



Sensory Characterization Program
for Cultured **HARD CLAMS**,
Mercenaria spp.

TP-179
August 2012

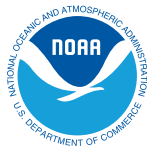
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Sensory Characterization Program for Cultured Hard Clams
Mercenaria Species

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SENSORY CHARACTERIZATION PROGRAM FOR CULTURED HARD CLAMS *MERCENARIA* SPECIES

SUMMARY

A sensory characterization program has been developed for cultured hard clams *Mercenaria mercenaria*, southern quahogs *M. campechiensis*, and their hybrids using established protocol with screened and trained panelists. The approach was based on proven profiling techniques used with many foods. Rating scales and standards for hard clams were derived from profiling differences and unique attributes for appearance, aroma, basic taste, flavor, aftertaste, texture, and mouth-feel. Users can be trained with established standards and actual products to rate and describe the unique character of the products in question. This sensory program can be used by investigators assessing product quality and shelf life, or commercial interests trying to distinguish products by location, season, or process. Popular use could lead to local product distinctions or appellations that stimulate and attract consumer interests. Through these efforts, a non-biased, science-based tool has been provided to help direct commercial practices and decisions for marketing and maintaining product standards.

INTRODUCTION

Sensory profiling is a well-established science used to describe food products to account for attributes that could influence production, product acceptance, and market values (Meilgaard, Civille & Carr, 2007; Lawless & Heymann, 1998). An actual profile for any product requires selection and training of a panel of experts. Panelists must demonstrate their ability to detect certain sensory measures in reference to a particular group of pre-determined standards that mimic or resemble certain and unique features for similar products. The standards must be established and tested prior to any product evaluations, and the testing period must establish metrics for panel agreement in ratings. This approach was used to complete the first sensory profile for molluscan shellfish in which post-harvest treatments of raw oysters *Crassostrea virginica* were characterized (Garrido, Garrido, Bogan & Otwell, 2007).

The goal of this project was to develop a formal, science-based sensory profile to characterize aquacultured hard clams *Mercenaria mercenaria*, southern quahogs *M. campechiensis*, and their hybrids. Investigators, scientists, and industry can use these sensory characterizations in assessing product quality, shelf life, or appellations that foster market opportunities. As a relatively new industry, Florida farm-raised hard clams can vary by harvest location and season, operational practices, and storage consequences. Sensory profiles could assist in advancing this industry by directing handling practices (e.g., harvest times, removal of grit by purging), establishing operational guidelines for expected survival in refrigerated storage, and distinguishing a brand that offers product differentiation and market values based on certain sensory attributes.

PROFILE DEVELOPMENT

Sensory Panel

The trained seafood sensory panelists at the University of Florida were used to conduct the evaluations. These panelists have been profiling and characterizing seafood products such as raw oysters, shrimp, and Alaskan pollock since 2003. The 12-member panel consisted of graduate students, professors, and personnel, 24 to 50 years of age, from the UF Food Science and Human Nutrition Department. Panelists were trained using cultured hard clam samples from the same harvest area using a descriptive sensory analysis method (Figure 1).

Sensory Standards and Ratings

During an orientation phase, the necessary lexicons, descriptive standards, and scoring metrics for rating clam products were developed. The seven sensory attributes included appearance, aroma, taste, flavor, aftertaste, texture, and mouth-feel. The approach involved multiple sessions to account for anticipated variables due to harvest time, environmental and weather conditions at harvest (e.g., salinity), and storage times. Further, this facilitated mutual agreement of the panelists and practice with scoring products relative to the standards. Each session involved sensory testing of products followed by a panel discussion to identify descriptive terms.



Figure 1. Panelist evaluating raw hard clams for aroma.

The sensory standards included actual items and mixtures that could be prepared and used to represent particular appearances or sensations for raw hard clams. These standards were developed through experience and expert consultation. In most cases, the standards were based on readily accessible items that remain consistent across regions and seasons. All accompanying standards were prepared the morning of each taste panel session using either Zephyrhills® or Dasani® brand water. The refrigerated standards (e.g., cheese, chicken) were stored below 35°F and presented in small containers for isolation. The frozen references used for odor standards were brought to room temperature a few hours prior to the session. A condensed version of the final profiling format for raw hard clams with assigned descriptions and standards for sensory references can be found in Appendix A. The product characterization rating form in Appendix B was divided into sections, one per attribute. For each attribute, several product descriptors or lexicons were defined. Lexicons for appearance included color of meat and shell, volume of meat, and plumpness. Aroma included briny and seaweed, earthy, and metallic. Basic taste included salty, umami, sour, and bitter. Umami is a Japanese term for “pleasant, savory taste.” Flavor included seaweed, chicken liver-like, and earthy. Aftertaste included metallic and astringency. Texture included firmness and chewiness. Mouth-feel was based on the detection of grit. The lexicons for each attribute listed on the product characterization form were rated on a 10-point intensity scale where a value of 5 indicated a medium or average value.

Preliminary Product Characterization

The panelists were first exposed to samples of cultured hard clams from Cedar Key, Fla., in order to identify appropriate and uniform descriptive terms for raw clams. Six samples of six dozen clams were delivered to the UF Aquatic Food Products Lab within 24 hours of harvest from November 2008 through March 2009. The clams were graded and averaged 1" in shell width or thickness, which are referred to as "littleneck" clams. All harvests were from approved shellfish harvesting waters and certified farming operations in accordance with the National Shellfish Sanitation Program ("National shellfish sanitation," 2009). Samples were evaluated within 24 hours of receipt and were held in refrigerated storage (45°F or less) prior to testing. Raw clam product evaluations were conducted at a similar temperature (45°F or less) as customarily used for serving raw clams in restaurants. In order to maintain this temperature and to prevent dehydration, clams were shucked 30 minutes prior to each panel session and the half-shell product was stored on ice until consumed (Figure 2). Failure to maintain low temperatures in the raw clam products altered the flavor and odor perception. The panelists had to consume at least five clams per sample and then report the average ratings. Panelists evaluated no more than 20 clams per sitting to prevent errors due to fatigue. Samples were presented using blind codes.



Figure 2. A sample of hard clams shucked and placed on ice prior to the panel session.

The color ratings for samples of cultured hard clams harvested from Cedar Key are provided in Table 1. Outer shell color for all raw clam samples was similar, ranging from common gray-tones to more browns and some orange coloration. The color scale developed for the hard clam shell can be found in Appendix C, Figure 1. The raw meat color also did not vary among clam samples. The color scale developed for hard clam meat can be found in Appendix C, Figure 2. Florida clams exhibited meat colors that were predominantly beige with some peach and pink tones.

The profile development results were averaged for the six clam samples. The average rating and range of ratings for the various product characteristics, based on a scale of 0 to 10, are reported in Table 2. Results for earthy aroma, and sour and bitter tastes are not reported in the table as panelists did not detect any of these negative attributes in the samples. These characteristics are considered objectionable if found in clams. The ratings for each clam sample were also compared to the overall averages of the attributes by designating if the value was well below average (LL), below average (L), equal to the average (A), above average (H), or well above average (HH). The results illustrate how attributes of clams from the same harvest location can vary and be influenced by season, weather or other conditions.

Table 1. Color ratings for raw hard clams harvested during November 2008 through March 2009 from aquaculture operations located in Cedar Key, Fla. The stars represent quantity of color or amount of brittleness. No star represents absence, *=low quantity, **= moderate quantity, and ***=high quantity of the particular color or brittleness.

Attributes and Lexicons	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Shell Color						
Gray	***	***	**	***	**	***
Brown	*	**	***	*	***	***
Light Brown	**	*	*	**	*	*
Orange		*			**	*
Meat Color						
White/Gray	*	*	*	*	*	*
Beige	**	**	**	**	***	*
Peach	**	**	*	**	*	**
Pink	*		**	**	*	**
Yellow	*	*	*	*	*	**
Orange		*	*	*	*	*

Table 2. Product characterization results for six samples of raw hard clams harvested from aquaculture operations located in Cedar Key, Fla. Ratings for each clam sample are compared to the overall average of the samples where LL=well below average, L=below average, A=average for all clam samples, H=above average, and HH=well above average.

Attributes and Lexicons	Average	Range	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Appearance								
Volume of Meat	6.7	6.6-7.2	A	L	A	L	L	L
Plumpness	6.3	5.8-6.6	L	L	L	L	L	L
Aroma								
Briny	2.9	1.5-4.6	L	HH	L	H	L	H
Metallic	0.9	0.1-1.9	L	H	L	A	L	H
Basic Taste								
Salty	9.4	8.4-10.6	H	L	H	L	L	L
Umami	2.0	1.2-3.0	L	H	L	H	H	A
Flavor								
Seaweed	1.8	0.4-2.9	L	H	L	A	H	H
Chicken liver	2.3	1.0-3.5	L	L	L	L	A	H
Earthy	1.9	1.2-3.6	L	L	L	A	L	H
Aftertaste								
Metallic	1.4	0.5-2.3	L	L	L	L	L	L
Astringent	2.2	0.8-2.7	L	L	L	A	L	H
Texture, Meat								
Firmness	6.3	5.4-7.0	H	H	H	L	L	L
Chewiness	6.2	4.9-7.6	H	H	H	A	A	L
Mouth-Feel								
Detect Grit	2.4	0.8-4.5	L	L	L	HH	L	LL

CHARACTERIZATION OF HARD CLAMS FROM MASSACHUSETTS TO FLORIDA

Sensory profiling techniques were used to characterize the appearance and edible features of raw hard clams cultured from various locations along the Gulf of Mexico and Atlantic coasts. After the profiling format was established, the trained panel began assessing samples from commercial farms located from Massachusetts to Florida during January, February, and March in 2009. Harvest locations and number of samples received by location are reported in Figure 3. The intent was to distinguish attributes for various growing areas or farming operations. To assure authenticity of the samples, clams were shipped by overnight courier directly from certified shellfish wholesalers to the UF Aquatic Food Products Lab as soon as possible after harvest. All samples were received less than three days post-harvest. A sample consisted of 60 littleneck-size clams (1" shell width). Evaluation of samples followed those procedures developed in the preliminary product characterization.

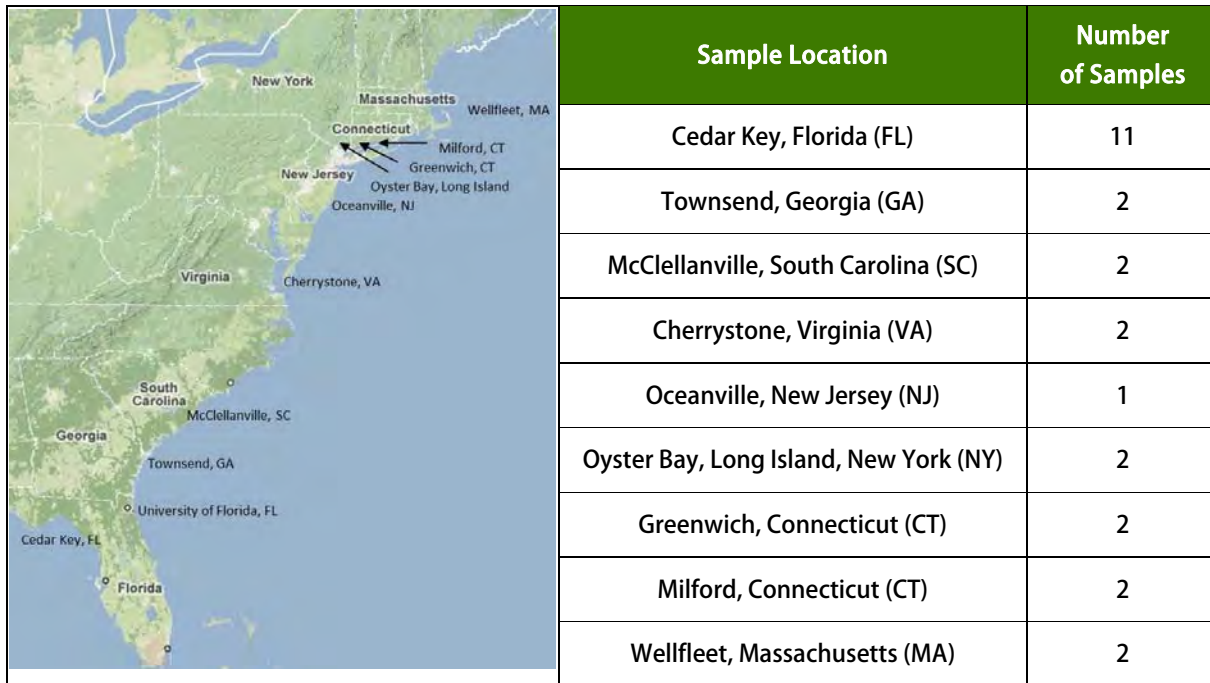


Figure 3. Harvest locations and number of hard clam samples evaluated by trained panelists.

The color and shell strength ratings for raw hard clams harvested from farms located from Massachusetts to Florida are presented in Table 3. Outer shell color among harvest locations was the least variable, ranging from common gray-tones to more browns and some orange coloration associated with the Florida hard clams. All shell colors were typically expected and should not necessarily influence product preference, unless there are local partialities. The edible meat color was more variable per location than shell color. Meat color should not have a negative impression, and there is no evidence that consumers would prefer meats with more pink, yellow, or peach tones. Interestingly, the clams from Florida and Georgia exhibited more variability in meat color per individual clams from the same harvest. Meat color could be used in marketing efforts to embellish or distinguish products, but there was no evidence that any one color indicated a better or inferior product. While preparing samples for evaluation, the panel leader encountered differences in shell strength. This was not observed in the Cedar Key clam samples during the preliminary characterization. This attribute was included in this evaluation and described as brittleness with standards based on actual samples. Shell brittleness was more obvious and a potential commercial concern for the clams from Massachusetts through New Jersey. Typically, shell brittleness is associated with fast growth, which should not have been the case for clams harvested during the winter from northeastern states.

Table 3. Color and shell strength ratings for raw hard clams harvested from commercial farms in Massachusetts to Florida. The stars represent quantity of color or amount of brittleness. No star represents absence, *=low quantity, **= moderate quantity, and ***=high quantity of the particular color or brittleness. Color scales can be found in Appendix III, Figures 1 and 2.

Attributes and Lexicons	MA	CT	NY	NJ	VA	SC	GA	FL
Shell Color								
Gray	**	***	***	***	***	***	***	*
Brown		*	*			**		**
Light Brown	*			*				
Orange								*
Meat Color								
White				*		*	*	
Beige	**		*	*			*	*
Peach	*	*			**		**	*
Pink	***	***	***	*	**	**		*
Yellow				*		*	***	
Orange		*		*				*
Gray								*
Shell Strength								
Brittleness	*	*	*	*				

The average and range of ratings for each attribute from all harvest locations are reported in Table 4. The edible meat volume (fill in the half-shell) and plumpness could be used to distinguish products as they were the more obvious and variable ratings for appearance (see Appendix C, Figure 3 for reference). However, additional work is necessary to determine how these visual characteristics may vary per season or reproductive status of the clams. In terms of taste, ratings for “salty” were by far the most distinguishing attribute. This result was expected and remains consistent with commercial experiences. In fact, the standard 10-point rating scale had to be expanded to account for the strong salty taste. This taste would not necessarily distinguish growing areas, but could reflect seasons or local environmental conditions. Although salty taste is a traditional and routine descriptor used by many consumers, it would be interesting to develop a consumer preference scale for salty clam flavor. There was an interesting range in ratings for umami taste, which has not been previously described for hard clams. Umami, which is a Japanese term for “pleasant, savory taste,” could be an attractive term to market clams. It is an accepted basic taste used by the oyster industry to promote raw, half-shell product. The high ratings for salty masked the flavor attributes, as ratings for seaweed, chicken liver, and earthy were consistently low. As expected, the average texture ratings of the clams were characteristically firm and somewhat chewy. These ratings are not negative but typical for raw clams. Presence of sand or grit in clams resulted in an unpleasant and negative mouth-feel. Some samples were rated high in grit.

Table 4. Average and range of ratings for attributes of raw hard clams harvested from commercial farms located in Massachusetts to Florida.

Attributes and Lexicons	Average Rating for Clams from MA to FL	Range of Ratings for Clams from MA to FL
Appearance		
Volume of meat	7.3	6.1 - 9.0
Plumpness	6.9	4.7 - 8.6
Aroma		
Briny	2.6	1.2 - 3.8
Metallic	1.0	0.1 - 2.1
Basic Taste		
Salty	9.7	7.0 - 12.7
Umami	2.2	1.2 - 3.0
Flavor		
Seaweed	1.8	0.4 - 2.9
Chicken liver	2.2	1.0 - 3.6
Earthy	2.2	1.3 - 4.3
Aftertaste		
Metallic	2.6	0.5 - 3.7
Astringent	1.4	0.7 - 2.7
Texture, Meat		
Firmness	6.1	4.3 - 7.3
Chewiness	5.6	4.3 - 7.6
Mouth-Feel		
Detect grit	2.0	0.8 - 4.5

The rating results of attributes averaged for each state were compared to the overall average of samples from all harvest locations in Table 5. These results reflect the period of harvest rather than an expected value for each location since the changes in growing conditions (e.g., salinity, phytoplankton composition and abundance) can change attributes for clams harvested from the same location. For each attribute, the ratings were designated as to whether the state’s average value was below average (L), equal to the overall average (A), or above average (H). Some ratings depended on the source or sample (D) due to the range of values obtained from different harvest locations within the same state.

A professional tasting of cultured raw clams from the states that participated in the sensory characterization was conducted in conjunction with a culinary event in Savannah, Ga., hosted by the East Coast Shellfish Growers Association (ECSGA). More than 100 shellfish aficionados who attended *Romancing the Clam* tasted clams and received a product evaluation form to complete. They were able to compare their results with those of the UF-trained sensory panel. Each participating state was provided with a distinctive award based on the results of their clams’ sensory profile. Videos and photographs of the event were made available to seafood wholesalers and distributors and are posted on the ECSGA’s website (www.ecsga.org), Facebook, and YouTube.

Table 5. Product characterization results and sodium levels (mg/100g) for raw hard clams harvested from commercial farms located from Massachusetts to Florida. Ratings of attributes for each state are compared to the overall average of samples from all harvest locations where L=below average, A=average for all clam samples, H=above average, and D=depends on the source or sample within the state.

Attributes and Lexicons	MA	CT	NY	NJ	VA	SC	GA	FL
Appearance								
Volume of Meat	H	H	H	A	H	D	H	L
Plumpness	H	H	H	A	H	D	H	L
Aroma								
Briny	D	H	A	L	L	L	H	H
Metallic	D	H	A	L	L	L	H	H
Basic Taste								
Salty	H	A	H	H	L	D	D	D
Sodium (mg/100g)	588	532	514	588	447	531	606	565
Umami	H	L	H	A	L	D	A	L
Flavor								
Seaweed	L	H	A	H	L	D	A	D
Chicken liver	L	H	A	H	L	D	A	D
Earthy	L	H	A	H	L	D	A	D
Aftertaste								
Metallic	A	H	L	L	L	L	L	L
Astringent	A	H	H	L	L	L	L	L
Texture, Meat								
Firmness	A	A	H	L	A	L	A	A
Chewiness	A	A	H	L	A	L	A	A
Mouth-Feel								
Detect Grit	D	D	A	L	D	D	D	L

CHARACTERIZATION OF HARD CLAMS, SOUTHERN QUAHOGS, AND THEIR HYBRIDS

The Florida clam culture industry is based primarily on the *notata* variety of the hard clam *M. mercenaria*, which may not be suited for some Florida environments. The local southern quahog *M. campechiensis* may have suitable production characteristics and readily hybridizes with *M. mercenaria*, but is known to gape during refrigerated storage. Therefore, production characteristics and shelf life of these species and their hybrids were examined (Sturmer et al. 2010). Southern quahogs (*Mc*) and reciprocal hybrid clams (female *M. mercenaria* x male *M. campechiensis* [*Mm* x *Mc*] and female *M. campechiensis* x male *M. mercenaria* [*Mc* x *Mm*]) were also characterized, as was done for hard clams (*Mm*), to assure product acceptability and compatibility.

Two sets of samples, each consisting of 75 clams for each clam species and hybrid stock, were harvested from field trials conducted in Cedar Key and delivered to the UF Aquatic Food Products Lab in September and October of 2009. Product was characterized by the seven sensory attributes: appearance (color, volume of meat, plumpness), aroma, basic taste, flavor, aftertaste, texture, and mouth-feel for both raw and cooked clams. Prior to tasting, half of the samples were steamed until the clams opened. Standard descriptors and the product rating form developed for raw hard clams were used for profiling cooked clams.

The shell and meat colors for both raw and cooked hard clams, southern quahogs, and their reciprocal hybrids are presented in Table 6. Whereas the predominant shell color observed for raw (uncooked) hard clams was brown with some light brown and gray tones, the hybrids and southern quahogs were lighter in color, as panelists observed more gray and light brown tones. The predominant shell color changed to gray with some brown and light brown tones for the cooked hard clams and hybrids. The southern quahog had a more even representation of colors. In addition, the panelists observed orange tones in all of the cooked shells. All clam samples were reported to have similar meat colors. The predominant meat color observed for both raw and cooked clams was beige with tones of yellow, orange, white, and gray. The raw meats also had pink tones.

Table 6. Colors of shell and meat for both raw and cooked hard clams (*Mm* x *Mm*), southern quahogs (*Mc* x *Mc*), and their hybrids (*Mm* x *Mc*, *Mc* x *Mm*) harvested from Cedar Key, Fla. The values represent the percentage (%) of panelists who observed the particular colors in their clam samples.

Attributes and Lexicons	Mm x Mm		Mm x Mc		Mc x Mm		Mc x Mc	
	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked
Color of Shell								
Gray	36	77	53	70	47	62	47	48
Brown	72	42	30	15	61	44	44	38
Light Brown	30	38	44	52	44	31	33	46
Orange	0	17	0	25	0	8	8	17
Color of Meat								
White	19	15	11	6	19	8	6	6
Beige	58	67	61	44	53	48	47	58
Peach	0	0	0	0	0	0	0	0
Pink	33	0	28	7	53	7	44	0
Yellow	22	21	31	19	25	29	25	33
Orange	14	0	14	38	19	23	33	17
Gray	28	12	36	17	28	17	19	35

The attribute ratings for both raw and cooked hard clams, southern quahogs, and their reciprocal hybrids are reported in Table 7. For both raw and cooked clam samples, the values obtained for the hybrid clams were either similar or intermediate of those values for the parental species. As expected, the volume of meat and plumpness were reduced and the texture (firmness and chewiness) was increased for all clams after cooking, mainly due to shrinkage. For basic taste (salty and umami) and aftertaste (metallic and astringent), values were lower after cooking because of loss of liquor. During cooking, it was observed that the hybrid clams and southern quahogs required less time to open than the hard clams (3 minutes versus 5 to 6 minutes).

Table 7. Product characterization results for both raw and cooked hard clams (Mm x Mm), southern quahogs (Mc x Mc), and their hybrids (Mm x Mc, Mc x Mm) harvested from Cedar Key, Fla.

Attributes and Lexicons	Mm x Mm		Mm x Mc		Mc x Mm		Mc x Mc	
	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked
Appearance								
Volume of Meat	6.2	4.8	6.7	5.7	7.3	6.2	7.2	6.3
Plumpness	5.8	5.1	6.4	6.0	6.7	6.0	6.8	5.7
Aroma								
Briny	3.6	3.3	2.7	3.2	3.3	3.2	4.9	2.7
Metallic	2.4	1.3	1.2	1.0	1.5	1.3	4.4	1.3
Basic Taste								
Salty	10.8	7.1	10.7	7.4	10.6	7.4	10.3	7.9
Umami	3.8	2.5	3.6	2.7	3.2	2.6	3.7	3.0
Flavor								
Seaweed	2.3	1.3	2.5	1.8	2.8	1.8	3.2	2.3
Chicken liver	3.2	1.1	2.9	2.0	3.0	1.5	3.0	1.4
Earthy	1.9	0.9	1.8	1.5	1.9	1.6	2.4	1.6
Aftertaste								
Metallic	3.1	1.0	2.5	1.4	2.7	1.9	2.6	1.4
Astringent	2.0	0.6	1.7	1.7	1.7	1.5	2.0	0.9
Texture, Meat								
Firmness	6.2	7.4	5.8	7.4	6.3	7.3	6.4	7.1
Chewiness	5.0	7.4	5.4	7.3	5.7	7.2	5.7	7.0
Mouth-Feel								
Detect Grit	1.8	0.5	1.3	0.5	1.7	0.7	1.2	1.1

To determine differences in product characterization ratings for both raw and cooked hard clams, southern quahogs, and the reciprocal hybrids, an analysis of variance was conducted. The data analysis and subsequent output was generated using SAS software (version 9.2, 2011, SAS Institute Inc, Cary, N.C.). Treatment means of dependent variables were separated by a Tukey's honestly significant difference test. All statistical tests were considered significant when $p \leq 0.05$. No significant differences were detected for any of the attribute values when comparing the four clam stocks. Thus, wholesalers, retailers, and consumers should not consider hybrid clams to be any different from hard clams or southern quahogs based on their sensory profiles.

CONCLUSIONS

A new program has been developed to judge and rate the “romance” of hard clams. This technique, known as sensory profiling, is simply a science-based approach to describing or characterizing the attributes of raw and cooked hard clams. The attributes include standard measures for product appearance, aroma, taste, flavor, aftertaste, texture, and mouth-feel. The rating scales use such terms such as plumpness, briny, metallic, salty, umami, seaweed, earthy, firm, chewiness, grit, brittle shell, and a rainbow of colors. The necessary product descriptors (lexicons), reference standards, vocabulary, and intensity scales (ratings) are available for a complete product characterization. The science is in the development of standards for reference and training for proper ratings, while the romance is in the description (much like consumers use to describe their wines and other foods). This technique can be useful in directing commercial production and processing operations, as well as consumer selection and enjoyment. Proper and best use of these evaluation tools requires training for orientation, interpretation, and implementation.

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APPENDICES

APPENDIX A. Sensory standards developed for attributes and lexicons in the evaluation of cultured hard clams *Mercenaria mercenaria* and southern quahogs *M. campechiensis* to be used with a 0 to 10 scale.

Attributes and Lexicons	Description	Standard (Std)
Appearance		
Color	Color(s) of the clam parts captured by human eye	Appendix C, Figures 1 (shell) and 2 (meat)
Volume of meat	Refers to how much of the clam shell is covered by the meat	Appendix C, Figure 3
Plumpness	Refers to how the clam meat is well-rounded and full in form	Actual samples provided by panel leader during training
Shell strength	Refers to the brittleness of shell during shucking	Actual samples prepared by panel leader, not evaluated by panel
Aroma		
Briny and seaweed	Relating to seaweed and resembling saltiness or the sea	Std 10 - Ito-Wakame dried seaweed imported by Rhee Bros, Inc., Columbia, MD
Metallic	Relating to, or having the characteristic of, a metal	Std 10 - 2 capsules of Sundown iron 28 mg in 440ml of water, rub on skin and smell or shake bottle, open and smell
Undesirable/Objectionable Basic Aroma		
Earthy	Refers to the characteristics of damp soil and wet plants	Std 10 - Whole white mushrooms with soil, cut in half and smell
Basic Taste		
Salty	Taste stimulated by sodium salts, such as sodium chloride and sodium glutamate, and, in part, by other salts, such as potassium chloride (Meilgaard et al. 2007)	Std 5 - 0.3% salt Std 10 - 0.55% salt Std 15 - 0.7 % salt (Meilgaard et al. 2007)
Umami	Taste produced by substances, such as Monosodium Glutamate (MSG), a meaty, savory or mouth-filling sensation	Std 5 - 1/4 tsp of Accent in 500ml water Std 10 - ½ tsp of Accent in 500ml water
Undesirable/Objectionable Basic Taste		
Sour	Taste stimulated by acids, such as citric, malic, or phosphoric (Meilgaard et al. 2007)	Std 5 - 0.1% citric acid, presence or absence (Meilgaard et al. 2007)
Bitter	Taste stimulated by substances, such as caffeine and hop bitters (Meilgaard et al. 2007)	Std 10 - 0.08% caffeine solution, presence or absence (Meilgaard et al. 2007)
Flavor		
Seaweed	Relating to, or having the characteristic of, a flavor like seaweed	Std 10 - Ito-Wakame dried seaweed imported by Rhee Bros, Inc., Columbia, MD
Chicken liver-like / iron	Refers to the iron flavor of cooked liver (organ) meat	Std 4 - Chicken liver (Tyson), add to boiling water and keep boiling for 10 minutes
Earthy	Refers to the characteristics of damp soil and wet plants	Std 10 - Whole white mushrooms with soil, cut in half and taste
Aftertaste		
Metallic	Relating to, or having the characteristic of, a metal	Std 5 - 1 capsule of Sundown iron (28) mg in 440ml of water
Astringency	Refers to the chemical feeling factor combining three different aspects - drying of the mouth, roughing of oral tissues, and drawing (shrinking) sensation felt in the cheeks and the muscles of the face	Std 5- 1/8 tsp (0.5g) of alum (McCormick) in 500 ml of water or Std 5- Fresh spinach (Ready Pac)
Texture and Mouth-feel		
Firmness Chewiness	Refers to the consistency of how soft versus how firm in resistance the clams meat holds; amount of maceration required to comfortably swallow the clam	Std 1- Jell-O, soft Std 5 - Tofu (Grill-Marjon, original) Std 10 - Dried apricots (Sun-Maid, Mediterranean)
Grittiness	Presence of sand	Actual samples provided by panel leader during training

APPENDIX B. Sample of a product characterization rating form developed for cultured hard clams *Mercenaria mercenaria* and southern quahogs *M. campechiensis*. Each triangle represents the rating of a standard that panelists used for evaluation (as defined in Appendix A). The number of triangles equals the number of standards given for each attribute. For example, if three triangles appear, panelists were given three standards for that attribute. If no triangle appears, no standard was given for that attribute.

Clam Product Characterization Form

Panelist: _____

Date: _____

Sample Number: _____

Appearance

Color of the outer shell

Light Gray Gray Brown Brown and Orange

Color of the Meat

White Pink Yellow Gray Beige Orange

Volume of Meat

Hardly Covered

Full



Plumpness

Flaccid

Plump



Aroma/Smell

Briny and Seaweed

Not Briny

Extremely Briny



Metallic

Not Metallic

Extremely Metallic



Earthy

Not Earthy

Extremely Earthy

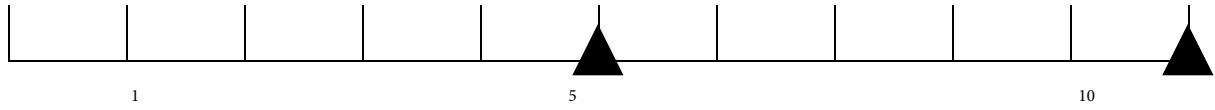


Basic Taste

Salty

Not Salty

Extremely Salty

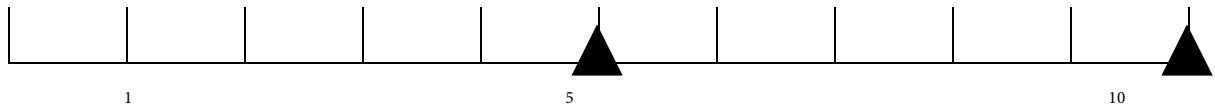


If salinity is more than 10, please write the rating here _____

Umami

Not Umami

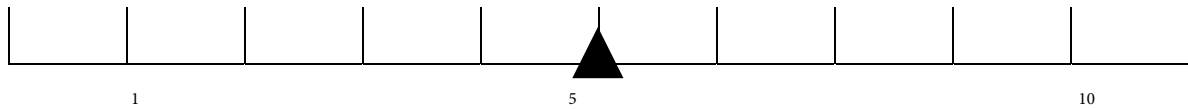
Extremely Umami



Sour

Not Sour

Extremely Sour



Bitter

Not Bitter

Extremely Bitter



Flavor

Seaweed

No Seaweed

Extreme Seaweed



Chicken Liver-Like/Iron(CLLI)

Not CLLI

Extreme CLLI



Earthy

Not Earthy

Extremely Earthy

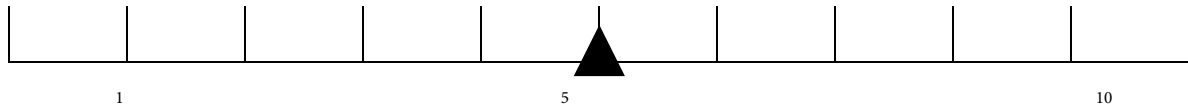


Aftertaste

Metallic

Not Metallic

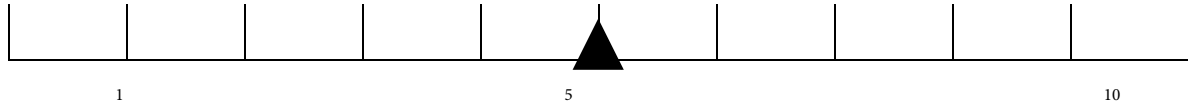
Extremely Metallic



Astringent

Not Astringent

Extremely Astringent



Texture of Meat

Firmness

Mushy

Extremely Firm



Chewiness

Not Chewy

Extremely Chewy/Rubbery

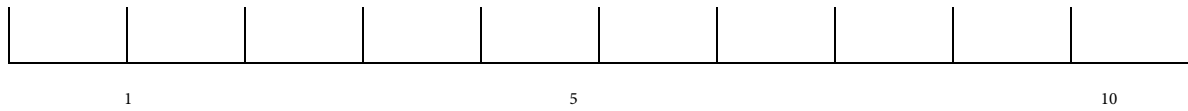


Mouth-Feel

Gritty

Not Gritty

Extremely Gritty



APPENDIX C. Reference standards developed for the evaluation of hard clams *Mercenaria mercenaria* for shell color (Figure 1), meat color (Figure 2), and volume of meat (Figure 3).



Figure 1. Color scale for the shell of hard clams.

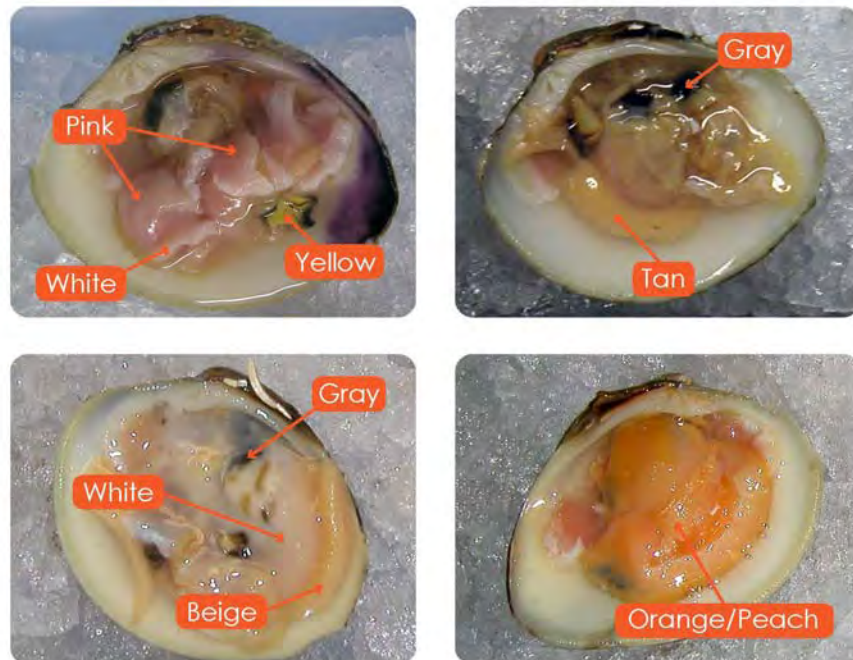


Figure 2. Color scale for the meat of hard clams.

Standards for Volume of Meat



Partial Cover (5)



Full Cover (10)

Figure 3. Standards for the volume of hard clam meats, where partial coverage of the meat to shell is rated 5 and full meat coverage of the shell is rated 10.



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