Design of Home Winemaker to Improve Impurity Filtration in Fermentation

Yuen-Chen Lin, Fang-Lin Chao, Chun-Yu Huang, and Shao-Heng Lai

***Abstract*—The family-based brewing is sugar raw materials, and separate the juice and slag by pressing. The problem is the success rate sometimes different from person to person. This design utilized microelectronics technology to improve fermentation of fruit wines. Fruit wines are produced in a special container so that proper handling of these ingredients, peels, and seeds. The brewing machines consist of sealing, brewing, pressing, and controller. The fermentation reaction is completed at the pre-set time to perform brewing — linear actuator employed in the presser to reduce bitterness. The implemented sensors detect changes in CO_2 concentration and pressure level based on the Arduino platform. The usability considerations on the interface are the icon which reflects its meaning to help the user to operate smoothly.**

***Index Terms*—Winemaker, fermentation, product design, Arduino.**

I. Introduction

In recent years, organic and natural ingredients is an essential value in today's society, ensuring the health of people. In the process of investing in organic agriculture, farmers often produce excessive amounts of fruits and vegetables, causing sales problems. Making the fruit into wine is a beneficial way. The most basic family-based brewing method is to ferment starch or sugar raw materials and separate the juice and slag by pressing and then filter or clarify to obtain alcohol. Most of the liquor brewing in the family is solid-state fermentation, and the fermentation process determines the quality of the wine.

Due to the popularity of microelectronics technology, smart home brewing equipment had introduced. Apparatus includes incubators, fermenters, cooling or heating pipes; it produced brewing beer, rice wine, and many other wines. To solve the problem of failure rate, we focused on the improvement of Impurity filtration of fruit. Raw materials of fruit contain peels and seeds; proper handling of these ingredients may help the success rate.

A. Fermentation Process

The classification of major Taiwanese wines is [1] red wine, white wine, non-sparkling wine, sparkling wine, hardened wines, flavored wines. General winemaking divided into procedures: cooking, liquefaction, fermentation, and distillation. The beer brewing process needs to go through cooking, liquefaction, saccharification.

Most of the grapes wine concentrated in the summer. The weather is hot and rainy, and the fruit is natural to disease and affects the aromatic alcohol of wine. In the dry winter season, the glucose produced is high, and the aroma is strong. The low temperatures in winter are suitable for winemaking. Due to the high acidity of the winter grapes, sometimes the promotion was retarded. Hu [2] investigated the difference in acidity of grapes in different production periods and examined the effects of potassium ion concentration on acidity by using four different potassium sulfate rates. "Black grapes are affected by factors such as variety and planting environment, and high acidity cannot produce good quality red wine." Hu [3] uses lactic acid bacteria to ferment malolactic acid to reduce the sharpness of the wine. Author compared effects of fermentation inoculation time on quality. The consumer evaluation score had improved.

The effect of red wine fermentation on the fate of seven fungicides and three insecticides had investigated. "Dicofol had a significant inhibitory effect on the catabolism of malic acid, whereas chlorothalonil, chlorpyrifos, and fenarimol had a minor effect [4]."

Data provided on the formation of histamine and tyramine during the winemaking process of five Spanish wines. Small amounts of tyramine formed in the five wines during alcoholic fermentation. The number of added sulfur dioxide seems to have a more significant influence [5] on tyramine formation than on histamine formation.

B. Related Machines for Brewing Wine

As shown in Fig. 1, many winemaking facilities had proposed. In [6] uses local fruit, from planting hops and grains to pruning [6]. A kit apparatus adapted for home by simplified processes. It comprises a rigid container in the form of a barrel provided with upper and lower halves. A pair of flexible plastic bags adapted for accommodation to a bung hole in one-half of the barrel [7] for fermentation.

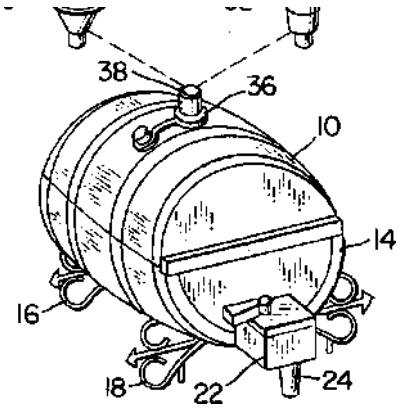

Fig. 1. Winemaking by simplified processes [7].

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Smart machine integrates micro-controller technology and art of red wine. The intelligent brewing machines consist of sealing, brewing, control and monitoring system [8]. Miracle Machine [9] is an affordable winemaker for the home. The fermentation chamber produces wine with five steps over three days. A mobile app is used to guide users and monitor the fermentation process (Fig. 2).

In the beginning, the app prompts ingredients required for fermentation and flavor development [10]. Chamber drives by electrical sensors, transducers, heaters to maintain an environment for fermentation stages. The app monitors the water, concentrate, and yeast sitting in the chamber. It will send an alert that the wine is ready to drink. Ultrasonic transducer underneath the chamber resonates to speed up the flavor development.

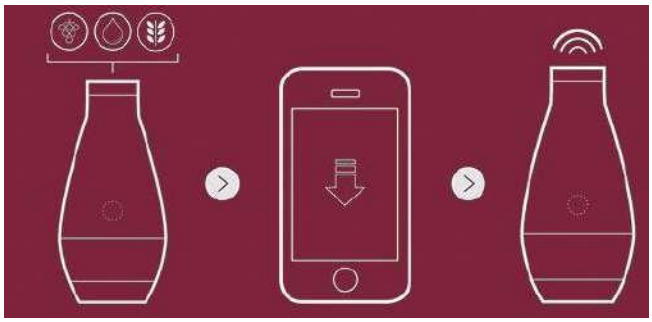


Fig. 2. Smart winemaking device for the home [9].

Fig. 3. The ALCHEMA is a hard cider making system [11].

The ALCHEMA is a hard cider making system for the home that turns fresh fruit into hard cider, mead, beer-like cider (Fig. 3). Built-in weight sensor automatically tells a user how much ingredients to use [11]. The UV-C LED sanitizer cleans the contamination; the sensors measure temperature, pressure, and alcohol content. When the detected CO_2 excess the limit, the pressure relief valve will discharge excess carbon dioxide.

II. Product Design

Different tools are used to accomplish the essential steps of brewing, sterilization, fermentation, distillation, and filtration in brewing equipment. Every stage requires a careful operation, so the success rate is different from person to person. This design proposed a proper fermentation tank which can distill and cool to get the desired wine.

Sensing sufficient temperature for yeast is about 13 to 23 degrees C. The enzymes required for different fruit wines with a suitable working temperature. If the temperature is high, it causes the acetic acid bacteria to become active. If there are other bacteria during the brewing, an air bladder pattern appears on the surface of the alcohol and decrease success rate. To keep the contents of the container simple is also a key in brewing. Our design goal is to achieve:

Temperature control makes sure the added yeast species are operating at a suitable temperature. Instead of using hand-pick, the fruit juice is squeezed out with a presser. Combined with the setting of the personalized menu, the user can change the parameters of the fermentation according to needs and preferences.

A filtering function is provided to separate the fermented juice (some of which has turned into wine) from the peel and impurities. For example, white wine can be filtered immediately after pressing to prevent the color of the grape skin spreading into the juice. The broken fruit peels generate the bitter taste from the crushed seeds.

The wine produces carbon dioxide during fermentation which causing bottle was bursting. The installation of the unloading valve and the modular container can reduce the problem.

A. Concept

From the conceptual sketch I, the structure comprises a brewing storage layer, a brewing sensing layer and a fermentation control loop. A corresponding amount of water is prepared in the brewing vessel and placed in the brewing vessel (Fig. 4). The user can adjust the fermentation conditions on the touch panel: set the sweetness or alcohol concentration of the wine. According to personal preference, the fermentation reaction completed at the right time. Small weight pressured valves uses for internal gas pressure control.

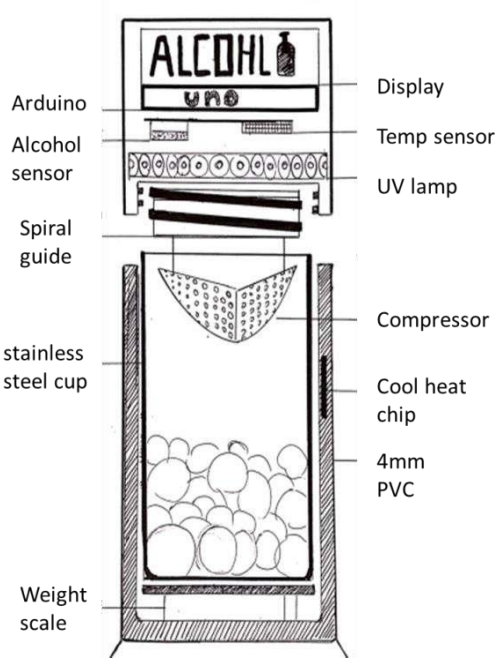


Fig. 4. A conceptual sketch I.

The average user can make wine at home with low-cost

equipment. A brewing ripening detection device is provided, including a detecting unit, a gas concentration detector, a solenoid valve element and a linear actuator — the processor connected to the valve and the detecting unit. When the solenoid valve element opened, the generated gas can be released.

The various components integrated into the chassis. As conceptual sketch II, compressors (Fig. 5) extracted the grape juice by a press and rotate. A weight meter provided below to sense the amount of raw materials. There are sensing modules and control units above and the linear actuators. An LCD interface is provided on the front panel to perform touch setting of each parameter.

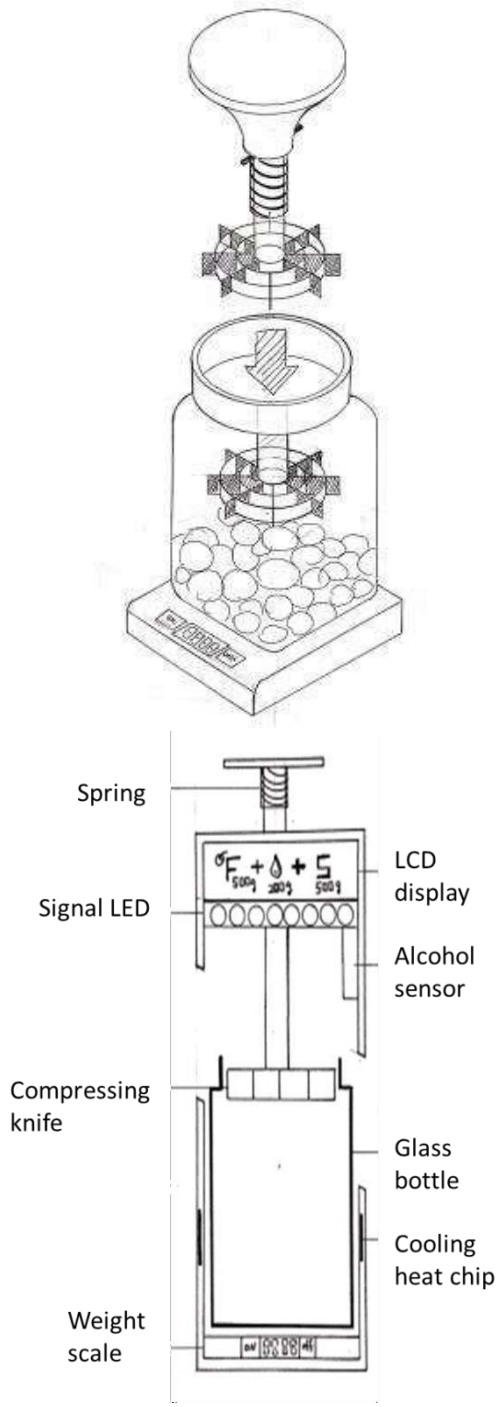


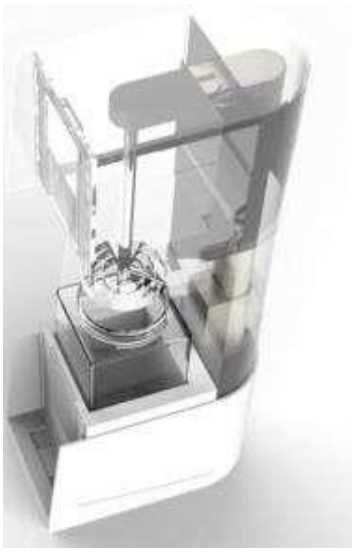
Fig. 5. Conceptual sketch II: use glass containers to avoid complicated leakage problems — the handles made of PVC plastic material. The top opened in a rotating manner, and the base is provided with a soft rubber material to avoid the impact of a collision.

B. Sensor and Control

Different alcohol concentrations also produce different amounts of heat. When the sensor connected to the power supply for heating, the internal resistance of tg130 will change accordingly. The resistance and voltage represent gas content (ppm). Assume Vc is the circuit voltage, Vrl is the output signal, Vh is the hot wire voltage; Rs is sense resistance, Rl is load impedance, and the relationship are:

$$Rs = \{(Vc*Rl)/Vrl\}-Rl \quad (1)$$

The linear actuator provides vertical movement of presser (Fig. 6, 7). The sensing components base on the Arduino. Android includes a C/C++ library that can be used by different parts in the system. Fig. 8 shows a TGS822 gas sensor which detects changes in gas concentration and connects Arduino through the analog input port. The output port activates the valve while the level of input port changes. Because Arduino is cheap, it has been integrated into environmental sensing, wireless communication, and transmission components, and used in the industry. When the concentration changes, the alcohol sensing module changes via the internal voltage (the higher the level, the higher the voltage). The concentration data through the Bluetooth module activates the subsequent responses.



(a)

(b)

Fig. 6. Components and efficacy (a) container and pressor, (b) fill ingredient and operation.

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Fig. 7. Linear actuator.

Fig. 8. Sensor modules.

III. Prototyping and Testing

A. Prototyping and Installation

Touch panel adjustment and installation of brewing, hot wire voltage, induction resistance configuration. The steps of the fermentation determined by the program loops of the Arduino processor. As shown in Fig. 9, the primary challenge of prototyping is the installation of the linear actuator — the chassis made by 3D printing (Fig. 10). The detection unit, the electromagnetic valve, and the linear brake release the generated gas to improve the success rate of the winemaking.

(a)

(b)

Fig. 9. (a) Computer rendering of prototyping and (b) installation of the linear actuator.

The methodology of machine operating depended on timing, temperature, and CO_2 concentration. In the fermentation process, personalized brewing promptly refers to personal preferences and experience. The method of fermentation is related to the raw materials, formulas and user preferences used, so he needs to adjust according to experience gradually. The general controller uses circuit design to perform these adjustments, so there is no flexibility. Variability is the most significant advantage of microcontrollers. The microcontroller is composed of a hardware connection and a software setting. Re-feeding the control software can change the behavior of the microcontroller. Simple parameters changed at setup, and complex changes require software modifications to improve efficiency.

The test run result of the fermentation process by using new design showed a better taste without bitterness. The reason is that we remove broken fruit peels and set proper pressure which would not crush seeds. The bottle is secure and safe with unloading valve. After the pressure relief valve activates, the CO_2 concentration level is 412.2 ppm which is slightly higher than the general atmosphere.

Fig. 10. Prototyping: chassis made by 3D printing.

B. Interface Design

The control unit provides an LCD panel for input settings and display. We used graphics icon and placed component reasonably on the board. After the line connection test, the interface control unit connected.

A user can set the required value through the touch interface. The responses of icon, text, or sound allow users to understand the current status.

The user interface menu contains the selection and input of the wine recipe; the amount of sugar added and the amount of water, as well as the current overall weight value (Fig. 11). Through the humidity and ethanol fermentation conditions, we can determine the time of fermentation completion. When turned on, the screw can be controlled to rise and fall, and a beep will sound when the correct position reached.

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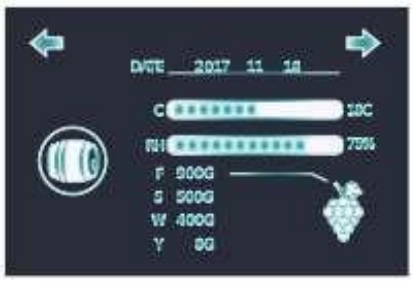

(a)

(b)

Fig. 11. Usability consideration on interface (a) input of the wine recipe, (b) sugar, water, and overall weight.

The usability considerations on the interface are a specific design of icon which reflects its meaning. The image design uses the features of the real object as much as possible to reduce the time recognized by the user. The amount of water represents by an icon of water droplets. Similarly, we use the bucket-shape icon for storage, the irregular crystal-icon for sugar. This design helps the initial user to operate the interface smoothly.

IV. Conclusion

Sensors and actuators were used to accomplish the essential steps of brewing, sterilization, fermentation, distillation, and filtration. The segmentation stage requires a proper setting during winemaking. We implemented an impurity filtration tank which can distill and treat within the machine to get better sterilization and filtration. This integrating made the user adjust the fermentation conditions on the touch panel much more natural. According to personal preference, the fermentation reaction completed at the proper time — the linear actuator used in the vertical movement of a presser. The sensing components sent the signal through the analog port. Icon design helps the initial user to operate the setting smoothly.

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