A Comparison of Methods Used to Quantify Chalkiness of Head Rice

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ABSTRACT

Chalkiness of rice impacts functionality, visual perception, and marketability. A study was initiated to compare chalkiness scores resulting from the current, manual Federal Grain Inspection Service (FGIS) method and newer, semi-automated, digital-imaging systems. Chalkiness of head rice was determined for one medium- and two long-grain cultivar lots using the FGIS method and two digital-imaging methods. For the least-chalky lot, the digital-imaging methods predicted similar chalkiness values to those of the FGIS method. As surface chalkiness increased, the digital-imaging methods indicated increasingly greater chalkiness than did the FGIS method. However, alternative reporting formats show promise in reconciling chalkiness scores of digital-imaging methods with those of the manual FGIS method.

INTRODUCTION

Chalky (opaque) rice kernels are characterized by loosely packed starch in the endosperm. Chalkiness can be caused by environmental stresses such as elevated nighttime air temperatures occurring during kernel development (Ambardekar et al., 2011; Lanning et al., 2011). Chalkiness of rice impacts marketability (McClung, 2013), milling quality (Lanning et al., 2011), and end-use functionality (Lisle et al., 2000). The United States standard for determination of chalk in rice defines chalky kernels as “whole or broken kernels of rice which are one-half or more chalky” (USDA-GIPSA-FGIS, 2014). This U.S. standard is relatively conservative when compared to visual appraisal of chalkiness on a kernel-area basis, and may not relate well to processing operations such as puffing.
Digital-imaging technologies have been developed to quantify chalk on a kernel-area basis. For several years, one such system (WinSEEDLE Pro 2005a, Regent Instruments Inc., Sainte-Foy, Quebec, Canada) has been used by various laboratories, and is reasoned to quantify chalkiness as perceived by a consumer’s visual inspection. In addition to the Winseedle, another digital-imaging system (SeedCount SC5000TR, Next Instruments Pty Ltd., Condell Park, NSW, Australia) has recently been introduced. Working in a similar manner to the WinSEEDLE, the SeedCount quantifies chalky area of rice kernels, but differentiates between chalky and non-chalky area according to pre-established standards for U.S. and international markets. A study was conducted to compare chalkiness determination by the manual U.S. standard method with the semi-automated WinSEEDLE and SeedCount digital-imaging methods.

PROCEDURES

Harvested in 2012, one medium-grain (MG) cultivar lot, and two long-grain (LG) cultivar lots, were evaluated. The MG lot was harvested near Stuttgart, Ark., while the two LG lots (LG1 and LG2) were harvested near Keiser, Ark. All lots were cleaned with a dockage tester (XT4, Carter-Day, Minneapolis, Minn.), and conditioned (26 °C and 56% relative humidity) in a climate-controlled chamber (5580A, Parameter Generation & Control, Black Mountain, N.C.) to 12.0 ± 0.5% (wet basis) moisture content. Moisture content was determined using a moisture meter (AM5200, Perten Instruments, Hägersten, Sweden). After conditioning, lots were stored at 40 ± 2 °F, then equilibrated to room temperature for 24 h prior to use.

For each lot, four, 150-g samples of rough rice were dehulled using a laboratory sheller (THU 35B, Satake Corp., Hiroshima, Japan) with a clearance of 0.019 inch between the rollers. Each sample was milled (McGill No. 2, RAPSCO, Brookshire, Texas; equipped with a 3.3-lb weight on the lever arm, situated 6 inches from the milling chamber centerline) for a 30 s duration. Two of the milled samples (1 and 2) were submitted to the Federal Grain Inspection Service (USDA-GIPSA-FGIS), Stuttgart Field Office, Stuttgart, Ark., for determination of chalk according to the U.S standard (FGIS) method. For the FGIS method, chalk was determined for one 25 g subsample of each sample, of which each rice kernel was manually evaluated (Fig. 1). Individual kernels were scored as chalky if greater than 50% (by volume) of the kernel was chalky (USDA-GIPSA- FGIS, 2014). Chalkiness was calculated as the mass percentage of chalky kernels relative to the original subsample mass.

For the remaining two milled samples (3 and 4) of each lot, head rice (kernels at least 0.75 of their original length) was separated from broken kernels using a sizing device (61, Grain Machinery Manufacturing Corp., Miami, Fla.). In contrast with the FGIS method, chalkiness of head rice from each of these two samples was determined using semi-automated, digital-imaging systems (Fig. 1). The WinSEEDLE method consisted of randomly selecting duplicate 100-kernel subsamples of head rice kernels (200 kernels in total; approximately 4 g) from each of the two samples. Each of the 100-kernel subsamples was digitally scanned with the WinSEEDLE system in order
to determine chalkiness, which was expressed on an area-percentage basis, the ratio of
the chalky area to the entire, scanned area of the 100 kernels. Prior to chalk measure-
ments, the WinSEEDLE system was configured to color-classify chalk by selecting
and scanning a completely chalky kernel of head rice into the imaging system as a
reference color for chalk.

The SeedCount method consisted of randomly selecting duplicate 500-kernel
subsamples of head rice (1,000 kernels in total; approximately 20 g) from each of the
two samples. Similar to the WinSEEDLE, the SeedCount employed a flat-bed scanner
to create a digital image of rice kernels, from which the SeedCount system also
quantified chalkiness as an area percentage. The SeedCount system was factory pre-
calibrated to detect chalkiness. Prior to this study, sensitivity of the SeedCount method
was adjusted, such that chalkiness results correlated well \( r = 0.985 \) with those of the
WinSEEDLE method.

Kernel-by-kernel data from the two digital-imaging systems also allowed for
alternative scoring of chalkiness, as compared to the typical, area-percentage scores
for each subsample. Thus, chalkiness from the WinSEEDLE and SeedCount methods
was also reported as a number percentage of kernels exceeding either 25% or 50%
chalky area per kernel.

**RESULTS AND DISCUSSION**

The FGIS method resulted in chalkiness of 1.4% for the MG lot (Fig. 2). In
contrast, the WinSEEDLE and SeedCount methods resulted in area-percentage chalki-
ness scores of 3.8% and 3.7%, respectively. Alternately, number-percentage scoring
for kernels with chalkiness greater than 25% of kernel area resulted in 5.1% and 5.2%
for the WinSEEDLE and SeedCount methods, respectively. For kernels with chalki-
ness exceeding 50% of kernel area, number percentages were 1.6% and 2.2% for the
WinSEEDLE and SeedCount methods, respectively, thus, closely approximating mass-
percentage results of the FGIS method.

Chalkiness of the LG1 lot was determined to be 0.4%, 0.8%, and 1.1% by the
FGIS, WinSEEDLE, and SeedCount methods, respectively (Fig. 3a); differences be-
tween methods were considerably less for this least-chalky lot than observed for the
MG lot (Figs. 2 and 3a). For both digital-imaging methods, the number percentage of
LG1 kernels with chalkiness exceeding 50% of kernel area closely approximated the
chalkiness score of the FGIS method.

The FGIS method resulted in chalkiness of 1.4% for the LG2 lot (Fig. 3b); however, the WinSEEDLE and SeedCount methods indicated chalkiness of 11.7% and 7.9%, respectively, reflecting greater surface chalkiness. The number percentages of LG2 kernels with chalkiness exceeding 25% of kernel area were 17.3% and 13.6% for the WinSEEDLE and SeedCount methods, respectively. For this LG2 lot with the greatest chalkiness, number percentages of kernels with chalkiness exceeding 50% of kernel area more closely approximated those of the FGIS method, with 4.4% and 6.8% for the WinSEEDLE and SeedCount methods, respectively.
SIGNIFICANCE OF FINDINGS

These data illustrate the challenge in relating digitally-imaged chalkiness measurement to that of the current U.S. standard methodology. Chalkiness determined by the manual FGIS method remained relatively consistent across these three cultivar lots. The WinSEEDLE and SeedCount methods provided a rapid determination of rice chalkiness, with minimal training requirements. Using area-percentage based scoring of chalkiness, these digital-imaging methods reflected increasing surface chalkiness—a potential benefit when predicting visual impact of surface chalkiness, and when chalkiness of any sort impacts end-use processing. However, the digitally-imaged, area-based scoring of chalkiness did not always compare well with the standard FGIS method. Alternative, number-percentage based scoring available with the WinSEEDLE and SeedCount methods shows promise in reconciling digitally-imaged determination of chalkiness with that of the FGIS methodology.

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LITERATURE CITED

Rice harvested in 2012: one medium-grain and two long-grain cultivar lots

Samples 1 & 2

FGIS, Stuttgart Field Office

Samples 3 & 4

U of A Rice Processing Program, Rice Quality Laboratory

FGIS Method (Manual)
- Evaluated by trained technician
- Single 25-g sub sample of milled rice for each sample
- Chalkiness data presented as
  - an average of samples 1 & 2
  - mass percentage of kernels with >50% chalkiness by volume

WinSEEDLE Method (Digital Imaging)
- Technician 'trains' the software to identify chalk
- Duplicate 100-kernel (~2 g) sub-samples of head rice per sample, averaged
- Chalkiness data presented as
  - an average of samples 3 & 4
  - area percentage (standard)
  - number percentage of kernels with either >25% or >50% chalky area (alternative)

SeedCount Method (Digital Imaging)
- Pre-calibrated, sensitivity adjusted to match WinSEEDLE Method
- Duplicate 500-kernel (~10 g) sub-samples of head rice per sample, averaged
- Chalkiness data presented as
  - an average of samples 3 & 4
  - area percentage (standard)
  - number percentage of kernels with either >25% or >50% chalky area (alternative)

Fig. 1. Sample disposition and details of the manual U.S. standard Federal Grain Inspection Service (FGIS), WinSEEDLE, and SeedCount methods of chalk determination.
Fig. 2. Chalkiness of the medium-grain (MG) cultivar lot, as determined by the manual U.S. standard Federal Grain Inspection Service (FGIS), WinSEEDLE, and SeedCount methods. Data are reported as a mass-, area-, or number-percentage, dependent on the capabilities of each method. Number percentages represent the proportion of kernels exceeding either 25% or 50% chalky area per kernel.
Fig. 3. Chalkiness of the two long-grain (LG) cultivar lots, (a) LG1 and (b) LG2, as determined by the manual U.S. standard Federal Grain Inspection Service (FGIS), WinSEEDLE, and SeedCount methods. Data are reported as a mass-, area-, or number-percentage, dependent on the capabilities of each method. Number percentages represent the proportion of kernels exceeding either 25% or 50% chalky area per kernel.