A Colorimetric Method for Estimating Spaghetti Cooking Losses[1]

R. R. MATSUO, L. J. MALCOLMSON, N. M. EDWARDS, and J. E. DEXTER

Cereal Chem. 69(1):27-29

ABSTRACT

The amount of residue in the cooking water is widely used as an indicator of cooked spaghetti quality. Traditional methods are time-consuming and in some instances give results that are difficult to reproduce. A quicker and more precise method was developed by reacting a clarified aliquot of cooking water with iodine and measuring the absorbance at 650 nm, the absorption maximum for the amylose-iodine complex. Strong linear relationships ($r^2 > 0.80$) were found between iodine absorption and cooking loss for both durum wheat and hard red spring wheat, indicating that cooking loss can be estimated reliably from iodine absorption values.

Early studies on pasta cooking quality stressed the importance of resistance to disintegration during cooking (Borasio 1935), and this remains an established quality parameter. Resistance to disintegration was estimated by determining the amount of residue in the cooking water. Binnington et al (1939) described a "breaking-strength tester" as well as a cooking test procedure for estimating, among other characteristics, cooking water residue. These two studies were the basis for the official AACC pasta cooking test for many years (AACC 1957). The latest edition of the Approved Methods of the AACC (1983) still refers to the Borasio system for testing the cooking characteristics of pasta. The method of Binnington et al (1939) for determining cooking loss by evaporating the cooking water to dryness and then drying at 130°C for 1 hr is still widely used. The standard procedure for determining cooking loss at the Grain Research Laboratory is to determine the residue in the cooking water by freeze-drying (Dexter and Matsuo 1979).

In more recent years, many studies have been made on pasta textural characteristics (e.g., Matsuo and Irvine 1969, 1971; Walsh 1971; D'Egidio et al 1976; Damidaux and Feillet 1978; Dexter et al 1983; Seibel et al 1985). A number of studies have reported on the effects of pH and hardness of the cooking water on surface stickiness, on the amount of material rinsed off the surface of cooked spaghetti (the total organic matter, or TOM, test of D'Egidio et al 1982), and on cooking loss. Water hardness was found to increase both surface stickiness and cooking loss, while a weakly acidic water (approximately pH 6.0) minimized stickiness and surface disintegration (Alary et al 1979, Abecassis et al 1980). On the other hand, Menger (1980) reported that surface characteristics were affected more by the mineral composition than by the pH of the cooking water. Dexter et al (1983) found that both stickiness and cooking loss increased with increasing water hardness.

Traditional methods for determining cooking loss by drying the cooking water are time-consuming. We previously reported preliminary results that showed that a colorimetric method measuring the absorption of the iodine-amylose complex in cooking water held promise as a simple rapid estimator of cooking loss (Matsuo and Dexter 1986). This article reports on refinements to that method.

MATERIALS AND METHODS

Composite samples of Canada Western Amber Durum wheat representing milling grades exported during the first half of the 1988-89 crop year, composite grade samples of the newly harvested 1988 crop, and samples of No. 1 Canada Western Red Spring wheat composited from exports over the same 1988-89 crop year were selected for the study.

These samples were milled on a Buhler experimental mill in duplicate in conjunction with a laboratory purifier to produce durum semolina of about 65% extraction (Dexter et al 1985) and red spring farina of about 50% extraction. Spaghetti samples were processed from all the millings on a Demaco S-25 laboratory-scale press at 26% absorption (14% moisture basis). Each extruded sample was split in two, with one half dried at 70°C and the other half at 39°C. Drying cycles used have been described by Dexter et al (1981). The total number of spaghetti samples processed was 40 from amber durum wheat and four from red spring

[1]Paper No. 664 of the Canadian Grain Commission, Grain Research Laboratory, Winnipeg, Manitoba, R3C 3G8.

wheat. Other samples tested included seven commercial spaghetti processed from durum semolina and two from red spring wheat.

Cooking Water

A standardized cooking water prepared for this study contained the following minerals (ppm): Ca = 32.5, Mg = 3.5, Na = 72.6, K = 13.4, and SO_4 = 16.5. Its pH was 7.5, and its hardness was 96.1 ppm $CaCO_3$.

Cooking Test

One important factor for standardizing the cooking test was to select beakers with flat bottoms to maximize the area of contact with a ceramic-top hot plate to ensure a uniform boiling rate. Otherwise, the vigor with which water boils and thus the amount of material leached into the cooking water varies. With nonuniform beakers, the volume of cooking water after a normal cooking time of 12 min varied from 70 to 95 ml (starting volume 125 ml).

Five grams of spaghetti was added to 125 ml of rapidly boiling prepared water. The cooking time was taken as the time required for the white core in the strands to disappear. For laboratory-processed samples, the cooking time was 12 min; for commercially processed samples, depending on the diameter, the cooking time ranged from 10 to 15 min. The water level in the cooking beaker was maintained a little below 100 ml by adding boiling distilled water as required. Upon completion of cooking, the cooking water was poured into a 100-ml volumetric flask through a nylon sieve (1.1-mm aperture) that held back the strands and large particulate matter. The cooking water was allowed to cool to room temperature (about 1 hr), then made up to volume with distilled water.

The contents of the volumetric flask were thoroughly mixed, and 10 ml was filtered through a GF/A filter paper, using suction. To 1 ml of the filtered cooking water in a 25-ml volumetric flask, 20 ml of distilled water and 1 ml of iodine solution (2.0 g of KI plus 0.2 g of I_2 made up to 100 ml) was added; this was made up to volume and allowed to stand for 10 min. Absorbance at 650 nm was measured with a Beckman DU7 spectrophotometer (Beckman Instruments, Inc., Irvine, CA), using 1 ml of iodine solution diluted to 25 ml as a blank.

Actual cooking loss was determined on the remainder (90 ml) of the cooking water in the volumetric flask. The solution was poured into a plastic freezing tray, combined with water used for rinsing the volumetric flask, and freeze-dried. The freeze-dried material was weighed and corrected for moisture, for the amount of salt residue present in the prepared water, and for the volume loss (10 ml) used for the iodine test. The cooking loss was expressed as a percentage of the weight of the spaghetti before cooking.

All samples were also overcooked to give a wider range in cooking loss. Cooking tests were replicated, and mean values were used for statistical analysis.

RESULTS AND DISCUSSION

It is well established that the starch component producing a dark blue color with iodine is amylose and that it has an absorption maximum at 650 nm. A wavelength scan of the cooking water-iodine complex produced a maximum at 650 nm. It was therefore assumed that amylose was a principal component in the cooking water residue. D'Egidio et al (1983) have reported that the principal starch component in the cooking water is amylose.

To ascertain that the relationship between the absorption of the amylose-iodine complex and the amylose concentration was linear, a solution of soluble potato starch with a 25% amylose content was prepared (0.160 mg/ml) and diluted to eight concentrations; the absorption of the iodine complex was measured at 650 nm. A linear relationship ($r^2 = 0.999$) was found between absorption of the amylose-iodine complex and amylose concentration, up to a concentration of 0.080 mg/ml. At higher amylose concentrations, where absorbance readings were greater than 1.6, the relationship became curvilinear.

The stability of the amylose-iodine complex was determined by varying the time interval between iodine addition and absorption reading from 10 min to 2 hr on a selected number of spaghetti samples. The color complex was found to be stable up to 2 hr, so that strict timing of iodine addition and absorption measurement was not necessary (results not shown). It was also noted that the iodine solution is stable up to two weeks when stored in the dark; thus, the iodine solution need not be freshly prepared every day. The filtered cooking water is stable during the working day (at least 6 hr) but should be tested the same day, as the amylose precipitates out if left overnight.

Results of the iodine absorbance test and the freeze-drying cooking-loss test, determined for seven commercial spaghetti samples, are shown in Table I.

Analysis of variance (SAS Institute, 1988) revealed that both tests could discriminate between samples ($P < 0.01$), but the F values for differences between samples were greater for the iodine test (Table I). The coefficient of variation calculated from the analysis of variance was lower for the iodine absorbance test than for the freeze-drying test. Therefore, the iodine test is more sensitive in distinguishing differences among samples.

The greater variability of the freeze-drying results may be attributed to small particles of spaghetti (<1.1 mm) that break off during cooking and pass through the nylon sieve used to filter the cooking water, thereby becoming included in the freeze-dried residue. The absorbance method is subject to some variability as well because it is difficult to ensure consistent vigor of the boiling action due to the nonuniformity of the beakers (i.e., flatness of the bottom surface).

Figure 1 shows the plot of cooking loss vs amylose-iodine absorption at 650 nm. The 135 points comprise the following:

TABLE I
Iodine Absorbance and Cooking Loss for Seven Commercial Spaghetti Samples Cooked to Optimum Time and Overcooked for 10 Minutes[a]

	Optimum		Overcooked	
Sample	Absorbance at 650 nm	Cooking Loss (%)	Absorbance at 650 nm	Cooking Loss (%)
A	0.931 a	6.85 a	1.659 a	10.22 a
B	0.836 b	6.18 ab	1.348 bc	8.41 b
C	0.806 bc	5.97 ab	1.226 cd	7.84 b
D	0.782 b–d	5.65 bc	1.400 b	7.97 b
E	0.757 c–e	5.38 bc	1.425 b	8.66 b
F	0.719 de	4.81 c	1.334 bc	7.71 b
G	0.697 e	5.22 bc	1.130 d	7.53 b
ANOVA[b]	19.96	6.85	22.04	7.67
CV	5.39	10.91	6.39	9.75

[a] Means of six determinations. Means followed by different letters are significantly different (LSD, $\alpha = 0.01$).
[b] Analysis of variance F values for effect of sample.

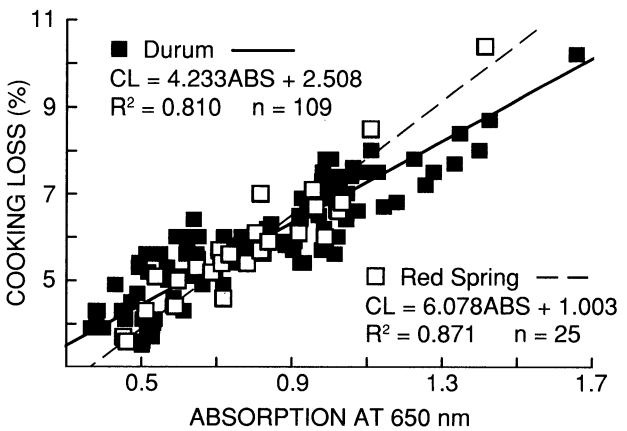

Fig. 1. Relationship between cooking loss (CL) and amylase-iodine absorption (ABS) at 650 nm.

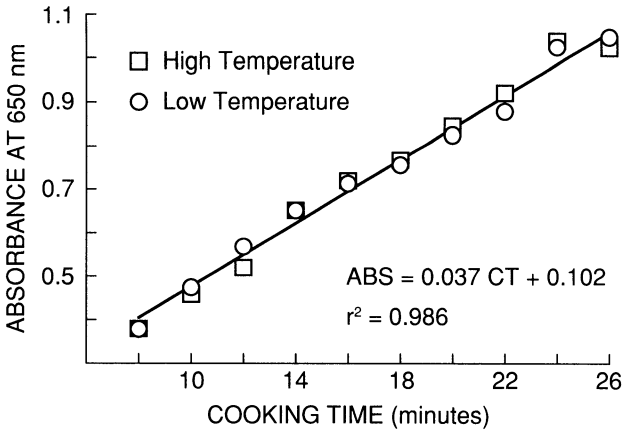

Fig. 2. Effect of drying temperature on iodine absorption (ABS) at various cooking times (CT).

38 durum samples cooked at two cooking times (76), one durum sample dried at two temperatures and cooked at 10 cooking times (20), seven commercial durum spaghetti cooked at two cooking times (14); one red spring wheat spaghetti dried at two temperatures and cooked at 10 cooking times (20), two commercial red spring wheat samples and one laboratory-processed red spring wheat sample cooked at normal cooking time (3), and one laboratory-processed red spring wheat sample cooked at two cooking times (2).

The slopes of the regression lines for the iodine absorbance test vs the freeze-dried cooking loss test for durum wheat and red spring wheat were heterogeneous (SAS Institute 1988). Therefore, it was not valid to combine the data to calculate one regression equation. The r^2 values for both wheat classes were high (0.80 for durum and 0.87 for hard red spring), indicating that cooking loss can be estimated reliably from iodine absorption values. Three overcooked HRS samples were not included in the regression equation because the absorption values were greater than 2.0 and beyond the limit of linearity.

Regression equations for samples dried at high and low temperatures were homogeneous within each wheat class, indicating that the drying procedure does not influence the relationship between test results. In addition, the relationship between the two test procedures was linear over a wide range of cooking times. Typical results for a laboratory-processed durum wheat sample dried at high and low temperatures and cooked at various cooking times are shown in Figure 2.

The difference in the slope of the regression line for hard red spring wheat compared to that for durum wheat reflected higher cooking loss values for overcooked hard red spring wheat spaghetti. Apparently the rate of spaghetti breakdown with extended cooking time is greater in hard red spring pasta than in amber durum pasta. This confirms earlier reports that amber durum wheat pasta has better tolerance to overcooking than does hard red spring wheat pasta (Dexter et al 1983).

The mean absorption value for optimally cooked commercial samples was 0.792. This value is close to the intersection of the regression lines for the two wheat classes. The calculated cooking loss at this intersection point is 5.83% for amber durum and 5.86% for hard red spring. Thus, for optimally cooked spaghetti samples of unknown composition, the regression equation for durum wheat can be used with reasonable confidence.

The iodine test was found to have a distinct advantage over the freeze-drying method since it could be completed the same day as the cooking trials, whereas the freeze-drying method required a minimum of three days to complete.

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[Received November 2, 1990. Revision received June 5, 1991. Accepted June 7, 1991.]