Factors Affecting the Sensory Quality of Cooked Rice

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Introduction

- Rice is consumed largely in the cooked, whole grain form after de-hulling and milling.
- Although rice is considered as a “bland” food, the sensory properties (flavor, texture and visual) of cooked rice play a very important role in its acceptance by consumers, especially in areas of the world where rice is a staple.
Introduction

Factors that may affect rice sensory properties includes:

- Chemical composition of rice grains
  - Environmental conditions
  - Genetics
- Pre and Post-harvest handling (drying, storage, and milling)
- Cooking method
How are Sensory Properties Measured?

- Many methods are available
  - Analytical sensory methods such as descriptive analysis that used trained assessors
  - Instrumental methods (Texture and Flavor)
  - Hedonic methods that measure hedonic properties (liking) by consumers
Sensory Evaluation Considerations

- Rice cooking is a very important aspect of evaluating the sensory properties of rice...because the cooking method can completely change the sensory profile of a specific rice sample.

- In the US, rice samples (500 grams) for sensory evaluation are often cooked in electric rice cookers (e.g. National, model SR-W10FN) with a 1:2 rice to water ratio.
Sensory Evaluation Considerations

- Rice texture changes very rapidly after cooking…sensory results are dependent on serving temperature
- Rice is served in glass bowls insulated with styrofoam and covered with watch glass
- Ideally, the evaluation is done at rice temperatures about 120F
What is Descriptive Analysis?

- Description of the sensory properties (aroma, flavor, texture and visual characteristics) of a food and the intensity rating of these properties
- Samples are evaluated by trained panelists according to specific methodologies and scales
**Descriptive Analysis**

- Samples are typically evaluated multiple times so that panelist reproducibility can be assessed.
- Samples are assessed in individualized booths featuring controlled lighting.
- Software is used to control and randomize sample presentation order and present the questionnaire.
- The samples are coded with random codes to not bias the assessors evaluations.
- Data is analyzed by analysis of variance to determine significant differences among samples studied.
Rice Sensory Attributes

- Aroma and Armatics: Sulfury, Starchy, Grainy, Carboard, Metallic, Haylike, Barnyard, popcorn, woody, Buttery, nutty, floral, Dairy, rancid, earthy

- Texture: Adhesiveness to lips, hardness, cohesiveness of mass, roughness of mass, toothpull, particle size, toothpack, loose particles
Flavor Lexicon for Sensory Descriptive Profiling of Different Rice Types

M. Limpawattana and R.L. Shewfelt

ABSTRACT: Rice flavor is a significant factor in determining quality and consumer acceptability as exemplified by scented rice, which is highly favored and commands a price premium. Sensory descriptive analysis has primarily been performed to assess rice flavor characteristics, but these studies feature only a limited lexicon for characterizing specific flavors or the range of flavor types is limited. This study was undertaken to establish a descriptive lexicon with reference standards for describing the flavor properties of a broad spectrum of rice types and use the developed lexicon to characterize which sensory attributes are most important in rice flavor quality. A rice flavor lexicon consisting of 24 descriptive notes was developed and expanded by 8 trained sensory panelists to characterize the flavor of cooked rice differing in terms of forms, types, and specialty (n = 36). Of these 24 descriptive terms, 19 were aromatic notes and 5 were fundamental tastes and oral feeling factors. Eighteen aromatic terms were significantly present in most rice samples whereas some descriptors exhibited unique characteristics of a specific-rice type. Subsequent multivariate analysis indicated that 18 descriptive terms were required to fully understand the characteristics of rice flavor in greater details. This lexicon covered a wider range of rice samples than in the previous studies and will facilitate targeting the characteristic notes important to rice processors as well as producers.

Keywords: flavor, lexicon, multivariate, rice, sensory
Table 2 – Sensory descriptors, definitions, references, and their intensity for cooked rice flavor evaluation.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Definition</th>
<th>References®</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Popcorn</td>
<td>Aromatics reminiscent of popcorns</td>
<td>Orville Redenbacher’s Gourmet® poping corn</td>
<td>90</td>
</tr>
<tr>
<td>Starchy</td>
<td>Aromatics associated with the starch of a particular grain source</td>
<td>Bob’s Red milled rice flour : water (1:1)</td>
<td>50</td>
</tr>
<tr>
<td>Woody</td>
<td>Aromatics associated with dry cut fresh wood</td>
<td>Toothpicks</td>
<td>50</td>
</tr>
<tr>
<td>Smoky</td>
<td>Aromatics associated with any type of smoke flavor</td>
<td>Colgin liquid smoking flavor</td>
<td>90</td>
</tr>
<tr>
<td>Cooked-grain</td>
<td>Aromatics associated with cooked grains</td>
<td>Nabisco Cream of wheat</td>
<td>50</td>
</tr>
<tr>
<td>Grain</td>
<td>Aromatics associated with overall character impression of grain such as corns, wheat, and oats</td>
<td>Grain mixture (rice flour, corn meal, white flour, and ground oatmeal; 2:2:2:1)</td>
<td>40</td>
</tr>
<tr>
<td>Sulfury</td>
<td>Aromatics associated with sulfurous compound</td>
<td>Hard boiled egg</td>
<td>50</td>
</tr>
<tr>
<td>Corn</td>
<td>Aromatics reminiscent of canned yellow cream-style corn</td>
<td>Libby’s cream-style corn</td>
<td>80</td>
</tr>
<tr>
<td>Nutty</td>
<td>Aromatics associated with roasted nuts</td>
<td>Planters roasted peanut</td>
<td>90</td>
</tr>
<tr>
<td>Floral</td>
<td>Aromatics associated with flowers</td>
<td>Twinings® Jasmine tea</td>
<td>50</td>
</tr>
<tr>
<td>Dairy</td>
<td>Aromatics reminiscent of pasteurized cow’s milk</td>
<td>Great value 2% pasteurized milk</td>
<td>50</td>
</tr>
<tr>
<td>Hay-like</td>
<td>Aromatics associated with a dry, Dusty, slightly brown aroma</td>
<td>Kaytee natural Timothy hay</td>
<td>80</td>
</tr>
<tr>
<td>Barny</td>
<td>Aromatics reminiscent of barnyard and stocks (manure, urine, moldy, hay, feed, and so on)</td>
<td>Kroger white pepper</td>
<td>110</td>
</tr>
<tr>
<td>Buttery</td>
<td>Aromatics associated with natural fresh butter</td>
<td>Land O’ Lake butter</td>
<td>55</td>
</tr>
<tr>
<td>Green</td>
<td>Aromatics (slightly sweet) associated with cut grass or green vegetable</td>
<td>Sunny creek organic alfalfa sprouts</td>
<td>80</td>
</tr>
<tr>
<td>Rancid</td>
<td>Aromatics associated with oxidized fats and oils</td>
<td>Canola oil aged 14 d at 80 °C</td>
<td>60</td>
</tr>
<tr>
<td>Waxy</td>
<td>Aromatics associated with medium chain fatty acids</td>
<td>Candle wax</td>
<td>70</td>
</tr>
<tr>
<td>Earthy</td>
<td>Aromatics reminiscent of decaying vegetative matters and damp black soil</td>
<td>Sliced raw button mushrooms</td>
<td>50</td>
</tr>
<tr>
<td>Sweet-aroemtics</td>
<td>Aromatics associated with sweet tastes</td>
<td>Bordeaux cookies Pepperidge Farm</td>
<td>65</td>
</tr>
<tr>
<td>Sweet</td>
<td>Basic taste sensation elicited by sugar</td>
<td>2% and 5% sucrose solution</td>
<td>20, 50</td>
</tr>
<tr>
<td>Salty</td>
<td>Basic taste sensation elicited by salts</td>
<td>0.2% and 0.35% NaCl solution</td>
<td>25, 50</td>
</tr>
<tr>
<td>Bitter</td>
<td>Basic taste sensation elicited by caffeine</td>
<td>0.05% and 0.08% caffeine solution</td>
<td>20, 50</td>
</tr>
<tr>
<td>Astringent</td>
<td>Puckering or tingling sensation elicited by grape juice</td>
<td>Welch’s grape juice</td>
<td>65</td>
</tr>
<tr>
<td>Metallic</td>
<td>Chemical feeling factor stimulated on the tongue and teeth by metal</td>
<td>Spring Valley, 1 Iron tablet/L</td>
<td>85</td>
</tr>
</tbody>
</table>

*aAdapted from Civille and Lyon (1996), Goodwin and others (1996), and Meilgaard and others (2007). Reference intensities were iteratively calculated as the mean rating of the group of 8 panelists using a 150-mm unstructured line scale where 0 = none and 150 = very high.*
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual stickiness</td>
<td>The force required to separate the fingers after compressing the sample</td>
<td>Compress 5 grains between thumb and forefinger. Evaluate the force required to separate your fingers.</td>
</tr>
<tr>
<td>(mstick)</td>
<td>between the thumb and forefinger.</td>
<td></td>
</tr>
<tr>
<td>Manual hardness</td>
<td>The force required to compress the sample between the thumb and forefinger.</td>
<td>Evaluate the force required to compress 5 grains between thumb and forefingers.</td>
</tr>
<tr>
<td>(mhard)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial cohesion</td>
<td>The degree to which the unchewed sample holds or sticks together.</td>
<td>Place 1/2 teaspoon of sample in mouth. Feel mass with tongue and quickly evaluate how tightly the mass is sticking together. Do not chew or manipulate!</td>
</tr>
<tr>
<td>(icohes)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Sensory Texture Attributes

### First Bite

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (hard)</td>
<td>The force required to compress the sample.</td>
<td>Compress or bite through the sample with molars or incisors.</td>
</tr>
</tbody>
</table>

### Chewdown

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toothpull (tpull)</td>
<td>The force required to separate the jaws during mastication.</td>
<td>Chew sample 2 times and evaluate on 2nd pull.</td>
</tr>
</tbody>
</table>
Consumer Testing

- Hedonic testing is another method used in sensory science to assess the sensory quality of food.
- In the case of hedonic testing, liking for a product sensory characteristics is measured.
- Hedonic tests are performed with untrained panelists (i.e. consumers).
Consumer Testing

- 9-point verbal hedonic scales are used to assess Overall liking and liking of specific attributes such as appearance, flavor and texture.

<table>
<thead>
<tr>
<th>Dislike extremely</th>
<th>Dislike very much</th>
<th>Dislike moderately</th>
<th>Dislike slightly</th>
<th>Neither dislike nor like</th>
<th>Like slightly</th>
<th>Like moderately</th>
<th>Like very much</th>
<th>Like extremely</th>
</tr>
</thead>
</table>

- 5 point-just about right scales used to evaluate the appropriateness of the level of a sensory attribute (e.g., gloss, color, flavor, stickiness, moistness, hardness.

<table>
<thead>
<tr>
<th>Not nearly sticky enough</th>
<th>Much too soft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not sticky enough</td>
<td>Too soft</td>
</tr>
<tr>
<td>Just about right</td>
<td>Just about right</td>
</tr>
<tr>
<td>Too sticky</td>
<td>Too hard</td>
</tr>
<tr>
<td>Much too sticky</td>
<td>Much too hard</td>
</tr>
</tbody>
</table>
Rice chemistry and sensory properties
Justification

- A lot is known about starch and its influence on texture properties of rice
  - Amylose content dictates firmness of rice (waxy, short, medium, long)
- Research dealing with establishing the role of proteins and lipids toward rice functionality (e.g., texture) has been conducted mostly on rice flour and not whole grain.
Role of Surface Lipids

- Milling degree is an indication of the amount of bran removed from the surface of a kernel
- Kernel firmness decreases while stickiness increases with increased DOM

Effect of Milling Ratio on Sensory Properties of Cooked Rice and on Physicochemical Properties of Milled and Cooked Rice

Jung Kwang Park, Sang Sook Kim, and Kwang Ok Kim

ABSTRACT

Quantitative descriptive analysis of cooked rice was performed to investigate the effect of milling ratios (8.0–14.0%, based on brown rice) on sensory characteristics of cooked rice, in relation to physicochemical characteristics of milled rice and cooked rice. The proximate composition of uncooked rice decreased with increased milling while whiteness increased. The initial pasting temperature of rice flour decreased with increased milling while peak, breakdown, and setback viscosities increased. The instrumental texture profile of cooked rice revealed that hardness and chewiness decreased with increased milling while adhesiveness increased. A trained panel found that color, crunchiness of grains, fluffy corn flavor, raw rice flavor, wet cardboard flavor, hay-like flavor, and bitter taste were lower while glossiness, plumpness, and sweet taste were higher with increased milling. Degree of agglomeration, adhesiveness, cohesiveness of mass, inner moisture, and toothpicking of cooked rice increased while hardness and chewiness decreased with increased milling. Sensory analysis of cooked rice was more discriminating than instrumental texture profile analysis in terms of hardness, adhesiveness, and cohesiveness. There were high negative correlations between descriptive attributes of sweet taste, degree of agglomeration, adhesiveness, cohesiveness of mass, and moisture (r = -0.94 to -0.87), protein (r = -0.96 to -0.83), and fat contents (r = -0.91 to -0.83). Instrumental hardness showed high correlation with sensory hardness (r = 0.89).

Effects of Degree of Milling, Drying Condition, and Final Moisture Content on Sensory Texture of Cooked Rice


ABSTRACT

Different cultures have different preferences for cooked rice flavor and texture characteristics. These differences provide opportunities for U.S. rice varieties to fit into global markets to meet consumer demands worldwide. It is important to assess the properties of U.S. rice varieties and determine the factors that influence their eating quality. Cooked rice texture attributes can be affected by postharvest handling practices, such as degree of milling, drying condition, and final moisture. This article reports the effects of postharvest handling parameters on the texture of cooked medium- and short-grain rice varieties grown in Arkansas (AR) and California (CA), as measured by descriptive sensory analysis. The rice samples were Bengal (AR), Koshihikari (AR), Koshihikari (CA), M-401 (AR), M-401 (CA), and M-202 (CA). The six rice varieties were regular- or deep-milled and dried under one of five drying conditions to achieve final moisture levels of 12 or 15% (n = 120). A trained sensory panel developed a lexicon of 16 sensory attributes that described cooked rice texture at different phases of evaluation, beginning with partial adhesiveness and ending with mouthfeel characteristics after oxidation. Rice varieties differed in some physicochemical and sensory properties. Significant differences (P < 0.05) in adhesive properties, such as adhesiveness and visual adhesiveness and stickiness to lips, were observed. Rice samples also differed in mouthfeel properties. Factor analysis of sensory data grouped attributes into four groups that explained 68.5% of the variation in data. Primary sensory differences were due to adhesive properties assessed in the early stages of evaluation.
Milling Experiment

Rough Rice → Milling → Surface Lipids

Milling duration vs. SLC

Target SLC

0.2, 0.3, 0.4, 0.5, and 0.6%
Cooking and Texture Measurements

Temperature controller

2:1 water to rice

Compression Test

Cooking 20 min

Conditioning 5 min

Cooked Rice MC

Force vs. Time Graph:
- Force 1
- Area 2

Time (sec)

Force (N)
Single Compression

- Force 1 = Hardness
- Area 2 = Stickiness

- 10 kernels
- Crosshead speed: 5mm/s
- Compression gap: 0.3mm
- 5s hold
Cooked Rice MC

Francis (Stuttgart, AR)

- Reduction of SL increases moisture adsorption

MC %

Surface Lipid

DOM

High HMC
Low HMC
Cooked Rice Firmness

Francis (Stuttgart, AR)

- Reduction of SL increases moisture adsorption
- Decreases firmness
- Greater hydration

Surface Lipid

Hardness (N)

- 0.6
- 0.5
- 0.4
- 0.3
- 0.2

High HMC

Low HMC
Cooked Rice Stickiness

Wells (Stuttgart, AR)

- Reduction of SL increases moisture adsorption
- Increases stickiness
  - Greater swelling
  - More starch leaching
Take Home Message

- Milling tends to decrease lipids and proteins
- Is the decrease in firmness and increase in stickiness with increasing DOM be due to greater hydration?
Cooked Rice Firmness

Hexane Washing

- SL removal by hexane wash tends to decrease hardness.
- SL removal allows greater hydration.

Francis (MC 14.7%)

<table>
<thead>
<tr>
<th>Surface Lipid</th>
<th>No Washing</th>
<th>Hexane Washing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>0.4</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>0.2</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Hardness (N) range: 60 to 120
Cooked Rice Stickiness

Hexane Washing

Francis (MC 14.7%)

- SL removal tends to increase stickiness
- Greater hydration

Stickiness (N.s)

Surface Lipid

0.6 0.4 0.2

No Washing Hexane Washing
Significant Findings

- Lowering rice SLC resulted in lower hardness and higher stickiness across cultivars and locations
  - greater water absorption during cooking
- Cooked rice texture properties controlled to some extent through controlling rice SLC
- Critical to control SLC in cooking tests
Role of proteins
Summary of study conditions

- Study conducted in 2001 with a hybrid rice (XL6, RiceTec).
- Multiple lot for fertilization studies harvested throughout the state.
- Rice was stored for up to 36 weeks under various regimes.
- The goal of the study was to understand the role played by starch and protein in dictating texture properties.
- Apparent amylose, crude protein, HPSEC and SDS-page.
- Both instrumental texture and sensory analysis were performed.
Methods...Rice Chemistry

Apparent amylose content
Starch structure profile by HPSEC

Protein content
SDS-PAGE profile of rice protein
Prediction of rice functionality from starch and protein profiles

Table 1.11: Model statistics for the prediction of instrumental texture using amylose and protein contents.

1Rcal = Calibration correlation coefficient
2Rval = Validation correlation coefficient; full cross validation was employed
3Weighted regression coefficient obtained from partial least squares regression for amylose content.
4Weighted regression coefficient obtained from partial least squares regression for protein content.
5Refer to figure 1.1 for a sample deformation curve and an illustration of parameters.

<table>
<thead>
<tr>
<th>Instrumental Texture</th>
<th>Rcal1</th>
<th>Rval2</th>
<th>Amylose3</th>
<th>Protein4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>0.22</td>
<td>-0.41</td>
<td>0.02</td>
<td>-0.23</td>
</tr>
<tr>
<td>Stickiness</td>
<td>0.22</td>
<td>-0.48</td>
<td>-0.16</td>
<td>-0.14</td>
</tr>
</tbody>
</table>

Table 1.10: Prediction of functional properties from SDS-PAGE and HPSEC data

1Optimal number of principal components used in the model (n=7)
2Rcal = Calibration correlation coefficient
3Rval = Validation correlation coefficient; full cross validation was utilized
4Viscosity profile of rice flour using RVA, refer to table for terms
5Refer to figure 1.2 for a sample pasting curve and an illustration of pasting parameters.
6Refer to figure 1.1 for a sample deformation curve and illustration of parameters.

<table>
<thead>
<tr>
<th>Instrumental texture</th>
<th>#PCs1</th>
<th>Rcal2</th>
<th>Rval3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>3</td>
<td>0.84</td>
<td>0.68</td>
</tr>
<tr>
<td>Stickiness</td>
<td>1</td>
<td>0.64</td>
<td>0.47</td>
</tr>
</tbody>
</table>
Crude Protein and Amylose contents are very poor predictors of rice texture. Need to better characterize the nature of the proteins and starch.
Prediction of Hardness from Protein SDS-page and Starch HPSEC

Proteins play a very important role in determining the texture of cooked rice. Protein quantity in rice is dictated by environmental conditions and cultivation practices such as nitrogen fertilization.
Processing Conditions and Rice Sensory Quality
Sensory Quality of Cooked Long-Grain Rice as Affected by Rough Rice Moisture Content, Storage Temperature, and Storage Duration

Jean-Francois Meullenet,1,2 Bradley P. Marks,3 Jean-Ann Hankins,1 Virginia K. Griffin,1 and Melissa J. Daniels3

ABSTRACT

The effects of postharvest conditions (i.e., rough rice moisture content, storage temperature, and storage duration) on sensory quality of one long-grain rice cultivar grown in Arkansas (Cypress) were evaluated using a professional descriptive sensory panel. Eight textural (adhesion to lips, hardness, cohesiveness of mass, roughness of mass, toothpulp, particle size, toothpack, and loose particles) and six flavor attributes (overall rice impression, sulfur, starch, grainy, metallic, and cardboard) were identified as most important in describing the sensory characteristics of cooked Cypress rice. Postharvest conditions had significant effects on rice sensory quality, and regression models illustrated the effects of each postharvest variable and their interactions.

Fig. 1. Vocabulary for sensory flavor attributes of cooked rice. Intensities based on a modified Spectrum universal aromatic scale (Mendiguard et al. 1991). Sodllo note in soda cracker is 3.0, cooked apple in appearance is 7.0, and cooked grape note in grape juice is 14.0.

Fig. 2. Vocabulary for sensory texture attributes of cooked rice.
Fig. 3. Contour plots for the effects of rough rice moisture content, storage temperature, and storage duration on cooked rice flavor profiles. Aroma profiles: sulfury, starchy, and grainy (a–c, respectively); aromatic profiles: cardboard, metallic, and grainy (d–f, respectively); aftertaste profiles: starchy (g and h) and metallic (i).

Sulfury aroma decreases with increased storage temp. and increases with storage time.

Starchy notes decrease with time and increased temperatures.
Fig. 4. Contour plots for the effects of rough rice moisture content, storage temperature, and storage duration on cooked rice texture profiles: adhesiveness to lips (a), hardness (b), cohesiveness of mass after three chews (c), cohesiveness of mass after eight chews (d), roughness of mass (e), toothpull (f and g), particle size (h), toothpack (i), loose particles (j).

Stickiness increases during the first 20 weeks of storage.

Higher storage MC results in softer rice; firmness tends to increase with storage duration.
Effects of Rough Rice Drying and Storage Conditions on Sensory Profiles of Cooked Rice

Jean-Francois C. Meullenet,1,2 Bradley P. Marks,3 Kaye Griffin,1 and Melissa J. Daniels3

ABSTRACT

In both domestic and international markets, the end-use quality of rice affects its market value and acceptability to consumers. The effect of various postharvest processing treatments on sensory characteristics of cooked rice was investigated using sensory descriptive methods. Cooked rice quality was affected (P < 0.05) by rough rice wet holding, drying temperature, storage temperature, and storage duration. Cohesiveness of mass and hardness of sample were significantly affected by the temperature of drying. A higher storage temperature reduced the cohesiveness of mass and glueness, while sample hardness, chuminess, and geometry of shurry increased. Storage duration had more profound effects on the sensory attributes studied. Perceived starchy note, chuminess, glueness, and overall sensory impression decreased after four weeks of storage. Storage duration also influenced hardness, moisture absorption, sulfury notes, and cardboardy notes.
Fig. 1. Effect of drying temperature on sensory profile of cooked rice. Letters associated with different attributes represent results of Duncan’s multiple comparison tests. The first and second letters are associated with high and low drying temperatures, respectively. Different letters indicate significant differences (a = 0.05) between treatments. High temperature drying (- - - -) and low temperature drying (———).

High drying temperature (50-55C) results in higher rice kernel firmness than for drying at 40C.
Fig. 2. Effect of storage temperature on sensory profiles of cooked rice.
Letters associated with different attributes represent results of Duncan’s multiple comparison tests. The first, second, and third letters are associated with results from storage temperatures of 4, 21, and 38°C, respectively. Different letters indicate significant differences (α = 0.05) between treatments. Storage temperature at 4°C (-----), 21°C (-- -- --), and 38°C (-----).

Higher storage temperature results in harder cooked rice, lower stickiness and cohesiveness of mass.
Fig. 3. Effect of storage duration on sensory profiles of cooked rice. Letters associated with different attributes represent results of Duncan’s multiple comparison tests. The first, second, and third letters are associated with results from weeks 0, 4, and 20, respectively. Different letters indicate significant differences ($a = 0.05$) between treatments. Storage for 0 (-- -- --), 4 (– – –), and 20 (———) weeks.

During rough rice storage, clumpiness, cohesiveness of mass (stickiness) decreases and hardness increases.
Effects of Postharvest Processing on Texture Profile Analysis of Cooked Rice


ABSTRACT

The effects of drying conditions, final moisture content, and degree of milling on the texture of cooked rice varieties, as measured by texture profile analysis, were investigated. Instrumentally measured textural properties were not significantly affected by drying conditions, with the exception of cohesiveness. Cohesiveness was lower in rice dried at lower temperatures (18°C or ambient) than in that dried at the higher commercial temperatures. Final moisture content and degree of milling significantly affected textural property values for adhesiveness, cohesiveness, hardness, and springiness; their effects were interdependent. The effects of deep milling were more pronounced in the rice dried to 15% moisture than that dried to 12%. In general, textural property values for hardness were higher and those for cohesiveness, adhesiveness, and springiness were lower in regular-milled rice dried to 15% moisture than in that dried to 12%. In contrast, hardness values were lower and cohesiveness, adhesiveness, and springiness values were higher in deep-milled rice dried to 15% moisture than in that dried to 12% moisture. Deep milling resulted in rice with lower hardness values and higher cohesiveness, adhesiveness, and springiness values.

Sensory and Instrumental Relationships of Texture of Cooked Rice from Selected Cultivars and Postharvest Handling Practices

Brenda G. Lyon, Elaine T. Champagne, Bryan T. Vinyard, and William R. Windham

ABSTRACT

Measurement of cooked rice texture attributes by sensory and instrumental methods is important because of the increased popularity of rice and rice products by globally diverse cultures. Many factors influence cooked rice texture, including cultivar, physicochemical properties, post-harvest handling practices (milling degree, drying conditions, and final moisture), and cooking method. Information on the relationships between sensory, physical, and chemical characteristics will lead to better methods to quickly evaluate and predict end-use qualities, which will help to match rice with specific characteristics to populations that demand those attributes. This article reports the relationships between two modes of measuring texture attributes of rice: sensory and instrumental texture analyzers. Six medium- and short-grain rice samples differing by cultivar or growing location were dried to achieve final moisture levels of 12 or 15% and then regular- or deep-milled (n = 120). Correlations between individual sensory descriptive attributes and instrumental texture profile parameters were weak. Of only 12 significant correlations, the highest value was r = 0.624. Combined sensory and instrumental data were factor-analyzed. This analysis revealed that sensory attributes still accounted for the most variation (35.32% out of 76.55%). Sensory descriptive analysis was more sensitive to subtle changes in initial texture perception including parameters relating to stickiness and adhesiveness. The two-cycle compression test for texture profile parameters (i.e., hardness, cohesiveness, adhesiveness, gumminess, springiness, and chewiness) accounted for less variation in the data on texture differences.
Effects of Degree of Milling, Drying Condition, and Final Moisture Content on Sensory Texture of Cooked Rice


ABSTRACT

Different cultures have different preferences for cooked rice flavor and texture characteristics. These differences provide opportunities for U.S. rice varieties to fit into global markets to meet consumer demands worldwide. It is important to assess the properties of U.S. rice varieties and determine the factors that influence their eating quality. Cooked rice texture attributes can be affected by postharvest handling practices, such as degree of milling, drying condition, and final moisture. This article reports the effects of postharvest handling parameters on the texture of cooked medium- and short-grain rice varieties grown in Arkansas (AR) and California (CA), as measured by descriptive sensory analysis. The rice samples were Bengal (AR), Koshihikari (AR), Koshihikari (CA), M-401 (AR), M-401 (CA), and M-202 (CA). The six rice varieties were regular- or deep-milled and dried under one of five drying conditions to achieve final moisture levels of 12 or 15% (n = 120). A trained sensory panel developed a lexicon of 16 sensory attributes that described cooked rice texture at different phases of evaluation, beginning with manual adhesiveness and ending with mouthfeel characteristics after swallowing. Rice varieties differed in some physicochemical and sensory properties. Significant differences (P < 0.05) in adhesive properties, such as manual and visual adhesiveness and stickiness to lips, were observed. Rice samples also differed in mouthfeel properties. Factor analysis of sensory data grouped attributes into four groups that explained 68.5% of the variation in data. Primary sensory differences were due to adhesive properties assessed in the early stages of evaluation.
Effects of Nitrogen Fertilization on Long-grain Rice Functionality
Introduction

- Nitrogen fertilization has been shown to affect endosperm chalkiness, head rice yield and grain protein.
- Fertilization particularly at heading has been shown to increase head rice yield due to higher protein concentration.
- It is therefore useful to examine how nitrogen fertilization relates to functional characteristics such as rice texture.
Objectives

• Examine the effects of nitrogen fertilization at pre-flooding and late season on rice functionality.
Materials

Rice samples

- 2 cultivars (XP701 and XL8) under 4 treatments giving a total of 8 samples.
  - XP701 90-0-30  XP701 90-0-60
  - XP701 120-0-30  XP701 120-0-60
  - XL8 90-0-30  XL8 90-0-60
  - XL8 120-0-30  XL8 120-0-60
Sample Name

- XP701 90-0-30
  - Pre-flood application (lbs/acre Nitrogen)
  - Late-season application (lbs/acre Nitrogen)
  - Mid-season application (lbs/acre nitrogen)
Materials

Milled rice and rice flour

- Rice was de-hulled then milled using a Mc Gill no. 2 and head rice retrieved.
- Rice flour was prepared from head rice using the Cyclone mill.
Methods

Amylose content

Pasting properties - Rapid Visco-Analyzer.

Protein content - micro-kjeldahl.

Texture Profile Analysis – Texture Analyzer

Sensory Analysis – Descriptive Panel
In both cultivars amylose content was affected by a combination of late-season and pre-flood nitrogen application. However, trends were not consistent across cultivars.

Protein content was also affected by a combination of both Nitrogen applications.
• In XL8, hardness decreased with increase in the late-season amount of nitrogen applied.
• In XP701, hardness was significantly affected by the interaction between pre-flood and late-season application.
Stickiness for both cultivars was affected by pre-flood and late-season application.

In XL8 90-0-30 had the highest stickiness value.
Conclusions

- Both pre-flood and late-season nitrogen application influence crude protein content and amylose content.
- Hardness and stickiness were affected by the amount of nitrogen applied.
Optimal Rice to Water Ratio
Introduction

- Rice texture is an important driver of liking for consumers
- In the case of rice, texture is probably more important than flavor
- In the United States, texture is thought to be liked firm and non-sticky
Introduction

- Rice texture is dictated by starch composition
  - Higher amylose = firmer and less sticky rice
- Texture can be manipulated through processing
  - Higher SLC rice tends to be firmer
- Or by adjusting the amount of water available during cooking
  - Decrease the water-rice ratio = increase in firmness
Objectives

- Determine the optimal water to rice ratio for rice consumers in the US
- Evaluate the existence of consumer segments?
Methods

- Wells and Medark
- Rice was milled with a continuous mill (Satake, Engineering, Co, LTD, Tokyo, Japan)
  - Mill setting was adjusted to achieve SLC of milled head kernels of 0.40%
Rice Cooking

- Rice was cooked to either 1.4, 1.6, 1.8, 2.0 or 2.2 water to rice ratio in an automatic household rice cooker (National, model SR-W10FN, Thailand)
- Rice was cooked until automatically switching off to warm position
- Cooked rice samples were kept at warm position for two minutes and were mixed using a plastic fork before serving
Results
Results Summary

OL-Medium Grain

Like extremely
Like very much
Like moderately
Like slightly
Neither dislike nor like
Dislike slightly
Dislike moderately
Dislike very much
Dislike extremely
Results Summary

OL-Long Grain

Like extremely
Like very much
Like moderately
Like slightly
Neither dislike nor like
Dislike slightly
Dislike moderately
Dislike very much
Dislike extremely
Glossiness

Medium Grain

Long Grain

- Much too Glossy
- Too Glossy
- Just about right
- Too Dull
- Much too Dull
Color

Medium Grain

Long Grain

- Much too dark
- Too dark
- Just about right
- Too light
- Much too light
Hardness

Medium Grain

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Long Grain

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Stickiness

Medium Grain

- Much too sticky
- Too sticky
- Just about right
- Not sticky enough
- Not at all sticky enough

Long Grain

- Much too sticky
- Too sticky
- Just about right
- Not sticky enough
- Not at all sticky enough
Preference Mapping

- Multivariate method to represent consumer liking
- MDPREF helps determine if there is consumer segmentation
- Is a single cooking ratio recommendation sufficient for the market?
20% who prefer lower water to rice ratio. These were consumers of long grain, brown rice and not parboiled or instant.
70% like a ratio of 1.8 to 2.0
10% prefer 2.2
Conclusions

- 1 to 1.8-2.0 most appropriate level for a majority of US consumers for both medium and long grain
- Small number of consumers (also consumers of brown rice) show preference for lower levels (1:1.6)
- Medium grain rice was found to be too sticky regardless of water to rice ratio
- Current recommendations are appropriate except maybe for 20% who like very firm rice