African Journal of Biotechnology Vol. 6 (2), pp. 120-122, 18 January, 2007
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2007 Academic Journals

*Short Communication*

# Measurement of the moisture content of the granulated sugar by infrared transphotometry

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Accepted 10 November, 2006

**The moisture content of granulated sugar is a critical parameter for its transformation into cubes. To the best of our knowledge there is no easy-to-use method for the determination of this parameter. To resolve this, a new method using infrared transphotometry technique based on the attenuation of an infrared radiation through a sample of sugar, was developed and tested in our laboratory. Using linear regression analysis it was observed that the transphotometer response varies linearly ($r^2 > 0.996$) with the moisture content of sugar. The results obtained by this new method compares very well (ANOVA, *p=5%*) with other known classical, but laborious and expensive methods of moisture determination.**

**Key words:** Sugar, moisture content, transphotometry, infrared.

## INTRODUCTION

The moisture content of the granulated sugar is a critical parameter for its transformation into cubes and requires a continuous follow-up in preparation for its automation. The literature on the measurement of the moisture content (Pande, 1974; Pyper, 1983; Hazarika et al., 2006) of food products shows a great variety of methods. Absolute methods like the Karl fisher method for example, standardised reference methods like heating at a moderately high temperature for example or rapid methods like conductimetry, infrared spectroscopy, dielectric spectrometry or nuclear magnetic resonance spectroscopy (NMR) for example, do not meet the requirements of automation in the Industrial setting. In the Cameroonian industrial context, for example, this parameter is measured from a chemical reaction based on the calcium carbonate (Ngneze, 1998) or by means of an infrared desiccator mounted on a weight balance (Eloumou, 1999). Hence, the idea of developing a new method of measuring the moisture content of the granulated sugar to satisfy the double demand of automation and cost. This method is presented in the second part of this paper. The results obtained are presented and discussed in the third part.

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## MATERIALS AND METHODS

### Materials

The granulated sugar used in this study came from NOSUCA company (Douala, Cameroon). The moisture content of this sugar was measured using infrared transphotometer, an apparatus built at the Laboratory of Biophysics and Food Biochemistry, National school of agro-industrial sciences (ENSAI) of the University of Ngaoundéré (Bitjoka and Tchatchueng, 2000).

### Infrared transphotometer principle

Absorption of infrared (IR) by water is the physical principle generally used in the measurement of the moisture content of a liquid or a solid product finely crusted (Bertrand and Dufour, 2000). This principle requires a specific absorption of water and a negligible contribution of other interactions to the attenuation of the incident wave, i.e. reflection and scattering. Absorption follows Beer-Lambert law that links the concentration of the absorbable substance (chromophore) to the intensity of transmitted wave. The absorption spectrum of water shows the height of absorption of more than $10^3$ $cm^{-1}$ to about 3 μm, where the phenomenon of absorption could

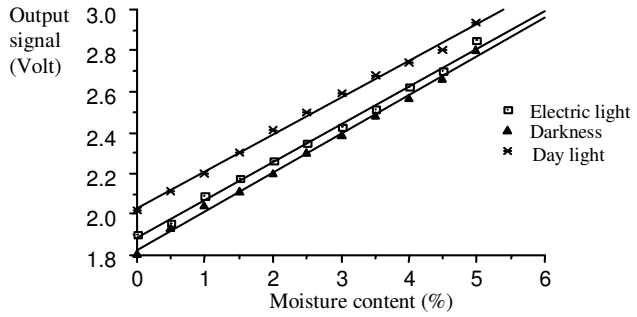


**Figure 1.** Response of the IR transphotometer in function of the moisture content (ultrafiltered water) of sugar: influence of undesired wave.

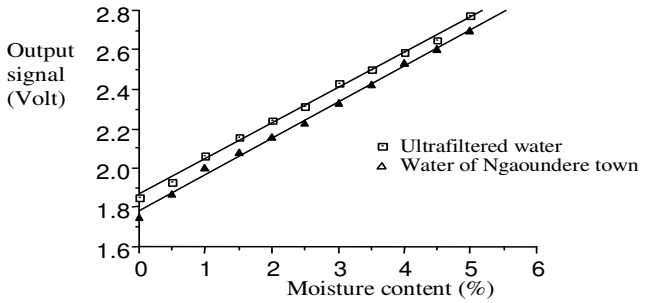


**Figure 2.** Response of the IR transphotometer in function of the moisture content of sugar: influence of the quality of water (dark room).

take over the others. It can even take over between 1.6 µm and 10 µm where absorption is greater than 10 $cm^{-1}$. But, to emit and to detect IR at these wavelengths is more costly than to emit and to detect IR at lower wavelengths. In addition, methods based on absorption rely on spectral analysis (spectroscopy) that increases the complexity and the cost of the method (Millis et al., 1986; Dupuy, 1993; Benoudjit et al., 2002).

Infrared transphotometer is based on the attenuation of very near infrared (VNIR), 0.9 µm, which propagates through a disperse system, consisting of a disperse phase in a dispersion medium such as emulsion, foam, granulated sugar, etc. This attenuation results from scattering and reflection phenomena and not from the absorption phenomenon. To avoid the spectroscopy, only the average value of the intensity of transmitted wave is taking into account. Infrared transphotometer delivers a signal proportional to the intensity of the transmitted wave. The sample to be analysed is placed in a spectrometric vat of 1 cm of optic path.

### Methods

The moisture content of granulated sugar was obtained empirically by linear regression, between the signal delivered by the IR transphotometer and a standardised range of samples of known water content. This water content was determined by means of drying at a moderately high temperature. To constitute this standardised range, the sugar was dried for two hours and conserved in a desiccator. Upon adding a mass Ms of this sugar to a volume of water of mass Me, we obtain a sugar sample of water content Me/Ms. Two standardised ranges were achieved, one with water from Ngaoundéré town and the other with ultra-filtered water (pore diameter of 4 nm) in order to evaluate the influence of the quality of water on the results, a critical factor for certain methods of measuring like electrical conductivity. Measurements were carried out during the day and in the night to evaluate the influence of undesired waves that come from the surrounding light. Previously, measurements were taken with empty vat measuring (1 cm), the vat containing water only and without the vat.

## RESULTS AND DISCUSSION

The results obtained from measuring empty vat, vat containing water, and without vat in every case were identical. This shows that the vat used is transparent to the IR used, and confirms that this wave is not absorbed by water. These results also show that the attenuation of the

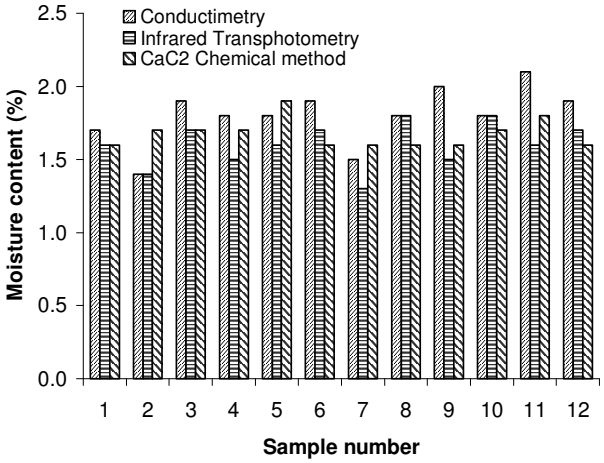


**Figure 3.** Comparison of moisture content measured by conductimetry, infrared Transphotometry and a chemical method based on reaction of sugar with calcium carbonate.

0.9 µm IR by reflection at the air–vat–water interfaces is negligible. Figures 1 and 2 show the results obtained with ultrafiltered water and with water from Ngaoundere town in darkness, day-light and under electric light. We notice that the signal delivered by the transphotometer varies linearly ($r^2$>0.996) with the water content of sugar. The quality of water (Figure 2) influences the response of the transphotometer less than undesired wave (Figure 1). The positive slope of lines obtained shows that water absorption is not predominant. If it was so, we would have had a response decreasing exponentially according to the Beer–Lambert law. All went here as if in the presence of water granulated sugar forms aggregates as less scattering as its size increases. This hypothesis is corroborated by the transphotometric response to humid sand of pouzzolane, a response which does not vary with its water content. In fact, the humid sand of pouzzolane does not aggregate.

The results obtained by IR transphotometry were compared to other results obtained by other methods, namely

the conductimetry and a chemical method based on reaction of the granulated sugar with calcium carbonate. The measurements taken during the day with the three methods, on several samples of granulated sugar of unknown content, led us to the results shown in Figure 3. Each sample was subdivided into three sub samples, one for each of the methods. The ANOVA test (completely randomised lump) at $p = 5\%$ shows that these three methods give in average the same moisture content for samples considered.

## CONCLUSION

This work was initiated to develop a method of measuring the moisture content of the granulated sugar to satisfy the double demand of automation and cost. A new method using infrared Transphotometry, technique based on the attenuation of an infrared radiation through a sample of sugar, was developed and tested in our laboratory. Using linear regression analysis it was observed that the transphotometer response varies linearly (r2 > 0.996) with the moisture content of sugar. The results obtained by this new method compares very well (ANOVA, p=5%) with other known classical, but laborious and expensive methods of moisture determination. The method presented in this paper will be further involved in comparison tests between several laboratories.

## ACKNOWLEDGEMENTS

The authors thank NOSUCA Company (Douala Cameroon) for its support to the achievement of this work, Mr. Lincoln Omam Ndougou and Professor Carl M. F. Mbofung for critical reading of the manuscript.

## REFERENCES

Benoudjit N, Cools E, Meurens M, Verleysen M (2002). Calibrage chimiométrique des spectrophotomètres : sélection et validation des variables par modèles non-linéaires. Chimiométrie 2002 proceedings, Paris (France), 4-5 December 2002, pp. 25-28

Bertrand D, Dufour E (2000). La spectroscopie infrarouge et ses applications analytiques. Ed. TEC&DOC, Lavoisier, Paris, France.

Bitjoka L, Tchatchueng JB (2000). Etude et réalisation de capteurs d'humidité pour des applications agro-industrielles. In Kapseu C. Kayem J (eds) Proceedings of an international workshop on drying and improvement of shea and canarium, Ngaoundéré, Cameroun. pp 195-206.

Dupuy N., Meurens M., Sombret B., Legrand P., Huvenne J.P. (1993). Multivariate determination of sugar powders by attenuated total reflectance infrared spectroscopy. Appl. Spectro. 47(4): 452-457.

Eloumou G (1999). Contribution à la qualité du sucre en morceaux de la société sucrière du Cameroun (SOSUCAM), Mémoire de fin d'études, ENSAI – Université de Ngaoundéré, Ngaoundéré, Cameroun.

Hazarika D, Laskar S, Sarma A, Sarmah PK (2006). PC-Based instrumentation system for the detection of moisture content of tea leaves at its final stage. IEEE Transactions on instrumentation and measurement, 55(5): 1641–1647.

Millis BL, Alyea EC, Van de Voort FR (1986): MID-infrared transmission spectroscopy of sugar solutions; instrumentation and analysis. Spectroscopy letters, 19(3): 277-291

Ngneze Kouteu LP (1998). Etude d'un capteur en vue de la régulation de l'humidité dans le process de conditionnement du sucre, Mémoire de fin d'étude, ENSAI – Université de Ngaoundéré, Ngaoundéré, Cameroun.

Pande A (1974). Handbook of moisture determination and control. Marcel Dekker, New York.

Pyper JW (1983). Analysis of moisture in solids: a review of the last decade, or from Pande to the present. Technical Report UCRL-53447, Lawrence Livermore National Lab., CA