OPENING MINDS:
RESEARCH FOR SUSTAINABLE
DEVELOPMENT

Portable Electronic Curd Quality Tester

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1 INTRODUCTION

Curd, the fermented milk product, which is packed in a clay pot is one of the most traditional dairy products in Sri Lanka. Curd should have a pleasant odour, a characteristic flavour, clean, and free from dirt and extraneous matter (SLSI, 1988). The annual buffalo milk production in Sri Lanka was about 49,251,360 litres in 2009 (Department of Census and Statistics Sri Lanka, 2009) and most of this volume is processed into curd and packed into at least fifty million clay pots (Dharmasena, 2005). There are some prescribed standard requirements for the processing of curd, and preservation is one of the requirements with respect to the Sri Lanka Standards (SLS). The requirements for the quality assessment of curd prescribed by the SLSI (Sri Lanka Standard Institution, 1988) can be categorized as the physical (organoleptic) parameters (smell and taste, texture, consistency and colour), chemical parameters (fat, Solids-Not-Fat (SNF) and pH) and the microbiological parameter (Coliform count). Here, the physical parameters can be analyzed by the sensory evaluation (e.g. by visually inspection-texture and colour) and the microbiological parameter are mainly measured in relation to the hygienic quality and 79% of the samples tested are free from coliforms (Tetrapak, 2016; Weerasekara, 2010). According to SLSI standards, curd shall comply with minimum milk fat percentage by mass, which is 5% (Curd) and 7.5% (Buffalo curd); minimum milk Solids Not Fat (SNF) percentage by mass which is 8.5% for both curd and buffalo curd and the maximum pH value which is 8.5. (Source: SLS 824: Part 1: curd). There is no obligation to obey the rules and regulations prescribed by the SLS, and the main quality parameters are not up to the standard level (Weerasekara, 2010). Moreover, curd manufactures can use preservatives to maintain the product for a long period in order to retain the curd without it expiring quickly (Gunathilake, 2015). However, based on personal communication with the Head, National Poisons Information Unit, NHSL, pots of curd liberally laced with formalin, ascetic acid, and calcium carbonate (aluhunu) are openly sold in food outlets across the country. In addition, these cheap, low quality and harmful preservatives are used to obtain a long shelf life in order to retain the curd without it expiring quickly. Therefore, according to the facts obtained, there is a need to develop an electronic device to test the quality of curd which can be used by public health inspectors. As a solution this paper presents a system focused on the chemical parameters for testing curd quality and to detect the presence of formalin which though used as a preservative in curd is toxic and carcinogenic.

2 METHODOLOGY

2.1 Conceptual model

The overall block diagram of the proposed system is shown in Figure 1 and it mainly consists of a sensory unit, a processing unit and the display unit. In the sensory unit, fat, SNF and pH are measured as the quality parameters and detection of formalin is done by using the formalin sensor. All sensor inputs are compared with the threshold values in the processing unit and that comparison is used to make the decision on the quality of the tested curd sample

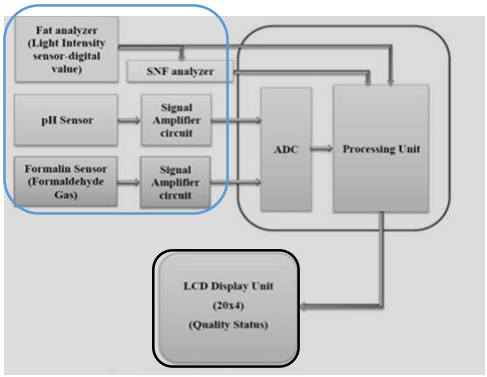

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Figure 1: Overall block diagram of the proposed system

2.2 Fat measuring technique

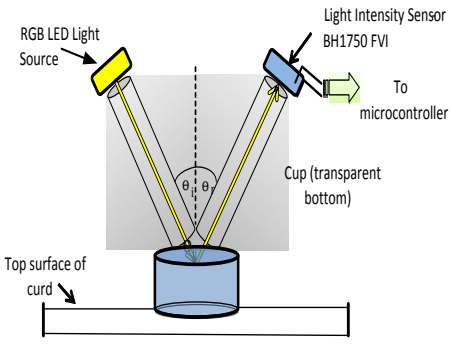

Figure 2: Fat detection mechanism and diffuse and specular reflection of light

The fat measuring sensor is the most important unit in this project as that reading is used for calculating SNF value as well. This sensor was designed and developed by using reflected illuminance of a light source to measure the fat concentration. It was analyzed for wavelengths in the visible range and R, G, B LED was used as the light source to obtain illuminance with different wavelengths.

2.3 The calibration model for the fat sensor

The calibration model for the fat sensor was developed using the linear model created by the linear regression technique of Matlab software (curve fitting tool), by obtaining the results of 20 samples.

With the graph drawn for Fat percentage vs. Light intensity (lx) (Figure 3), the modelled equation for fat sensor calibration is;

$$f(x) = p1*x\text{^}7 + p2*x\text{^}6 + p3*x\text{^}5 + p4*x\text{^}4 + p5*x\text{^}3 + p6*x\text{^}2 + p7*x + p8 \quad (1)$$

Where, f(x) = Fat % and x= total intensity Obtained from 7 wavelengths per cycle

Here, the detection of SNF is obtained by using the *Fleischmann formula*. It is essential to analyse the deviation in the density of many milk samples and to obtain the average density value (at $20℃ - 25℃$), and then acquire the fat value from the sensor.
The Fleischmann formula is given in the following equation,

$$T = 1.2F + 266.5 \times \frac{(d-1)}{d} \quad (2)$$

Where, T= Total solids in mass %,
F= Fat in mass % and d= relative density at 20

From the above equation it can be calculated the total solids % and then SNF % by,
SNF% = Total solids % - Fat % (3)

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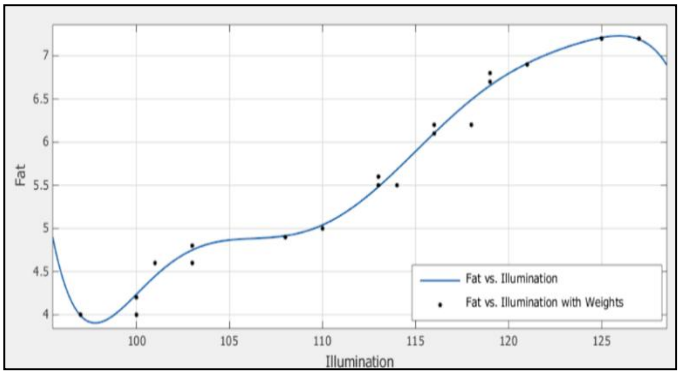

Figure 3: Fat percentage vs. Light intensity (lx)

Coefficients (with 95% confidence bounds):
p1 = -2.456e-08
p2 = 1.955e-05
p3 = -0.006655
p4 = 1.257
p5 = -142.2
p6 = 9631
p7 = -3.618e+05
p8 = 5.816e+06

Goodness of fit:
SSE: 0.1996,
R-square: 0.9868,
Adjusted R-square: 0.9791
RMSE: 0.129

(a) (b) (c)

Figure 4: (a) Control unit (b) Fat probe (c) Formalin probe

2.4 pH detection technique

A pH probe with BNC connector was used as the pH sensor. As the received signal from the probe is too low, it needs adequate amplification for the voltage signal from the pH probe. The OpAmp IC TLC 4502 was used for this and it has a feature of self-calibrating circuitry which digitally trims the input offset voltage to less than 40 µV within the first 300 ms of operation. pH sensor was calibrated using distilled water (pH 7) as the reference solution.

2.5 Formalin detection method

Formaldehyde gas sensor MQ138 was used to identify the presence of formalin. Here, the sensor MQ138 changes its resistivity with the concentration of formalin in the surface of the curd sample. Once the system had encountered a certain resistivity from the sensor, it will send the reading of resistance of the heater coil to the microcontroller. The microcontroller converts the resistivity (ρ) to its ppm value as referred to in the following equation.

$$ppm = \rho\ (V_i\ /\ 1023)$$

Where,

V_i = supply voltage to the sensor

i.e. 5V and 1023 was set as conversion constant of byte reading of the micro-controller unit.

3 RESULTS AND DISCUSSION

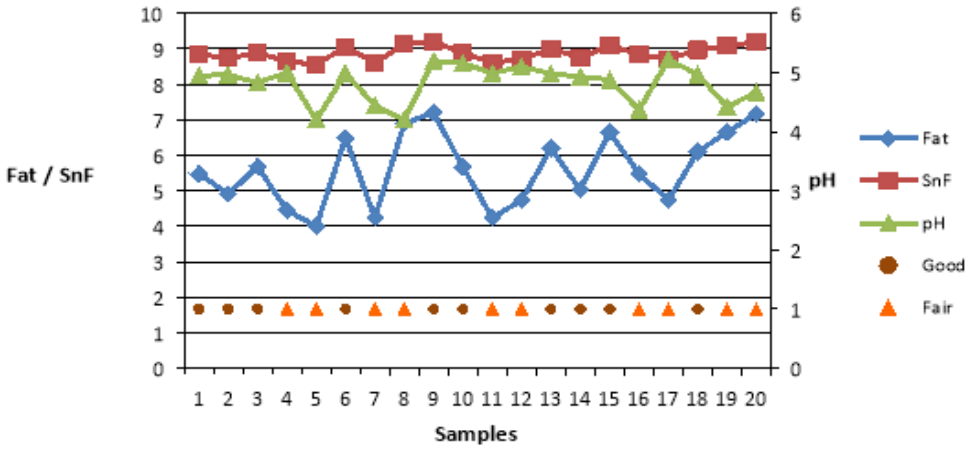

Figure 5: Test results obtained with the proposed system

3.1 Test results of samples for fat percentage

Here, 20curd samples were tested by the proposed system for Fat, and pH, and the accuracy of the proposed system was checked by comparing these findings with the chemically tested results obtained in the laboratory. The categories of the classes are Good, Fair, and Poor class. The Good class curd satisfies the parameters prescribed by SLS. In addition, the Fair and Poor class curd samples are not in accordance with the parameters prescribed by SLS. Here, the Fair samples have been consisted with the Fat range of 5% to 3.5%, range of 8.5% to 5% and pH range of 4.5 to 4.0. In addition, the Poor samples have been consisted with the Fat value of below 3.5%, value of below 5%, and pH value of below 4.0. The maximum variation of ±0.3% was observed with the results of the fat percentage by the proposed system over the chemically tested results.

4 CONCLUSIONS

The design of a user friendly portable device to test the quality of curd was presented in this paper as the quality of most curd products available in the market are not up to SLSI standards. The device also allows for the detection of the usage of toxic and carcinogenic agents to preserve the contents. For this work the SLS 824: part 1 was referred to recognize the quality parameters. The proposed device can be used to measure Fat as well as pH by selecting individual parameter test options. It can also be used to get the overall status of the measured sample as "Good sample", "Fair sample" or "Poor sample" by pressing only one button. As an additional feature the detection of formalin is also included.

According to the results obtained, the accuracy of the device is around 90%. Therefore, food inspectors can use the proposed device to check the curd quality as well as the presence of formalin in curd available at food outlets as this device is easy to use and is low cost**.**

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