A DAIRY-BASED ESPRESSO BEVERAGE MANUFACTURED USING THREE DIFFERENT COFFEE BEAN ROASTS

CHARLES A. BOENEKE[1,3], JOHN U. MCGREGOR[2] and KAYANUSH J. ARYANA[1]

[1]*School of Animal Sciences, Louisiana Agricultural Experiment Station*
Louisiana State University Agricultural Center
111 Dairy Science Bldg.
Baton Rouge, LA 70803

[2]*Department of Food Science and Human Nutrition,*
Clemson University
224 Poole Agricultural Center
Clemson, SC

Accepted for Publication November 3, 2006

ABSTRACT

The objective of this study was to evaluate the effects of coffee bean roast on the acceptability of a dairy-based espresso drink. Espresso coffee was made from freshly ground coffee beans with light-medium roast, between roast (between medium and dark) and dark French roast in order to show the influence of roasting on flavor. Samples were prepared by blending skim milk, soft-serve ice cream mix, ice and fresh espresso extracts. No significant differences ($P < 0.05$) were detected in total solids and fat content among treatments. Viscosity for the light-medium roasted beverage was significantly ($P < 0.05$) higher than the others. The beverage pH increased with increased darkening of roast. The beverage made with the light-medium roasted coffee had significantly ($P < 0.05$) higher preference scores for coffee flavor and overall flavor than beverages made with the between and French roasts. The between and French roasted treatments were shown to have a more intense coffee flavor by trained sensory panelists. Consumers in this study preferred a less intense coffee flavor.

PRACTICAL APPLICATIONS

This study evaluated the effects of coffee bean roasts on the acceptability of a dairy-based espresso drink. The espresso was manufactured using light-

[3] Corresponding author. TEL: 225-578-4411; FAX: 225-578-4008; EMAIL: Cboene1@LSU.EDU

 All Rights Reserved.
© 2007, Louisiana State University Agricultural Center

Journal compilation © 2007, Blackwell Publishing

medium roast, between roast, and dark French roast coffee beans. The darker roasts had a more intense coffee flavor when evaluated by a trained sensory panel. Consumers preferred a less intense coffee flavor. This research demonstrates the importance of choosing the correct intensity of coffee flavor when formulating any coffee flavored beverage. It shows that as roast increases, bitterness also increases. Sweetness must be adjusted if stronger coffee flavors are desired. If the espresso drink is formulated with milk, milk/sugar interactions will play a role in the perception of the coffee flavor and sweetness of the finished product.

INTRODUCTION

Flavor is critical to the development of new food products. The qualities imparted by flavoring material can be described as high, low, delicate, harsh and unnatural (Arbuckle 1986). In recent years, there has been an increase in the popularity of coffee as a flavorant, particularly in dairy-based products. Flavored milks have expanded their variety in 2003 to include flavors such as mocha and coffee (Dairy Facts 2004). In total sales, only flavored milks and eggnog have shown an increase in per capita sales from 11.8 and 0.3 lb to 14.4 and 0.5 lb (weight), respectively (Dairy Facts 2004). A report from Packaged Facts shows that ready-to-drink coffee beverages have grown 143.3% from 1999 to 2003 and is projected to grow annually at a rate of 12.6% until 2008. A large portion of these beverages contain milk (MarketResearch.com 2003). The 2004 National Coffee Drinking Trends showed half of all consumers surveyed reported consuming an espresso-based beverage within the past year (National Coffee Association 2004). Espresso can be defined as coffee brewed from beans roasted darker than the American norm but not black, with the brewing accomplished by hot water forced through a bed of finely ground, densely compacted coffee at a pressure of approximately nine atmospheres (Davids 1993). Two of the most popular drinks consumed are espresso-based beverages and iced coffee (National Coffee Association 2004). The demand from all consumers surveyed for fresh espresso drinks blended with ice has increased from 20% in 2003 to 29% in 2004 (National Coffee Association 2004). Many of these beverages contain milk.

Research examining the effect of potential interactions between milk and coffee flavor are key aspects to the acceptability of these beverages. Roast directly affects the coffee flavor and influences the quality of the beverage. As the roast level increases, the acidity level declines; the strength increases, and the flavor improves up to a point. After this point, it deteriorates to bitterness (Clarke and Macrae 1985). Roasting of coffee beans results in a number of color and flavor compounds (Schenker *et al.* 2000). More than 800 flavor

compounds have been identified in roasted coffee (Flament 1989). The objective of roasting was to produce beans of the desired taste and aroma in a brewed coffee, and to generate the beans in a dark color and a dry brittle texture (Schenker *et al.* 2002). The purpose of this research was to examine the effects of three different coffee bean roasts on the acceptance of a dairy-based espresso drink.

MATERIALS AND METHODS

Treatment Preparation and Sampling

Fresh blended iced espresso beverages were prepared using three commercially available coffee bean roasted treatments (Community Coffee Co., Port Allen, LA). Standards for bean roasts were carried out using an Agtron M colorimeter (Agtron, Inc., Reno, NV). Values were expressed as agtron units. Coffee treatments included a light-medium roast (60 agtron units), a between roast (42 agtron units), and a dark French roast (30 agtron units). Espresso coffee was made from freshly ground coffee beans that had different roasts in order to show the influence of these variables on flavor (Powers 1988). Samples were prepared by blending skim milk, soft-serve ice cream mix, ice and fresh espresso extracts. The soft-serve ice cream mix was prepared by combining cream, water, cane sugar, nonfat dry milk and stabilizer together in 19-L stainless steel pails according to the following formula: 3.5% milk fat, 12.5% MSNF, 15% sucrose and 0.35% stabilizer. The mixes were pasteurized in the pails by placing them in a steam box for 40 min at 89C. The mixes were homogenized at 12.4 and 3.4 MPa on the first and second stages using a Gaulin 300 DJF 4 2PS homogenizer (APV Gaulin, Wilmington, MA). Three different beverages were manufactured by taking the three mixes and combining them with skim milk. These blends were then placed into plastic containers and labeled. The mix/skim blend was combined with espresso (Community Coffee) made on a Faema Com1.s espresso machine (Faema Co., Milanese, Italy) and ice into a Vita-Mix Drink Machine Plus blender (Vita-Mix, Cleveland, OH). The mixture was blended for 15 s and then served at 4C. After blending, the beverages were analyzed for viscosity, pH, fat and total solids. The beverages were also analyzed by trained and consumer sensory panels. The experiment was replicated four times.

Determination of Fat, Total Solids and pH

Fat and total solids analysis was carried out by procedures described by Case *et al.* (1995). Tests were carried out in duplicate on each of the four replications.

The pH was determined using an Orion model 250A pH meter (Orion Labs, Boston, MA). The pH was measured in duplicate at 2-min intervals for a period of 24 min. Temperature varied from 16.2 to 20.5C.

Viscosity Determination

Viscosity measurements were performed using a Brookfield DVII viscometer (Brookfield Labs, Stoughton, MA) at 100 rpm using spindle number 1. The samples were tempered in an ice bath until a stable temperature of 4C was obtained. Measurements were taken at 1-min intervals for a period of 5 min. Results were recorded in centipoise.

Color Determination

Color analysis was carried out on a Hunter colorimeter (Hunter Labs, Reston, VA). The samples were placed into a clear glass cup and measured by the colorimeter for *L*, *a* and *b* color values. Readings were taken at 2-min intervals for a period of 6 min.

Procedures for Organoleptic Evaluation by Trained Panel

Organoleptic evaluation was performed by a seven-member trained panel ranging from 18 to 42 years of age. Four of the panel members were female and three were male. The panelists were screened to be able to differentiate intensities from the four basic tastes (ASTM Committee E-18, 1981). Next, the panelists were trained for 3 weeks using standards for viscosity, consistency/iciness, sweetness, coffee flavoring, bitterness, aftertaste and color. Results were analyzed using analysis of variance. Performance evaluation probabilities of $F \leq 0.05$ were considered as contributing to discrimination. Trained panelists then analyzed the beverages for intensities using a 0–10 intensity scale (0 = not detectable to slight, 10 = high intensity). The samples were coded with random three-digit numbers and were then presented to the panelists in a random order. The panel was conducted over a 2-day period. The panelists evaluated samples under controlled lighting.

Procedures for Organoleptic Evaluation by Consumer Panel

Organoleptic evaluation was conducted on the three beverages by a 100-member consumer panel. Fifty panelists were male and 50 were female. Thirty-six ranged in age from 18 to 24; twenty-six were from 25 to 34; nineteen were from 35 to 44; nine were from 45 to 54; six were from 55 to 64; and four were over 64 years of age. The consumer panelists analyzed the beverages for preference in separated booths using a 0–10 preference scale (0 = dislike extremely, 5 = neither like/dislike, 10 = like extremely). The con-

sumer panel was conducted over a 4-day period. The panelists were also asked to fill out a demographic information sheet.

Statistical Procedures

Results were analyzed by the general linear model in a completely randomized block design by SAS version 6.11 (SAS Institute, Inc., Cary, NC). Significant differences were determined at the ($P < 0.05$) level of significance using Duncan's multiple range difference test.

RESULTS AND DISCUSSION

Iced Espresso Beverage Composition, pH and Viscosity

Compositional analysis (Table 1) of iced espresso beverages showed no significant differences ($P < 0.05$) between percent total solids and fat content among the treatments. Although the percent total solids for the light-medium roasted beverage had a higher mean value than the others, statistical analysis did not find it significant. Viscosity for the light-medium roasted beverage was significantly higher ($P < 0.05$) than the others. This could be due to the differences in suspended solids. The beverage made with the lighter roasted coffee had more suspended solids, giving it a higher viscometer reading. The pH increased with increased darkening of roast (Table 1). Results from Illy and Viani (1995) and Clarke and Macrae (1985) support this finding. Although neither reference stated exactly why pH increases with increased darkening of the roast, it may be speculated that because coffee contains numerous chlorogenic and organic solids, some may be changed into other products because of heat, thus decreasing the acid content and increasing the pH.

Color Results for Beverages

Color results are shown in Table 2. The light-medium roasted treatment was significantly lighter in color than the medium-dark roast and French

TABLE 1.
MEAN FAT, TOTAL SOLIDS, VISCOSITY AND pH FOR FRESH BLENDED ICED ESPRESSO BEVERAGES

Treatments	Solids (%)	Fat (%)	Viscosity (cps)	pH
Light-medium roast	11.50[a]	1.2[a]	23.60[a]	6.68[b]
Between roast	11.13[a]	1.2[a]	23.37[b]	6.72[b]
French roast	11.25[a]	1.2[a]	23.34[b]	6.81[a]

[a,b] Means in the same column not followed by same letter differ significantly ($P < 0.05$).

TABLE 2.
MEAN COLOR* RESULTS FOR FRESH BLENDED ICED ESPRESSO BEVERAGES

Treatments	*L* values†	*a* values‡	*b* values§
	0–100	−50 to +50	−50 to +50
Light-medium roast	71.47[a]	6.64[a]	16.77[b]
Between roast	65.58[b]	7.61[b]	16.96[b]
French roast	58.56[c]	8.69[c]	17.39[a]

[a–c] Means in the same column not followed by same letter differ significantly ($P < 0.05$).
* Mean color measurements using Hunter colorimeter (Hunter Labs, Reston, VA).
† L = black to white.
‡ a = green to red.
§ b = blue to yellow.

roasted treatment. The beverage made with the French roasted treatment was redder than the beverage made with the between roasted treatment and light-medium roasted treatment. The French roast beverage was significantly more yellow than the between roasted and light roasted beverage treatment. Color values indicate that as roast increases, color darkens. Beverage manufacturers for these types of drinks must take this information into account in their formulations. In this study, the consumers preferred the lighter beverages. Depending on the target market, consumers in another demographic region may prefer a darker color. Color influences the taste of the finished product. In general, flavor intensity increases as color strength increases (Dubose *et al.* 1980).

Sensory Analysis

Results of the trained sensory panel are presented in Tables 3 and 4. Duncan's multiple range test for data collected from the trained panel revealed significant ($P < 0.05$) differences in coffee flavor intensity for each beverage. This indicated that the panel was able to pick out differences in beverages based on the different coffee roast used in this study. As degree of roast increased, the coffee flavor intensity increased.

No significant differences were found for sweetness for the light-medium and between roasted beverages. Mean values for these two beverages were 5.6 and 5.0, respectively. The sweetness of the beverage made with the French roasted coffee was significantly lower than the others even though all samples contained the same level of sweetener. The French roasted treatment tended to

TABLE 3.
MEAN COFFEE FLAVOR, SWEETNESS, AFTERTASTE AND BITTERNESS INTENSITY SCORES BY TRAINED PANEL

Treatments	Coffee flavor	Sweetness	Aftertaste	Bitterness
	(0–10)*			
Light-medium roast	2.9[a]	5.6[a]	2.0[b]	1.3[b]
Between roast	4.5[b]	5.0[a]	2.4[b]	1.9[ba]
French roast	7.3[c]	3.9[b]	4.9[a]	5.3[a]

[a–c] Means in the same column not followed by same letter differ significantly ($P < 0.05$).
* Mean flavor scores according to an 11-point scale (0 = not detectable or slight, 10 = high intensity).

TABLE 4.
MEAN VISCOSITY, CONSISTENCY AND COLOR INTENSITY SCORES OF FRESH BLENDED ICED ESPRESSO BEVERAGES BY TRAINED SENSORY PANEL

Treatments	Viscosity	Consistency/iciness	Color
	(0–10)*		
Light-medium roast	2.6[b]	3.7[b]	1.8[b]
Between roast	2.9[b]	4.0[b]	2.8[b]
French roast	3.9[a]	4.8[a]	4.6[c]

[a–c] Means in the same column not followed by same letter differ significantly ($P < 0.05$).
* Mean flavor scores according to an 11-point scale (0 = not detectible or slight, 10 = high).

have more intense "bitter" and "aftertaste" flavors. These strong flavors caused a masking of the sweetness. Sucrose was found to reduce the bitterness of regular coffee, making its addition in a beverage important (Illy and Viani 1995). Pangborn (1982) found that the sensory perception of bitterness decreased upon addition of sucrose. Calvino *et al.* (1990) also found that the suppression of bitterness and coffee flavor qualities increased when sucrose levels increased. The amount of sucrose added in this experiment was not enough to overcome the bitterness of the French roasted coffee. Depending on application, a coffee beverage manufacturer may want to increase sweetness if using a stronger coffee to mask bitter flavors or decrease sweetness to allow the stronger flavors to come through. Milk and milk/sugar interactions play a role in the perception of the coffee flavor. Optimum levels of sugar in the presence of a low milk concentration may be different than sugar levels with a high concentration of milk (Moskowitz 1985).

Trained panel viscosity intensity results of the beverages made with light-medium roast, between roast and French roasted coffees were 2.6, 2.9 and 3.9, respectively. Objective viscosity measurements did not support sensory results. These differences were probably due to color variations in the beverages. As roast increased, the color darkened. This darker color may have caused the beverages made with the between roast and French roasted treatments to be perceived as being thicker.

Significant differences were found with respect to beverage consistency in the trained panel. Mean values for consistency/iciness increased with increasing roast. Although all beverages were made the same way, perhaps the darker roasted coffees caused the beverages they were blended into to appear not as well blended as the beverages made with the lighter roasted coffees. Differences in color can cause incorrect conclusions of differences in texture (Meilgaard *et al.* 1987). Christensen (1983) did not find food color to affect texture of five different foods; however, he concluded that more specific questions about texture must be asked instead of presented as a general concept to observe a treatment effect. In other words, only including the word "texture" as an attribute would not elicit a treatment effect as would terms describing the texture. In this case, the consumers were asked specifically about the iciness of the samples.

The trained panel found significant differences in color. The beverage made with the French roasted coffee was found to have a more intense color than the between roast coffee and light-medium roasted coffees. Mean intensity values were 5, 3 and 2, respectively. As coffee roast increased, there was a darkening in the color of the coffee bean. This color difference in the beans carried through to the blended beverage.

Consumer preference panel results are presented in Tables 5–7. Interactions found to be significant ($P < 0.05$) were between coffee flavor and gender,

TABLE 5.
MEAN FLAVOR PREFERENCE SCORES BY CONSUMER PANEL

Treatments	Overall flavor	Coffee flavor
	(0–10)*	
Light-medium roast	6.4[a]	6.2[a]
Between roast	5.6[b]	5.5[b]
French roast	5.5[b]	5.6[b]

[a,b] Means in the same column not followed by same letter differ significantly ($P < 0.05$).
* Mean flavor scores according to an 11-point scale (0 = dislike extremely, 5 = neither like/dislike, 10 = like extremely).

TABLE 6.
MEAN FLAVOR PREFERENCE SCORES BY CONSUMER PANEL BASED ON MARITAL STATUS

Marital status	Overall flavor	Coffee flavor
	(0–10)*	
Never married	6.2[a]	6.3[a]
Married	5.5[a]	5.4[a]
Separated/divorced/widowed	4.3[b]	3.9[b]

[a,b] Means in the same column not followed by same letter differ significantly ($P < 0.05$).
* Mean flavor scores according to an 11-point scale (0 = dislike extremely; 5 = neither like/dislike; 10 = like extremely).

TABLE 7.
MEAN FLAVOR PREFERENCE SCORES BY CONSUMER PANEL BASED ON GENDER

Gender	Overall flavor	Coffee flavor
	(0–10)*	
Female	5.5[b]	5.5[b]
Male	6.1[a]	6.1[a]

[a,b] Means in the same column not followed by same letter differ significantly ($P < 0.05$).
* Mean flavor scores according to an 11-point scale (0 = dislike extremely, 5 = neither like/dislike, 10 = like extremely).

coffee flavor and marital status, coffee flavor and beverage, overall flavor and gender, overall flavor and marital status, and overall flavor and beverage. Replication was not significant ($P < 0.05$). This is very important because it means that the consumers were able to pick out differences between the beverages made the same way on different days.

The beverage made with the light-medium roasted coffee had significantly higher preference scores for both coffee flavor and overall flavor than beverages made with the between and French roasted treatments. The between and French roasted treatments were shown to have a more intense flavor by the trained sensory panelists. Consumers in this panel seem to prefer a less intense coffee flavor. Darker roasted coffees are being used to manufacture fresh blended iced espresso beverages.

People who were never married gave significantly higher scores for overall flavor and coffee flavor, suggesting that they liked the products more

TABLE 8.
NUMBER OF CONSUMER PANELISTS SELECTING PRODUCTS AS THEIR FIRST, SECOND OR THIRD CHOICE

Product	Total number of times selected
Regular coffee	41
Hot cappuccino	35
Café au lait	33
Frozen coffee drinks	30
Hot cocoa	22
Iced coffee	21
Café latte	19
Flavored coffee	13
Hot tea	11
Hot espresso	11

than married people or people in the separated/divorced/widowed category. The majority of single people were also between the ages 18–24, perhaps suggesting more of an age effect on the scores. The National Coffee Association's 2004 Drinking Trends showed almost an 85% increase in the number of 18–24 year olds consuming gourmet coffee beverages in 2004 as compared to 2003.

Males gave significantly higher scores for overall flavor and coffee flavor, suggesting that they liked the products more than females. This correlates to findings by the National Coffee Association's 2004 Drinking Trends, which found that men consume more coffee than women (1.76 cups versus 1.53 cups per day). Increased consumption patterns may be related to a greater preference for coffee flavor.

Information about frequencies for coffee consumption, frequency of visitation to coffee houses/espresso bars and frequency of purchase of 10 different beverages were collected. Of the 100 people surveyed, 51 consume a cup of fresh brewed coffee one or more times a day. Fifty-two infrequently go into coffee houses/espresso bars, while 24 frequent them one to two times per month; 11 frequent them one to two times per week, and 4 frequent them daily.

According to the number of consumer panelists selecting products as their first, second or third choice (Table 8), the most popular item in coffee houses is regular coffee followed by hot cappuccino, café au lait and frozen coffee drinks.

CONCLUSIONS

The trained panel found that as the degree of roast increased, the coffee flavor intensity increased. The French roasted treatment tended to have more

intense bitter and aftertaste flavors. These strong flavors caused a masking of the sweetness. The amount of sucrose added in this experiment was not enough to overcome the bitterness of the French roasted coffee. As coffee roast increased, there was a darkening in the color of the coffee bean. This color difference in the beans carried through to the blended beverage. Beverages made with the light-medium roasted coffee had significantly higher consumer preference scores for both coffee flavor and overall flavor than beverages made with the between and French roasted treatments. The between and French roasted treatments were shown to have a more intense flavor by the trained sensory panelists. Consumers in this panel preferred a less intense coffee flavor.

REFERENCES

ARBUCKLE, W.S. 1986. Defects, scoring and grading. In *Ice Cream*, 4th Ed., p. 319, Van Nostrand Reinhold Company Inc., New York, NY.

ASTM COMMITTEE E-18. 1981. *Guidelines for the Selection and Training of Sensory Panel Members, STP 758*. American Society for Testing and Materials, Philadelphia, PA.

CALVINO, A.M., GARCIA-MEDINA, M.R. and COMETTO-MUNIZ, J.E. 1990. Interactions in caffeine-sucrose mixtures: evidence of taste and flavor suppression. Chem. Senses *15*(5), 505–519.

CASE, R.A., BRADLEY, R.L. and WILLIAMS, R.R. 1995. Chemical and physical methods. In *Standard Methods for the Examination of Dairy Products* (G. Richardson, ed.) pp. 349–378, American Public Health Association, Washington, D.C.

CHRISTENSEN, C.M. 1983. Effects of color on aroma, flavor and texture judgments. of foods. J. Food Sci. *48*, 787–790.

CLARKE, R.J. and MACRAE, R. 1985. *Coffee Chemistry*, Vol 1, Elsevier Science Publishers, New York, NY.

DAIRY FACTS 2004. pp. 80–83, International Dairy Foods Association, Washington, DC.

DAVIDS, K. 1993. Espresso, Ultimate Coffee. St. Martin's Press, New York, NY.

DUBOSE, C.N., CARDELLO, A.V. and MALLER, O. 1980. Effects of colorants and flavorants on identification, perceived flavor intensity and hedonic quality of fruit-flavored beverages and cake. J. Food Sci. *45*, 1393.

FLAMENT, I. 1989. Coffee, cocoa, and tea. Food Rev. Int. *5*(3), 317–414.

ILLY, A. and VIANI, R. 1995. *Espresso Coffee*. Academic Press Limited, London.

MARKETRESEARCH.COM. 2003. *The U.S. Market for Coffee and Ready-to-Drink Coffee*, 4th Ed. Nov. Packaged Facts, New York, NY.

MEILGAARD, M., CIVILLE, G.V. and CARR, B.T. 1987. *Sensory Evaluation Techniques*, Vol 1, p. 10, CRC Press, Boca Raton, FL.

MOSKOWITZ, H.R. 1985. *New Directions for Product Testing and Sensory Analysis of Foods*, p. 31, Food and Nutrition Press, Inc., Westport, CT.

NATIONAL COFFEE ASSOCIATION OF USA, INC., 2004. National coffee drinking trends 2004 .

PANGBORN, R.M. 1982. Influence of water composition, extraction procedures and holding time and temperature on quality of coffee beverage. Lebensm.-Wiss. Technol. *15*, 161–168.

POWERS, J.J. 1988. Current practices and applications of descriptive methods. In *Sensory Analysis of Foods*, 2nd Ed. (J.R. Piggot, ed.) p. 196, Elsevier Science Publishers Ltd., New York, NY.

SCHENKER, S., HANDSCHIN, S., FREY, B., PERREN, R. and ESCHER, F. 2000. Pore structure of coffee beans affected by roasting conditions. J. Food Sci. *65*(3), 452–457.

SCHENKER, S., HEINEMANN, C., HUBER, M., POMPIZZI, R., PERREN, R. and ESCHER, F. 2002. Impact of roasting conditions on the formation of aroma compounds in coffee beans. J. Food Sci. *67*(1) 60–66.