

# Rapid Moisture Analysis in Baked Goods Manufacturing



## Introduction

Moisture content is one of the most critical parameters in establishing proper conditions for the taste, preservation, storability, and shipping of baked goods. Incoming ingredients require accurate analysis since price is calculated on a dry weight basis. In-process doughs and batters require very specific moisture levels to achieve proper dough processability and to minimize bake times. Most mix cycles for hydrates and doughs are relatively short, typically on the order of 10 minutes, which makes traditional air-oven moisture analysis impractical. With moisture playing an important role at every step of the manufacturing process, there is a clear need for a moisture analysis method that is rapid, highly accurate and robust.

Indirect techniques, such as NIR and FT-IR have been introduced to perform rapid analysis, but require costly calibrations and are limited to simple, uniform sample matrices. Because NIR and FT-IR are secondary methods, even slight formulation changes lead to time consuming channel development. Infrared moisture balances decrease test time compared to traditional oven methods, but still require up to 25 minutes to completely dry samples with moderate moisture levels<sup>1</sup>. Furthermore, infrared moisture balances struggle to completely dry high moisture mixes and ingredients, which tend to re-condense inside the drying cavity due to a lack of active ventilation.

The SMART 6™ Moisture Analyzer is uniquely designed to handle the wide variety of sample types in baked goods manufacturing, from dry mix ingredients to doughs, batters and inclusions. The SMART 6 utilizes dual-frequency energy, specifically microwave and infrared, to rapidly analyze moisture

content. Low frequency microwaves penetrate the entire sample to rapidly remove unbound moisture through dipole rotation, while high frequency infrared energy evenly heats the surface through molecular vibration. The two energy sources work in unison, providing benefits over microwave-only and infrared-only analyzers, with results in approximately 3 minutes. In addition to moisture analysis, CEM offers an upgrade option to include fat testing with the SMART 6 – ORACLE™ system<sup>2</sup>.

This study demonstrates that the SMART 6 can rapidly analyze a wide range of raw and baked goods for moisture with an average difference of less than 0.06 % compared to reference methods.

## Key System Benefits

- **Direct loss on drying** – Direct analysis of any sample without the need for expensive, time consuming calibrations.
- **Versatile** – Analyze any wet or dry product, including raw ingredients, in-process mixes, and finished products with inclusions like jelly, chocolate, and more.
- **Reliable** – Worry free analysis without discrepancies due to variation in color, density, consistency, or formulation.
- **Simple** – Intuitive touchscreen user interface facilitates rapid analysis regardless of operator experience.

## Experimental

To evaluate the performance of the SMART 6 Moisture & Solids Analyzer, five different samples were commercially obtained and analyzed in both raw and baked form: pie crusts, biscuits, sugar cookies, white cake, and brownies. For moisture determination, a 1.40 to 2.20 g sample of each product was analyzed in the SMART 6. Reference testing for moisture content was performed in triplicate in a vacuum oven according to AOAC method 925.40 to establish a basis of comparison.

## Results

Results for percent moisture using the SMART 6 ranged from 0.01 – 0.11 % difference compared to oven methods, demonstrating the high degree of accuracy of the SMART 6 analyzer, as shown in **Table 1**. **Table 2** highlights the precision of the SMART 6 dual frequency drying capabilities, which was  $\leq$  0.22 % standard deviation for all samples analyzed.

**Table 1:** Accuracy of Smart 6 Technology Compared to Reference Methods

Sample	Percent Moisture		
	SMART 6	Oven	Difference
Raw Pie Crust	21.14	21.18	-0.04
Baked Pie Crust	5.50	5.46	-0.04
Raw Biscuit	33.12	33.16	0.04
Baked Biscuit	25.89	25.97	0.08
Raw Sugar Cookies	15.36	15.31	-0.05
Baked Sugar Cookies	2.00	2.08	0.08
White Cake Batter	41.39	41.40	0.01
Baked White Cake	34.45	34.52	0.07
Brownie Batter	19.62	19.51	-0.11
Baked Brownie	14.39	14.31	-0.08

**Table 2:** Precision of SMART 6 Technology

Sample	Percent Moisture Replicates					Average	Range	Std. Dev.
	1	2	3	4	5			
Raw Pie Crust	21.25	21.11	20.89	21.12	21.31	21.14	0.42	0.16
Baked Pie Crust	5.32	5.52	5.51	5.53	5.64	5.50	0.32	0.12
Raw Biscuit	33.11	33.28	33.14	32.75	33.29	33.12	0.54	0.22
Baked Biscuit	25.89	26.12	25.77	25.91	25.74	25.89	0.38	0.15
Raw Sugar Cookies	15.59	15.13	15.48	15.34	15.24	15.36	0.46	0.19
Baked Sugar Cookies	1.96	1.91	1.94	2.08	2.10	2.00	0.19	0.09
White Cake Batter	41.53	41.38	41.21	41.46	41.38	41.39	0.32	0.12
Baked White Cake	34.44	34.33	34.56	34.56	34.34	34.45	0.23	0.11
Brownie Batter	19.78	19.77	19.41	19.68	19.45	19.62	0.24	0.18
Baked Brownie	14.29	14.39	14.37	14.38	14.53	14.39	0.37	0.09

## Conclusion

Taking advantage of the dual-frequency energy sources, the SMART 6 Moisture & Solids Analyzer rapidly dried all samples in approximately 3 minutes regardless of moisture content. The SMART 6 provided results approximately 8-times faster than a standard infrared moisture balance with accuracy comparable to AOAC oven method 925.40. By combining microwave with infrared energy, the benefits of both sources are realized and the result is rapid, complete drying for all sample types with excellent accuracy.

## Reference

- <sup>1</sup> Bradley, Robert L. Jr. (2006) Moisture and Total Solids Analysis. S. S. Nielsen. Food Analysis (4th Ed. pp. 85-215) West Lafayette, IN. Springer.
- <sup>2</sup> <http://cem.com/fat-analysis/>

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