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How to Control Milk Freshness at Home: Multi-Purpose Colorimetric Sensor to Face Milk Waste and Health Issue

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Abstract

Milk is an important food for the world's population but, Unfortunately, due to its high nutritional value, it is also an excellent growth medium for microorganisms and it is thus an extremely highly perishable product that possesses a short shelf life (Ziyaina et al., 2020). Furthermore, the standard for "spoiled" milk is strongly subjective and the term "spoilage" is difficult to normalize and to measure with accuracy. Nowadays, the shelf life is determined by the time duration to which the milk remains in its original state and expressed through "sell by" or "best if used by" dates. These dates are intrinsically inaccurate and can result either in the consumption of no longer eatable milk or in the waste of still safe product. This second option is even more likely nowadays since many dairy producers are introducing innovative active packaging that ensures significant elongation in milk shelf life, not taken into account by the date labels. As usually happens in food freshness monitoring, conventional qualitative and quantitative methods are currently used to detect milk level of freshness in dairy industry but, once in the supermarket or in the household, milk freshness could no longer be controlled due to the lack of rapid, low-cost and reliable methods. In this scenario, we developed a multi-purpose miniaturized sensor, based on a pH indicator covalently bound to polymeric material, following the already proposed synthetic pathway (Magnaghi et al., 2020), able to change colour according to milk freshness, following pH modifications provoked by microbial activity. Despite the apparent simplicity of the system, this sensor can give information at different levels. Firstly, when milk is no longer eatable, a glaring colour shift from green to yellow is observed. Secondly, the sensor colour evolution during milk freshness monitoring, expressed as average RGB triplets, were used to develop classification models using Linear Discriminant Analysis that allows predicting the freshness of milk samples at any time. Eventually, sensor colour can be used to calculate milk acidity, expressed as °SH/100 mL, using Partial Least Square regression. This last application represents a huge innovation since it allows to replace the reference Soxhlet-Henkel methodology, destructive and time-consuming, with a much simpler method with similar performances, both in terms of precision and accuracy.

Keywords: domestic food waste, health issue, colourimetric sensors, naked-eye evaluation, chemometrics

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