, astringent, and slightly acrid aromatics; other aromatics may include musty/dusty, floral/fruity, and/or fruity-dark.

**Reference:** Ground Black Walnut pieces = 12.0 (flavor)

**Preparation:** Measure out 1 tbsp each of various cultivars into a food processor and blend for 30 s. Serve in 1 fl oz cups.

**Overall Nutty:** Measurement reflecting the total of nutty characteristics and the degree to which these characteristics fit together. Nutty characteristics are: sweet, oily, light brown, slightly musty and/or buttery, earthy, woody, astringent, bitter, etc.

Examples: nuts, wheat germ, certain whole grains.

**Reference:** Gold Medal Whole Wheat Flour = 4.5 (flavor)

Kretschmer Wheat Germ = 7.5 (flavor)

Mixture of Diamond Slivered Almonds

and Kroger Chopped Hazelnuts = 7.5 (flavor)

Diamond Shelled Walnuts = 8.0 (flavor)

Diamond Pecan Halves = 9.0 (flavor)

**Preparation:** Puree the almonds and hazelnuts separately in blenders for 45 s on high speed. Combine equal amounts of the chopped nuts. Serve in individual 1 fl oz cups.

**Nutty-Woody:** Nutty aromatic characterized by the presence of woodiness, increased musty/dustiness, brown, astringent and bitter.

**Reference:** Diamond Pecan Halves = 7.5 (flavor)

Diamond Shelled Walnuts = 7.5 (flavor)



Nutty-Grain-like: Nutty aromatic characterized by the presence of a grainy aromatic, increased musty/dustiness and brown.

Reference: Gold Medal Whole Wheat Flour = 4.5 (flavor)  
Kretschmer Wheat Germ = 7.5 (flavor)

Nutty-Buttery: Nutty aromatic characterized by a buttery impression, and/or increased fatty aromatics and musty/earthy character.

Reference: HyVee Dry Roasted and Salted Macadamia Nuts = 5.0 (flavor)

Brown: Rich, full aromatic impression always characterized with some degree of darkness generally associated with certain attributes (e.g., toasted, nutty, sweet).

Reference: Bush's Best Pinto Beans (Canned) = 5.0 (flavor)  
Kretschmer Wheat Germ = 7.5 (flavor)  
Sethness AP 100 Caramel Color (Full Strength) = 13.0 (aroma)

Preparation: Drain beans and rinse with de-ionized water. Serve in 1 fl oz cups.  
Place ½ tsp caramel color in a medium snifter. Cover.

Caramelized: Round, full-bodied, medium brown aromatic.

Reference: C&H Golden Brown Sugar = 7.5 (aroma)  
C&H Golden Brown Sugar = 9.0 (flavor)

Acrid: Sharp/acrid, charred flavor note associated with something over baked or excessively browned in oil.

Reference: Alf's Natural Nutrition Puffed Red Wheat Cereal = 3.0 (flavor)

Burnt: Dark, brown, somewhat sharp, over-baked grain aromatic.

Reference: Alf's Natural Nutrition Puffed Red Wheat Cereal = 4.0 (flavor)

Floral/Fruity: Sweet, light, aromatics impression associated with flowers and fruits.

Reference: Welch's White Grape Juice = 5.0 (flavor)  
Preparation: Dilute 1 part juice with one part water.

- Fruity-dark:** Sweet, brown honey/caramel-like aromatics commonly associated with dark fruits such as raisins and prunes that have been cooked.
- Reference: 1/4 c Sun Maid raisins, 1/3 c dried Ocean Spray cranberries and 1/4 c Sun Maid prunes, and 3/4 c water = 5.0 (flavor), 7.0 (aroma).
- Preparation: Mix raisins, dried cranberries and prunes (chopped). Add 3/4 c of water and cook in microwave on high for 2 min. Pour juice into 1 fl oz cups, cover with lid. Put 1 tsp of cooked fruit with at least 1 piece of the chopped cooked prune in medium snifters. Cover with watch glass.
- Piney:** Slight resinous aromatic associated with fresh green pine needles.
- Reference: Kroger Pine Nuts = 6.0 (flavor)
- Musty/Dusty:** Dry, dirt-like aromatic associated with dry, brown soil.
- Reference: Potato Peel (covered) = 5.0 (aroma)
- Preparation: Put 0.5 g potato peel in a medium snifter. Cover.
- Musty/Earthy:** Humus-like aromatics that may or may not include damp soil, decaying vegetation, or cellar like characteristics.
- Reference: Sliced Button mushroom = 8.5 (aroma)
- Preparation: Place 3 slices in a medium snifter. Cover.
- Woody:** Sweet, brown, musty, dark, dry aromatics associated with the bark of a tree.
- Reference: Diamond Shelled Walnuts = 4.0 (flavor)  
Sigma-Aldrich Cedarwood Oil, Virginia = 6.5 (aroma)
- Preparation: Place one drop oil on a cotton ball in a medium snifter. Cover.
- Overall Sweet:** Aromatic associated with the impression of sweet substances.
- Reference: Post Shredded Wheat = 1.5 (flavor)  
General Mills Wheaties = 3.0 (flavor)  
Lorna Doone Cookie = 4.5 (flavor)
- Oily:** Light aromatics associated with vegetable oil such as corn or soybean oil.
- Reference: Kroger Slivered and Blanched Almonds = 4.0 (flavor)  
HyVee Dry Roasted and Salted Macadamia Nuts = 9.0 (flavor)

- Rancid: Aromatic commonly associated with oxidized fat and oils.
- Reference: Wesson Vegetable Oil = 2.5  
Preparation: Microwave 1/3 c of oil on high power for 2.5 min. Let cool and serve in 1 fl oz cups.
- Astringent: Feeling of a puckering or a tingling sensation on the surface and/or edge of the tongue and mouth.
- Reference: 0.030% Alum solution = 1.5  
0.050% Alum solution = 2.5  
0.075% Alum solution = 3.5
- Bitter: Fundamental taste factor of which caffeine is typical.
- Reference: 0.010% Caffeine Solution = 2.0  
0.020% Caffeine Solution = 3.5  
0.035% Caffeine Solution = 5.0
- Sour: Fundamental taste factor of which citric acid is typical.
- Reference: 0.015% Citric Acid Solution = 1.5  
0.025% Citric Acid Solution = 2.5
- Sweet: Fundamental taste factor of which sucrose is typical.
- Reference: 1.0% Sucrose Solution = 1.0

## Black Walnut Cookie Evaluation

**Technicians:** *Serve 2 cookies (cut into wedges) for evaluation.*

**Panelists:** *Take 1 wedge for evaluation.*

### **FLAVOR**

**Black Walnut ID:** Aromatics associated with black walnuts including musty/earthy, piney, woody, brown, sweet, buttery, oily, astringent, and slightly acid aromatics; other aromatics may include musty/dusty, floral/fruity, and/or fruity-dark.

**Reference:** Ground Black Walnut pieces = 12.0 (flavor)

**Preparation:** Measure out 1 tbsp each of various cultivars into a food processor and blend for 30 s. Serve in fl 1 oz cups.

**Overall Nutty:** Measurement reflecting the total of nutty characteristics and the degree to which these characteristics fit together. Nutty characteristics are: sweet, oily, light brown, slightly musty and/or buttery, earthy, woody, astringent, bitter, etc.

Examples: nuts, wheat germ, certain whole grains.

**Reference:** Gold Medal Whole Wheat Flour = 4.5 (flavor)

Kretschmer Wheat Germ = 7.5 (flavor)

Mixture of Diamond Slivered Almonds

and Kroger Chopped Hazelnuts = 7.5 (flavor)

Diamond Shelled Walnuts = 8.0 (flavor)

Diamond Pecan Halves = 9.0 (flavor)

**Preparation:** Puree the almonds and hazelnuts separately in blenders for 45 s on high speed. Combine equal amounts of the chopped nuts. Serve in individual 1 fl oz cups.

**Nutty-Woody:** Nutty aromatic characterized by the presence of woodiness, increased musty/dustiness, brown, astringent and bitter.

**Reference:** Diamond Pecan Halves = 7.5 (flavor)

Diamond Shelled Walnuts = 7.5 (flavor)

- Nutty-Grain-like: Nutty aromatic characterized by the presence of a grainy aromatic, increased musty/dustiness and brown.
- Reference: Gold Medal Whole Wheat Flour = 4.5 (flavor)  
Kretschmer Wheat Germ = 7.5 (flavor)
- Nutty-Buttery: Nutty aromatic characterized by a buttery impression, and/or increased fatty aromatics and musty/earthy character.
- Reference: HyVee Dry Roasted and Salted Macadamia Nuts = 5.0 (flavor)
- Brown: Rich, full aromatic impression always characterized with some degree of darkness generally associated with certain attributes (e.g., toasted, nutty, sweet).
- Reference: Bush's Best Pinto Beans (Canned) = 5.0 (flavor)  
Kretschmer Wheat Germ = 7.5 (flavor)  
Sethness AP 100 Caramel Color (Full Strength) = 13.0 (aroma)
- Preparation: Drain beans and rinse with de-ionized water. Serve in 1 fl oz cups.  
Place ½ tsp caramel color in a medium snifter. Cover.
- Flour-like: General term used to describe the light dusty/musty aromatics associated with wheat.
- Reference: Gold Medal all-purpose flour = 5.0 (flavor)
- Leavening: Aromatics associated with baking soda and/or baking powder in baked four products.
- Reference: Pancake = 7.0 (flavor)
- Preparation: Mix 1 c all-purpose flour, 1 tsp baking soda, 1/8 tsp salt, and 3/4 c water in a bowl. Cook on a skillet over medium to medium-high heat. Do not let either side brown. Cut edges off pancake and discard. Cut the remaining pancake into cubes and serve in 3.25 fl oz cups.
- Toasted: Brown, baked aromatic that may occur with grain products.
- Reference: General Mills Cheerios cereal = 7.0 (flavor)
- Acrid: Sharp/acrid, charred flavor note associated with something over baked or excessively browned in oil.
- Reference: Alf's Natural Nutrition Puffed Red Wheat Cereal = 3.0 (flavor)

- Floral/Fruity: Sweet, light, aromatics impression associated with flowers and fruits.  
Reference: Welch's White Grape Juice = 5.0 (flavor)  
Preparation: Dilute 1 part juice with one part water.
- Fruity-dark: Sweet, brown honey/caramel-like aromatics commonly associated with dark fruits such as raisins and prunes that have been cooked.  
  
Reference: 1/4 c Sun Maid raisins, 1/3 c dried Ocean Spray cranberries and 1/4 c Sun Maid prunes, and 3/4 c water = 5.0 (flavor), 7.0 (aroma).  
Preparation: Mix raisins, dried cranberries and prunes (chopped). Add 3/4 c of water and cook in microwave on high for 2 min. Pour juice into 1 fl oz cups, cover with lid. Put 1 tsp of cooked fruit with at least 1 piece of the chopped cooked prune in medium snifters. Cover with watch glass.
- Piney: Slight resinous aromatic associated with fresh green pine needles.  
  
Reference: Kroger Pine Nuts = 6.0 (flavor)
- Musty/Dusty: Dry, dirt-like aromatic associated with dry, brown soil.  
  
Reference: Potato Peel (covered) = 5.0 (aroma)  
Preparation: Put 0.5 g potato peel in a medium snifter. Cover.
- Musty/Earthy: Humus-like aromatics that may or may not include damp soil, decaying vegetation, or cellar like characteristics.  
  
Reference: Sliced Button mushroom = 8.5 (aroma)  
Preparation: Place 3 slices in a medium snifter. Cover.
- Woody: Sweet, brown, musty, dark, dry aromatics associated with the bark of a tree.  
  
Reference: Diamond Shelled Walnuts = 4.0 (flavor)  
Sigma-Aldrich Cedarwood Oil, Virginia = 6.5 (aroma)  
Preparation: Place one drop oil on a cotton ball in a medium snifter. Cover.
- Rancid: Aromatic commonly associated with oxidized fat and oils.  
  
Reference: Wesson Vegetable Oil = 2.5  
Preparation: Microwave 1/3 c of oil on high power for 2.5 min. Let cool and serve in 1 fl oz cups.

Vanilla/Vanillin: Aromatics associated with natural or non-natural vanillin which may or may not include brown, bean-like aromatics.

Reference: McCormick vanilla extract in 2% liquid milk = 4.0 (flavor)

Preparation: Mix 1/8 tsp vanilla extract in 1/2 c 2% liquid milk. Serve in 1 fl oz cups.

Overall Sweet: Aromatic associated with the impression of sweet substances.

Reference: Post Shredded Wheat = 1.5 (flavor)

General Mills Wheaties = 3.0 (flavor)

Lorna Doone Cookie = 4.5 (flavor)

Brown Sweet: Sweet, round, light brown aromatics which may also include the character notes identified as vanillin and caramelized.

Reference: Pepperidge Farm Bordeaux cookies = 7.5 (flavor)

Astringent: Feeling of a puckering or a tingling sensation on the surface and/or edge of the tongue and mouth.

Reference: 0.030% Alum solution = 1.5

0.050% Alum solution = 2.5

0.075% Alum solution = 3.5

Bitter: Fundamental taste factor of which caffeine is typical.

Reference: 0.010% Caffeine Solution = 2.0

0.020% Caffeine Solution = 3.5

0.035% Caffeine Solution = 5.0

Salty: Fundamental taste factor of which sodium chloride is typical.

Reference: 0.20% Sodium chloride solution = 2.5

0.25% Sodium chloride solution = 3.5

Sour: Fundamental taste factor of which citric acid is typical.

Reference: 0.015% Citric Acid Solution = 1.5

0.025% Citric Acid Solution = 2.5

Sweet: Fundamental taste factor of which sucrose is typical.

Reference: 1.0% Sucrose Solution = 1.0

## Appendix E - Baking Recipes for Descriptive and Consumer Black Walnut Cookies

### AACC International Method 10-53.01: Baking Quality of Cookie Flour – Macro Wire-Cut Formulation

#### *Apparatus*

1. Electric mixer, with timer control. Use appropriate flat beaters furnished with mixer.
2. Aluminum cookie sheet, 3003-H14 aluminum alloy, about 2.0 mm (0.1 in) thickness, size 30.5 x 40.6 cm (12 x 16 in) or 25.4 x 33.0 cm (10 x 13 in), or other sizes required to accommodate oven doors and shelves. See Note 1.
3. Metal gauge strips, two, 7 mm (0.275 in) thick and length of the baking sheets. Strips can be attached to long edges of sheets. Strips should be kept clean of any buildup of grease residue. See Note 1.
4. Rolling pin, 5.7-7.0 cm (2.25-2.75 in) diameter, with no. 3 size surgical seamless, tubular gauze or equivalent covering. If wood, check often for any wear to edges from rolling along gauge strips.
5. Cookie cutter, 60 mm inside diameter. See Note 1.
6. Thermometer, hygrometer (see Note 2), and barometer.
7. Baking oven, reel or rotary, with hearth consisting of ceramic-fiber-reinforced structural alumina refractory product (0.64 cm [0.25 in] thick) as a shelf liner cut to dimensions of and placed on steel baking shelf. Oven shelves consisting of wire mesh baking surface are also suitable and may not need shelf liner (to prevent excessive bottom browning). Oven should be electrically heated and capable of maintaining temperature range of  $\pm 2$  at 205C ( $\pm 5$  at 400F).

#### *Procedure – Formula per Batch*

<i>Ingredients at 21C <math>\pm</math> 1C (70F <math>\pm</math> 2F)</i>	<i>Weight (g)</i>
Sucrose (see Note 3)	94.5
Nonfat dry milk (see Note 4)	2.3
NaCl	2.8
Sodium bicarbonate	2.3
All-purpose shortening (see Note 5)	90.0
High-fructose corn syrup (HFCS), 42%	3.4
Ammonium bicarbonate	1.10
Deionized water; g = (225 – g flour) + 49.5	Variable
Flour, 13% moisture basis (see Note 6, Table 1)	225.0



### ***Method***

1. Weigh appropriate amounts of dry ingredients for number of batches plus one, and transfer into 3.8 L (1 gal) jar. Mix dry ingredients by tumbling jar 20 times.
2. Weigh appropriate amount of shortening for number of batches plus one into 9.5 L (10 qt) mixing bowl. See Note 7. Add dry ingredients on top of shortening. Mix in 9.5 L bowl for 3 min on speed 1 (Hobart) or stir speed (KitchenAid), scraping every minute.
3. Scrape 191.9 g creamed mass into 2.8 L (3 qt) or 4.8 L (5 qt) mixing bowl.
4. Weigh 3.4 g HFCS into a 250 mL beaker. Add appropriate amount of water and swirl. Add 1.10 g ammonium bicarbonate to HFCS-water mixture and swirl to dissolve. Add liquid to creamed mass and mix 1 min on speed 1 (Hobart) or stir speed (KitchenAid). Scrape. Mix 1 min on speed 2 (Hobart) or speed no. 2 (KitchenAid).
5. Add calculated amount of flour. Mix 2 min on speed 1 (Hobart) or stir speed (KitchenAid), scraping every 30 s.
6. Gently scrape dough from bowl and divide into eight relatively equal portions. See Note 8. Handling dough as little as possible, gently round each portion and make into oblong shapes having approximately 5 cm length. Place four portions on each of two lightly greased baking sheets. Place gauge strips along longer sides of baking sheets. Roll to thickness with one forward stroke of rolling pin. Cut dough with cookie cutter, discard excess dough, and remove cutter.
7. Immediately place in 205C (400F) oven for 11 min. See Note 9. On removal from oven, cool 5 min and remove cookies from baking sheet. Wipe baking sheet with damp towel to remove grease. Wash it in warm, un-soapy water, dry thoroughly, and allow to come to room temperature before next use. See Note 1.

### ***Notes***

1. Cookie sheets are purchased with gauge strips fastened to the long edges of sheets. New cookie sheets may be conditioned by lightly greasing and placing in hot oven for 15 min, cooling, and repeating this process two or three times. Cookie sheets should be washed while warm in water (without any soaps or detergents) and wiped dry after each bake to prevent buildup and blackening of oil on their surface.
2. Dough consistency and stickiness and cookie spread are affected by temperature and humidity. Room and ingredient temperature of  $21^{\circ}\text{C} \pm 1^{\circ}\text{C}$  ( $70^{\circ}\text{F} \pm 2^{\circ}\text{F}$ ) and relative humidity of 30-50% are recommended. Data variance is increased by conditions in excess of those recommended.
3. Sucrose must be commercial grocery store table sugar having a sieve profile as follows: over US sieve no. 20 (850  $\mu\text{m}$ ), 5% max.; over US sieve no. 50 (300  $\mu\text{m}$ ), 40% min. and 90% max. with 65% target; over US sieve no. 100 (150  $\mu\text{m}$ ), 15% max.; through US sieve no. 100 (150  $\mu\text{m}$ ), 10% max.
4. Nonfat dry milk should be ground, if necessary, to pass through a US no. 30 (589  $\mu\text{m}$  openings) wire sieve.
5. Shortening should be hydrogenated, all-vegetable fat of non-emulsifier type, not containing methyl silicone.
6. The table below gives weights of flour at various moisture contents corresponding to 225 g flour weight at 13% moisture basis.

7. Minimum recommended creamed mass size is five batches. Maximum recommended creamed mass size is 10 batches. A consistent creamed mass size produces more consistent results.
8. Operators should wash their hands to remove any hand creams and should avoid excessive handling of dough.
9. Oven should be warmed to temperature with oven shelves turning. Bake “dummy” cookies out of scrap dough or extra flour to condition oven before making test bake at beginning of baking series or if oven has not been used for 15 min.

<i>Flour Moisture (%)</i>	<i>Flour Weight (g)</i>
12.0	222.4
12.1	222.7
12.2	222.9
12.3	223.2
12.4	223.5
12.5	223.7
12.6	224.0
12.7	224.2
12.8	224.5
12.9	224.7
13.0	225.0
13.1	225.3
13.2	225.5
13.3	225.8
13.4	226.0
13.5	226.3
13.6	226.6
13.7	226.8
13.8	227.1
13.9	227.4
14.0	227.6
14.1	227.9
14.2	228.1
14.3	228.4
14.4	228.7
14.5	228.9

## Modified Cookie Recipe and Baking Procedures Used in Current Study

### *Apparatus*

1. KitchenAid Professional 600 stand mixer (model KP26M1XWH, Whirlpool Corporation, Benton Harbor, MI) with 6 qt stainless steel bowl and flat beater attachment.
2. Electric oven (model RB160PXYB, Whirlpool Corporation, Benton Harbor, MI), aluminum baking sheet, and metal cooling rack.
3. Wooden rolling pin with 0.375 mm thick rubber dough guides placed on the ends of the rolling pin.
4. Cookie cutter measuring 63.5 mm (2.5 in) inside diameter.
5. Miscellaneous kitchen utensils: rubber spatula, small metal spatula, paring knife, and several spoons.
6. 250 mL glass beaker and several bowls (small and medium-sized) for holding the individual ingredients

### *Procedure – Formula per Batch*

<i>Ingredients at 21C ± 1C (70F ± 2F)</i>	<i>Source</i>	<i>Weight (g)</i>
Sucrose	Kroger granulated sugar (Kroger Co., Cincinnati, OH)	189.0
Nonfat dry milk	Kroger instant nonfat dry milk, fort. with vitamins A and D (Kroger Co., Cincinnati, OH)	4.6
NaCl	Morton salt, plain, no iodide (Morton Salt, Inc., Chicago, IL)	5.6
Baking powder (cornstarch, sodium bicarbonate, sodium aluminum sulfate, and monocalcium phosphate)	Kroger baking powder (Kroger Co., Cincinnati, OH)	18.4
All-purpose shortening	Crisco all-vegetable shortening, original (The J.M. Smucker Co., Orrville, OH)	180.0
High-fructose corn syrup (HFCS), 42%	Karo light corn syrup (ACH Food Companies, Inc., Oakbrook, IL)	3.4
Baking powder (cornstarch, sodium bicarbonate, sodium aluminum sulfate, and monocalcium phosphate)	Kroger baking powder (Kroger Co., Cincinnati, OH)	4.4
Deionized water; g = (225 – g flour) + 49.5		49.5
Flour, 13% moisture basis	Kroger all-purpose enriched flour, bleached (Kroger Co., Cincinnati, OH)	225.0
Chopped black walnuts		90.0

### ***Method***

1. Pre-heat an electric oven to 205C (400F), and lightly coat an aluminum baking sheet with all-purpose shortening.
2. Weigh out all ingredients into individual bowls or containers. Weigh the high-fructose corn syrup into a 250 mL beaker; add the 49.5 g of water to the beaker.
3. Combine the sugar, nonfat dry milk, salt, and 18.4 g of baking powder into a medium bowl and stir to mix thoroughly.
4. Place the all-purpose shortening and dry ingredients from Step 3 into the bowl of the KitchenAid stand mixer. Mix on stir speed for 3 min, scraping sides of the bowl every 1 min.
5. Weigh out 191.9 g of the creamed mass into a medium bowl. Discard the remainder creamed mass.
6. Add the 191.9 g of creamed mass back to the bowl of the KitchenAid stand mixer.
7. Add the 4.4 g of baking powder to the beaker with the high-fructose corn syrup and water. Swirl to combine and add to the bowl of the KitchenAid stand mixer.
8. Mix the ingredients for 1 min on stir speed. Scrape down sides of the bowl. Mix for 1 min on speed 2.
9. Add flour and black walnuts to the bowl of the KitchenAid stand mixer. Mix for 2 min on stir speed, scraping the sides of the bowl every 30 s.
10. Scrape the dough onto a lightly-floured countertop.
11. Using a wooden rolling pin with rubber dough guides, roll the dough out to specified thickness using as few strokes as possible. Lightly flour the rolling pin as necessary.
12. Use the 63.5 mm (2.5 in) cookie cutter to cut out cookies from the dough. Score cookies into 1/8ths (for descriptive testing) or 1/2 (for consumer testing) using the edge of the metal spatula.
13. Use a small metal spatula to transfer the cookies onto the baking sheet. Place in the pre-heated electric oven and bake for 5.5 min. Rotate pan 180 degrees and bake for an additional 5.5 min.
14. Remove cookies from the oven and let cool on the baking sheet for 5 min. Then, transfer to a cooling rack to cool completely.
15. Place cookies in a freezer-grade, gallon-sized, re-sealable plastic bag (no more than 2 cookies stacked on top of one another) and store in a freezer ( $-26\text{C} \pm 1\text{C}$ ) until time for evaluation.

## Appendix F - Consumer Screener for Black Walnut Cookies

Respondent Name: \_\_\_\_\_

Respondent Number: \_\_\_\_\_

Phone Number: \_\_\_\_\_

Address: \_\_\_\_\_

Email Address: \_\_\_\_\_

Interview Date: \_\_\_\_\_

SCHEDULED SESSION TIME: \_\_\_\_\_

***Quotas:***

***N = 100***

***Gender: Male 50%/Female 50%***

***Age: 18+ years (distributed)***

Hello. My name is \_\_\_\_\_ from the Sensory and Consumer Research Center on the Kansas State University Olathe Campus. We are doing a consumer test and would like to ask you a few questions to see if you qualify.

**Please circle or place an 'X' in front of each appropriate response:**

1. Please indicate your gender:      MALE      FEMALE

***EQUAL DISTRIBUTION OF MALES/FEMALES***

2. Which of the following best describes your age?

17 or younger      18-25      26-35      36-45      46-55      56-65      66 or older

***TERMINATE***

***CHECK DISTRIBUTION OF AGES***

3. Do you have any known food allergies or dietary restrictions?      YES      NO

***TERMINATE***

4. Do you or any of your immediate family work for a market research firm, advertising firm, or food manufacturing company?

YES

NO

***TERMINATE***

5. For some of our studies, we need people who have participated in taste tests in the past and for others we do not. When was the last time you participated in a consumer research study (where you tasted food, used a product and completed a survey or met to discuss a food or product for pay)?

\_\_\_\_\_ **TERMINATE IF LESS THAN 3 MONTHS**

6. Which of the following foods do you eat? Mark All That Apply.

Beans                      Nuts                      Yogurt                      Rice                      Cereal

**TERMINATE IF 'NUTS' IS NOT SELECTED**

7. You said that you eat nuts. How often do you eat nuts of any kind?

Everyday	At least once every 1-2 weeks	At least once a month	Once every 2-3 months	Once every 6 months	Never
				<b>TERMINATE</b>	<b>TERMINATE</b>

8. Which of the following nuts/legumes would you be willing to eat? Mark All That Apply.

Peanuts                      Black Walnuts                      Cashews                      Almonds                      Pistachios

**TERMINATE IF 'BLACK WALNUTS' IS NOT SELECTED**

9. Which of the following food categories would you be willing to taste nuts? Mark All That Apply.

Cookies                      Ice Cream                      Pasta or Rice Dishes                      Salad

**TERMINATE IF 'COOKIES' IS NOT SELECTED**

You have qualified for a Black Walnut Cookie Study we are conducting on February 21 and 22. Would you be interested in participating in a 45-minute survey at the KSU Olathe Campus?

Schedule time:

Day 1: Tuesday, Feb. 21

9:00  
10:00  
11:00  
12:00  
1:00  
2:00  
3:00  
4:00  
5:00  
6:00  
7:00  
8:00

Day 2: Wednesday, Feb. 22

9:00  
10:00  
11:00  
12:00  
1:00  
2:00  
3:00  
4:00  
5:00  
6:00  
7:00

As a participant, you must comply with the following rules of the center:

- Bring a photo ID that verifies your name and age
- Do not eat, drink, or smoke within 30 minutes of the study – this includes chewing gum and drinking coffee
- Do not wear any fragrances on the day of testing
- Arrive at the Center 10 minutes earlier than your scheduled session for check-in purposes
- There is no childcare available at the center. Please bring another adult to supervise any children while you are participating in the study
- If you are under 18, please bring a parent/guardian to sign the consent form for the child's participation
- If you use glasses for reading, please bring them to the session as you will be reading a paper questionnaire

Do you agree to follow these rules? \_\_\_\_\_ ***Must respond "yes"***

Failure to comply could result in disqualifying for this study. We look forward to seeing you at 22201 W. Innovation Drive, Olathe in room 160. If you have any difficulties finding the facilities or are unable to attend, please call Marianne at 913-307-7354

## Appendix G - Consumer Consent Form for Black Walnut Cookies

INFORMED CONSENT STATEMENT  
THE SENSORY AND CONSUMER RESEARCH CENTER  
Kansas State University  
22201 W Innovation Drive, rm 160  
Olathe, KS 66061

1. I (print) \_\_\_\_\_, agree to participate as a panelist in research conducted by The Sensory and Consumer Research Center at Kansas State University – Olathe Campus.
2. I understand that the purpose of this project is to participate in a taste test evaluating black walnut samples.
3. For this test, I will receive \$35 when I complete this 45 minute study.
4. I understand my performance as an individual will be treated as research data and will in no way be associated with me for other than identification purposes, thereby assuring confidentiality of performance and responses.
5. I understand that I do not have to participate in this research, and may choose not to participate without penalty.
6. I understand that I may withdraw from the research at any time.
7. If I have any questions concerning this study, I understand that I that I may contact Marianne Swaney-Stueve at 913.307.7354 at the KSU Olathe Campus in Room 162.
8. If I have any questions about my rights as a consumer or about the manner in which this research was conducted, I may contact Dr Rick Scheidt, Chair, Committee on Research Involving Human Subjects, or Dr. Gerald Jaax, Associate Vice-provost for Research, 1 Fairchild Hall (532-2334), Manhattan, KS, 66506.

I understand the above statements (Participant must sign):

\_\_\_\_\_  
(Participant Signature)

Date: \_\_\_\_\_



## Appendix H - Moderator's Guide for Consumer Tests

Hello. My name is \_\_\_\_\_. On behalf of The Sensory and Consumer Research Center, I would like to thank you for your participation in this study. This session will last approximately 30 minutes. You will receive \$35 for your time and opinions at the completion of the session.

You will be asked to answer questions pertaining to your liking and intensity of various aspects of black walnut cookie samples. Each sample will be evaluated one at a time. When you receive a sample, please check to make sure that the code on the plate matches the one on the ballot. Taste each sample as many times as needed to evaluate each sample.

Ballots are printed front to back. Please make sure that you have answered each question before moving on to the next sample.

At the end of the ballot is a demographic questionnaire. You may fill this out after completing the evaluation of the final sample. Please do not complete this before the end of the test.

There are several things you need to remember as you participate today.

- Please silence your cell phones.
- Be honest in answering the questions. There is no right or wrong answers to any of the questions.
- Do not discuss your answers with your neighbors. We want to know your own opinion.
- Take your time considering each sample - your input is very important to us.
- If you have any questions during the session, please let us know.
- There will be short periods of wait time in between serving of the samples. Please sit quietly during that time.
- Please take a bite of cracker and a sip of water between samples. Pass your empty napkin or cup through the breadbox door if you need more crackers or water.
- The results of this study are confidential. Please do not discuss what you have tested with anyone outside this room.
- Make sure that you answer all of the questions. Please double check all responses when you are done to make sure all questions have been answered.

After you complete all pages and have double checked that all questions have been answered you may leave the room quietly to receive your payment.

Thank you again for your time and opinions.

## Appendix I - Consumer Ballot for Black Walnut Cookies

Date: \_\_\_\_\_

Panelist #: \_\_\_\_\_

Sample: \_\_\_\_\_

Mark an "X" in the box that best represents your answer.

Please taste the sample and answer the following questions. Re-taste as necessary.

1. How much do you **LIKE** this sample **OVERALL**?

Dislike ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Like  
Extremely

2. How much do you **LIKE** the **OVERALL FLAVOR** of this sample?

Dislike ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Like  
Extremely

3. Please rate the **INTENSITY** of the **OVERALL FLAVOR** of this sample.

Not at all ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Extremely  
Flavorful

4. How much do you like the **BLACK WALNUT FLAVOR** in this sample?

Dislike ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Like  
Extremely

5. Please rate the **INTENSITY** of the **BLACK WALNUT FLAVOR** of this sample.

Not at all ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Extremely  
Flavorful

Please write any other comments you have about this sample below:

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*Please take a bite of cracker and a drink of water before tasting the next sample.*

Date: \_\_\_\_\_

Panelist #: \_\_\_\_\_

Sample: \_\_\_\_\_

Mark an "X" in the box that best represents your answer.

Please taste the sample and answer the following questions. Re-taste as necessary.

1. How much do you **LIKE** this sample **OVERALL**?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Like  
Extremely

2. How much do you **LIKE** the **OVERALL FLAVOR** of this sample?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Like  
Extremely

3. Please rate the **INTENSITY** of the **OVERALL FLAVOR** of this sample.

Not at all  
Flavorful

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Extremely  
Flavorful

4. How much do you like the **BLACK WALNUT FLAVOR** in this sample?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Like  
Extremely

5. Please rate the **INTENSITY** of the **BLACK WALNUT FLAVOR** of this sample.

Not at all  
Flavorful

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Extremely  
Flavorful

Please write any other comments you have about this sample below:

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*Please take a bite of cracker and a drink of water before tasting the next sample.*

Date: \_\_\_\_\_

Panelist #: \_\_\_\_\_

Sample: \_\_\_\_\_

Mark an "X" in the box that best represents your answer.

Please taste the sample and answer the following questions. Re-taste as necessary.

1. How much do you **LIKE** this sample **OVERALL**?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Like  
Extremely

2. How much do you **LIKE** the **OVERALL FLAVOR** of this sample?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Like  
Extremely

3. Please rate the **INTENSITY** of the **OVERALL FLAVOR** of this sample.

Not at all  
Flavorful

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Extremely  
Flavorful

4. How much do you like the **BLACK WALNUT FLAVOR** in this sample?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Like  
Extremely

5. Please rate the **INTENSITY** of the **BLACK WALNUT FLAVOR** of this sample.

Not at all  
Flavorful

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Extremely  
Flavorful

Please write any other comments you have about this sample below:

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*Please take a bite of cracker and a drink of water before tasting the next sample.*

Date: \_\_\_\_\_

Panelist #: \_\_\_\_\_

Sample: \_\_\_\_\_

Mark an "X" in the box that best represents your answer.

Please taste the sample and answer the following questions. Re-taste as necessary.

1. How much do you **LIKE** this sample **OVERALL**?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Like  
Extremely

2. How much do you **LIKE** the **OVERALL FLAVOR** of this sample?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Like  
Extremely

3. Please rate the **INTENSITY** of the **OVERALL FLAVOR** of this sample.

Not at all  
Flavorful

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Extremely  
Flavorful

4. How much do you like the **BLACK WALNUT FLAVOR** in this sample?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Like  
Extremely

5. Please rate the **INTENSITY** of the **BLACK WALNUT FLAVOR** of this sample.

Not at all  
Flavorful

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Extremely  
Flavorful

Please write any other comments you have about this sample below:

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*Please take a bite of cracker and a drink of water before tasting the next sample.*

Date: \_\_\_\_\_

Panelist #: \_\_\_\_\_

Sample: \_\_\_\_\_

Mark an "X" in the box that best represents your answer.

Please taste the sample and answer the following questions. Re-taste as necessary.

1. How much do you **LIKE** this sample **OVERALL**?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Like  
Extremely

2. How much do you **LIKE** the **OVERALL FLAVOR** of this sample?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------

Like  
Extremely

3. Please rate the **INTENSITY** of the **OVERALL FLAVOR** of this sample.

Not at all  
Flavorful

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------

Extremely  
Flavorful

4. How much do you like the **BLACK WALNUT FLAVOR** in this sample?

Dislike  
Extremely

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Like  
Extremely

5. Please rate the **INTENSITY** of the **BLACK WALNUT FLAVOR** of this sample.

Not at all  
Flavorful

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Extremely  
Flavorful

Please write any other comments you have about this sample below:

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---

*Please take a bite of cracker and a drink of water before tasting the next sample.*

Date: \_\_\_\_\_

Panelist #: \_\_\_\_\_

Sample: \_\_\_\_\_

Mark an "X" in the box that best represents your answer.

Please taste the sample and answer the following questions. Re-taste as necessary.

1. How much do you **LIKE** this sample **OVERALL**?

Dislike ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Like  
Extremely

2. How much do you **LIKE** the **OVERALL FLAVOR** of this sample?

Dislike ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Like  
Extremely

3. Please rate the **INTENSITY** of the **OVERALL FLAVOR** of this sample.

Not at all ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Extremely  
Flavorful

4. How much do you like the **BLACK WALNUT FLAVOR** in this sample?

Dislike ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Like  
Extremely

5. Please rate the **INTENSITY** of the **BLACK WALNUT FLAVOR** of this sample.

Not at all ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Extremely  
Flavorful

Please write any other comments you have about this sample below:

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---

*Please take a bite of cracker and a drink of water before tasting the next sample.*

**Demographic Information:**

**Panelist #:** \_\_\_\_\_

1. Gender: ☐ **Male** ☐ **Female**

2. Which of the following best describes your age?

☐ **18-24** ☐ **25-35** ☐ **36-45** ☐ **46-55** ☐ **56-65** ☐ **66 or older**

3. How often do you eat black walnuts?

☐ **Never** ☐ **About every 6 months** ☐ **About every 2-3 months**  
☐ **About every month** ☐ **About once a week** ☐ **2 or more times a week**

4. If you eat black walnuts, in what form do you eat them?

☐ **Alone/By themselves** ☐ **In ice cream** ☐ **In cookies/cake**  
☐ **In granola bars/trail mix** ☐ **In candy/fudge/confectionary**  
☐ **Other** \_\_\_\_\_

5. What other types of nuts/legumes do you consume?

☐ **Almonds** ☐ **Cashews** ☐ **Brazil nuts**  
☐ **Peanuts** ☐ **Macadamia Nuts** ☐ **Pistachios**  
☐ **English Walnuts** ☐ **Pecans** ☐ **Other** \_\_\_\_\_

6. How often do you eat other nuts/legumes BY THEMSELVES (i.e. not in a food product)?

☐ **Never** ☐ **About every 6 months** ☐ **About every 2-3 months**  
☐ **About every month** ☐ **About once a week** ☐ **2 or more times a week**



7. How often do you consume/buy food products (breads, cereals, desserts, etc.) containing nuts of any kind?

- |  |   |   |
|--|---|---|
| <input type="checkbox"/> Never             | <input type="checkbox"/> About every 6 months | <input type="checkbox"/> About every 2-3 months |
| <input type="checkbox"/> About every month | <input type="checkbox"/> About once a week    | <input type="checkbox"/> 2 or more times a week |

8. If so, which type of products do you consume/buy containing nuts?

- |                                  |   |                                      |
|----------------------------------|---|--------------------------------------|
| <input type="checkbox"/> Cookies | <input type="checkbox"/> Ice Cream        | <input type="checkbox"/> Breads      |
| <input type="checkbox"/> Cakes   | <input type="checkbox"/> Granola Bars     | <input type="checkbox"/> Trail Mix   |
| <input type="checkbox"/> Candy   | <input type="checkbox"/> Breakfast Cereal | <input type="checkbox"/> Other _____ |

9. Which nuts do you typically look for when purchasing these products?

- |   |  |  |
|---|--|--|
| <input type="checkbox"/> Almonds        | <input type="checkbox"/> Cashews         | <input type="checkbox"/> Peanuts                               |
| <input type="checkbox"/> Macadamia Nuts | <input type="checkbox"/> English Walnuts | <input type="checkbox"/> Pecans                                |
| <input type="checkbox"/> Black Walnuts  | <input type="checkbox"/> Pistachios      | <input type="checkbox"/> Nuts are not the focus of my purchase |
| <input type="checkbox"/> Other _____    |  |  |

***Thank you for your time and opinions. This concludes the study. You may now leave and collect your payment.***