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Toward Real Time IoT Based Paste Monitoring System for Small to Medium Enterprise (SME)

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Abstract. Quality and consistency of a product have always been the most critical demand in the food paste industry. One of the ways to retain its high standard is through managing consistency. An affordable prototype of the Internet of Things (IoT) based tool used for paste consistency monitoring of various paste property sensors by means of low cost Arduino based embedded system is presented. For a Small and Medium Enterprise (SME), the word 'Affordable' is a critical term. They could not compete with a big enterprise corporation in term of having a high-end monitoring system. Four paste properties were measured: thickness, color, pH and temperature. The status of all parameters was monitored and displayed in two modes: local LCD screen and remote screen from any Wi-Fi based portable gadget. The in-house Arduino based scripting code was developed to integrated the system. The result shows that the developed system could be implemented as a local measurement tool and also be monitored remotely as an IoT based system. The measurement system was validated with the manual measurement. The framework to rescale the project into a bigger scale system was also developed in order to make this system ready for the Industrial 4.0 requirement.

1. Introduction

In the semisolid food production sector, maintaining the consistency of a product is exceptionally essential. It is important as it builds trust with the consumer, creates a reputation and enhances markets demand [1]. According to Bourne [2], the quality of foods depends on its appearance, flavour, texture as well as nutritional value. In the case of the semisolid food product, the texture of food is the most concern quality attribute relevant to meet consumer acceptability. Rheological behaviour of food is associated directly with the textural quality factor. It concerns the flow and deformation of substances. Its properties can be measured through various instruments.

1.1. Problem statement

Food companies are competitively trying to produce a final product that consistently has the same overall properties through proper quality control. Maintaining quality control as well as quality assurance require in-house laboratory with enough facilities to carry out testing. However, the level of investment in research and development (R&D) done by Small and Medium Enterprise (SMEs) is very low among other business. These indicate that SMEs are still lacking in preserving their quality control (QC) and quality assurance (QA).



1.2. Objectives and the significance of the research

One of the effort to solve the problem as stated in the previous sub chapter is through the development of a comprehensive paste consistometer. The term ‘consistometer’ refers to ‘measuring consistencies’ of the paste [3]. The goal is to measure the paste properties at different stages of the paste along the paste production flow. The data of some parameters could be extracted straightforward using the relevant sensor for example temperature, pH and color. The data of some other parameters are not extracted directly such as the thickness parameter or density.

The second stage is to develop a framework for migrating the paste consistometer from the standalone system into Industry 4.0 ready. It is highly beneficial for SMEs in maintaining a high quality of their product while reducing QC and QA testing cost [4].

The significance of this project is SMEs able to migrate from manual and separated measurement activities into electronic, automated and integrated measurement activities. With the add-on of the local and remote monitoring system, it will make SMEs one step closer to become Industry 4.0 ready.

2. Consistency in Food Quality

In the food processing industry, quality is directly related to how consistent the overall properties; appearance, texture, and flavor of the final product is. It is a powerful key for food companies as it builds trust with the consumer, creates a reputation and enhances markets demand. It was stated that the ability to produce high-quality product is the foundation for success in this competitive industry [5]

Particularly, the importance of consistency in food quality does make a huge impact in the food production industry. Strong customer relationships are built on the basis of consistency. By consistently producing a high quality product, quality of a company as a whole is raised as well [6]. Maintaining its consistency becomes an extremely important part of the process. Thus, the potential for the company to not only grow but reach to a higher level is becoming more realistic.

However, to cultivate the foundation to ensure consistency in food quality, processing of food production must undergo standard operating procedures and guidelines. Testing for quality assurance must be done in instrumentation laboratories for precise and accurate results.

Naturally, any consumable food product has some rheological attribute. Foods that can be eaten without being a process such as fruits contain elements that have a major impact on the rheology of the final product. Thus, the importance of those parameters have become a concern towards raw material manufacturers and food processors for many years. Now, consistency measurement is considered a necessity analytical tool used by food scientist on a daily basis.

Currently, there are wide ranges of measuring instruments used to determine the rheological properties of fluid and semi-solid foods. Some facilities are considered expensive, and only big company or laboratories are afford to purchase the equipment. For SMEs, the demand to have an affordable consistency measurement tool is considered high [7].

3. Methodology

This research was started with the early stage of the ingredients analysis. The consistency can only be maintained as a comprehensive activity starting with the ingredients selection. Refers to the Malaysian Standard on Food Grading, for example, MS 894:2010 [8], the guidance of chili grading was presented. Some other standards for different ingredients were also collected.

The next stage was investigating the overall paste processing flow. From this stage, some Quality Control (QC) activities will be determined and placed.

Figure 1 shows the overall paste processing flow in the company “X”. The letters show either the ingredients or the activities. Details of the coding are shown in Table 1. Quality Control activities are performed at particular stages as shown with the QC symbol.

Parallel with the previously mentioned activity, the development of the Arduino based monitoring system was developed. The reason for using Arduino was the popularity of this system in term of a large number of supported sensors as well as the open source community. Arduino is also a platform which is ready to support IoT and big data’s platform.

After some considerations, four parameters were selected: Temperature, pH, thickness, and color. To implement this system, some sensors were used as shown in as Figure 2. Thickness measurement was utilizing two color sensors.

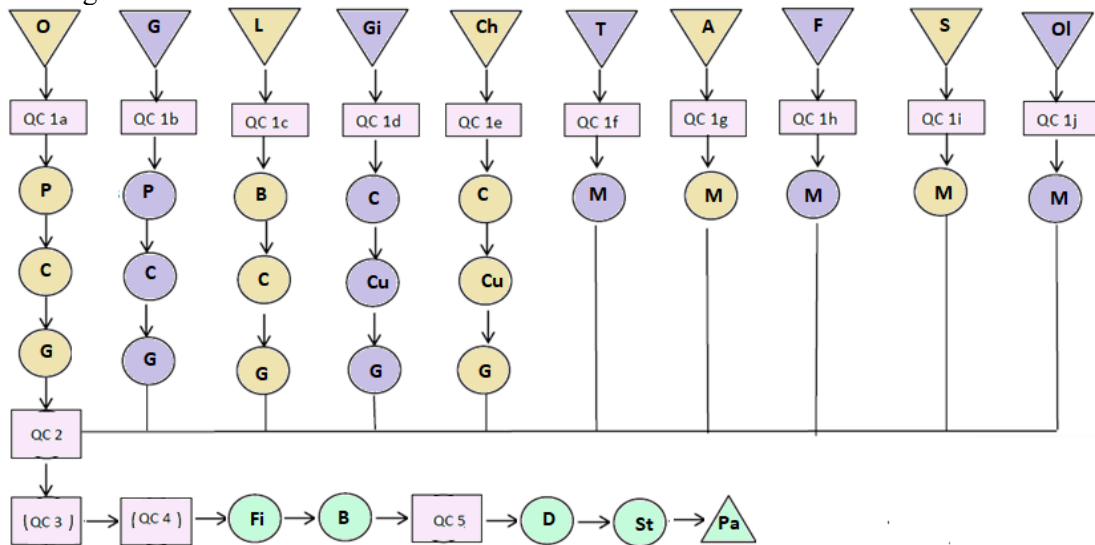


Figure 1. Overall of the paste processing flow.

Table 1. The coding of the paste processing flow.

Code	Meaning	Code	Meaning	Code	Meaning	Code	Meaning	Code	Meaning
A	Acid citric	Cu	Cut	G	Grind	O	Onion	Pa	Packaging
B	Boil	D	Drying	Gi	Ginger	Oi	Oil	T	Turmeric
C	Clean/Rinse	F	Fenugreek	L	Lemongrass	S	Salt		
Ch	Dried chili	Fi	Filling	M	Measure	St	Store		

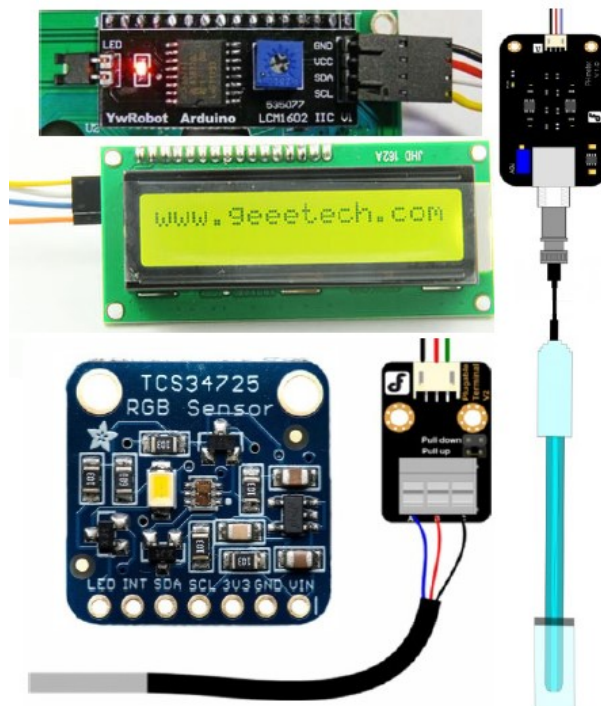


Figure 2. Arduino based sensors: RGB, pH, and temperature.

The developments of the code were divided into two stages: (1) Local system and (2) remote system based on Wi-Fi/Bluetooth connection. To make both systems work on the same hardware, Bluno, a type of Arduino board equipped with Bluetooth connection was used.

Finally, the last stage was the development of the System's Compartment (SC). To make faster prototyping of the compartment, it was built using Lego Technic. The developments, as well as the integration processes, are shown in figure 3. The Arduino coding consists of five sub routines: LCD screen, pH, Temperature, Color and thickness based on Bostwick consistometer. All measurements were validated using the standard manual measurement.

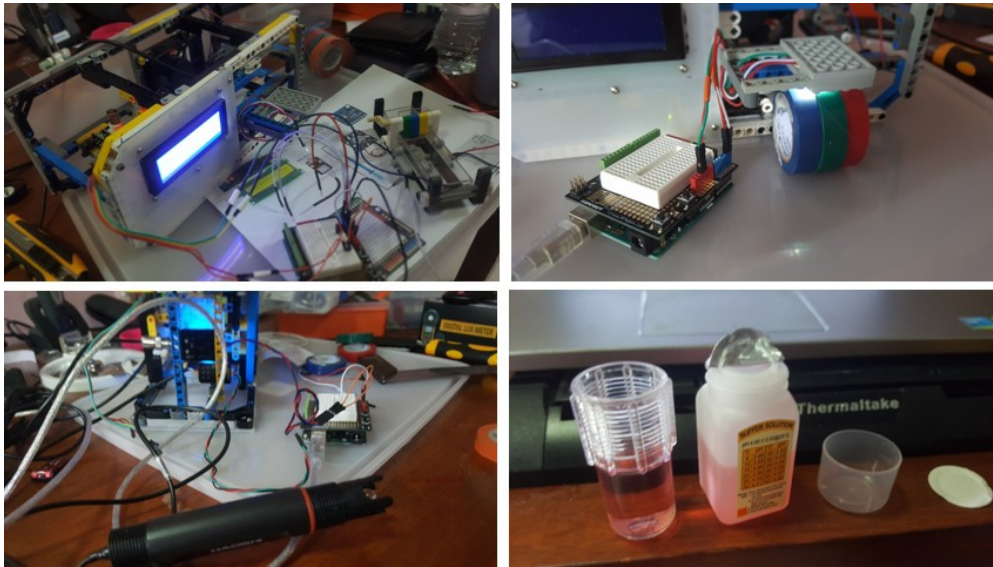


Figure 3. Development process of the system compartment and system integration

4. Result and discussion

4.1. System's compartment

The final System's Compartment (SC) is displayed in Figure 4. As seen from the figure, this SC has two screen alternatives. The local screen is attached to the SC while the remote screen is the virtual screen. The virtual screen was an Ipad application which was developed using Blynk's platform.

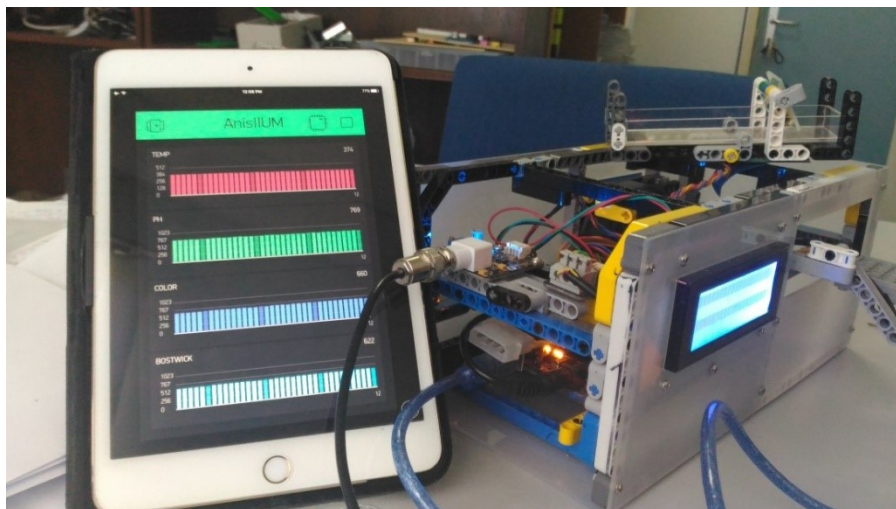


Figure 4. Development of IoT based system monitoring tool.

A sample of the parameters' reading of the system was listed in Table 2. It can be seen that the reading of those parameters consider has a consistent result.

Table 2. Sample of the monitoring results.

ID	Spec.	SAMPLE 1										Mean Temperature
		pH			Mean pH	Weight (g)	Volume (ml)	Density (g/ml)	Temperature (0^C)			
1	ST.A1	4.89	4.91	4.88	4.89	14.67	18	0.82	29.8	29.8	29.7	29.77
2	ST.A2	5.32	5.3	5.41	5.34	17	18	0.94	29	28	29	28.67
3	ST.A3	4.71	4.81	4.82	4.78	16.74	18	0.93	28.8	28.8	28.1	28.57
4	ST.A4	6.24	6.1	6.05	6.13	16.84	18	0.94	29.3	29.4	29.1	29.3
5	ST.B1	5.15	4.96	4.87	4.99	16.93	18	0.94	29.2	28.8	29.1	29.03
6	ST.B2	3.92	3.94	3.93	3.93	17.51	18	0.97	29.6	29.5	29.6	29.57
7	ST.C1	3.66	3.69	3.68	3.68	19.29	18	1.07	31.3	30.4	31.1	30.93

ST.A1	Blended shallot	ST.B1	Mixed ingredients (before added seasoning)
ST.A2	Blended garlic	ST.B2	Mixed ingredients (after added seasoning)
ST.A3	Blended dried chillies	ST.C1	cooked products
ST.A4	Blended ginger		

4.2 Framework of the iot and big data

To make this system Industry 4.0 ready, some modifications of the framework have to be developed. The schematic of the SC is shown in Figure 5. The paste should flow in and out of the SC continuously while all four parameters were read, recorded and written in a real time manner. For the IoT based alternative system, a mobile gadget or web based application could be developed.

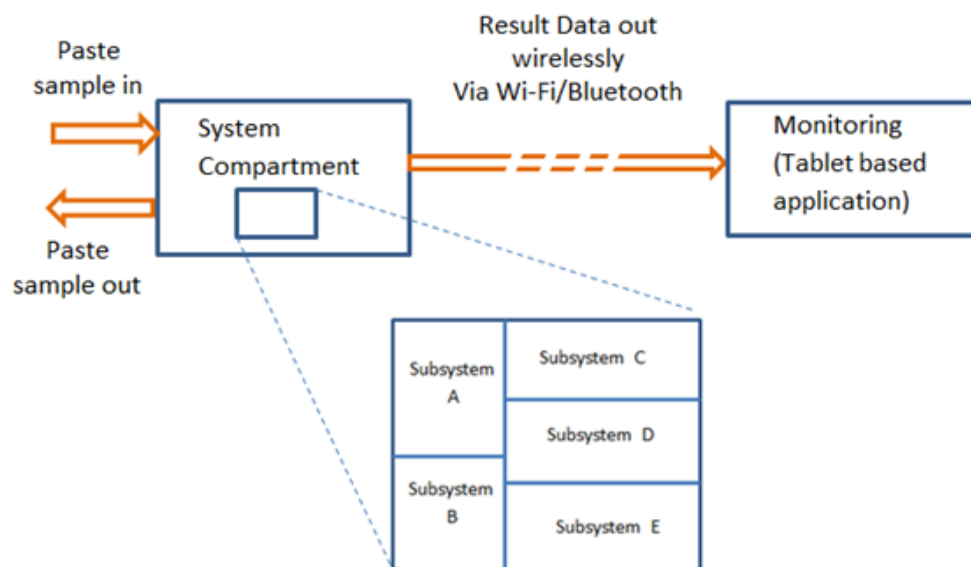


Figure 5. System compartment.

To fit this framework as part of a big data system, ideally, SC need to be placed at every stage of the QC activity refer back to Figure 1. As a simplification, for example, if the process is utilizing four food processors as shown in Figure 6, then four SCs will be attached. The next modification is to make the Monitoring System (MS) centralized at one point. If the factory has hundreds of SCs, then the model is fit to be considered as a big data system.

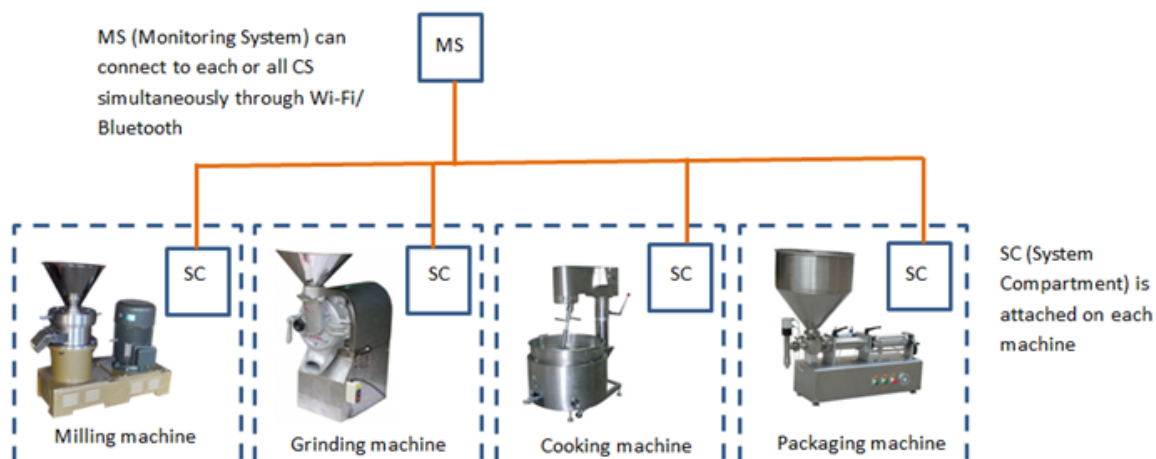


Figure 6. Placement of the system's compartment at each machine.

5. Conclusions

From the presentation and discussion above, the main objective to develop a prototype of the Paste Consistency measurement tools have been achieving. The tool has two features: (a) as a standalone tool and (b) IoT based paste monitoring tool.

The second objective to develop a framework that fits with the big data criteria was also achieved. In order for the SME Company to become Industry 4.0 ready, significant investments need to be made. Infrastructure, hardware, and application need to be overhauled and upgraded. It is a challenge for the SME Company to implement Industry 4.0.

6. References

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