All Nations University Journal *of* Applied Thought (ANUJAT)
A Multidisciplinary Approach

Volume 6/Number 1 November 2018 Article 9

Auto Homogenizing Feeding Bottle for Experimental Small Laboratory Animals

ARCHIBALD E. D. DANQUAH AMOAH

ARCHIBALD E. D. DANQUAH AMOAH holds a PhD in Rehabilitation Engineering (Biomedical Engineering). He is the Assistant Dean of the School of Allied Health Science at All Nations University, Koforidua, Ghana.

SETHINA AKWELEY ADJETEY

SETHINA AKWELEY ADJETEY is a student in the Department of Biomedical Engineering, All Nations University, Koforidua, Ghana.

DANKYI BERKO

DANKYI BERKO is a student in the Department of Biomedical Engineering, All Nations University, Koforidua, Ghana.

Arcibald, E., D., D., A, Adjetey, S., A. & Berko, D. (2018) Auto Homogenizing Feeding Bottle for Experimental Small Laboratory Animals. All Nations University Journal of Applied Thought, 6(1):144-159.

ABSTRACT

The concept of homogeneity is applicable at every level of sedimentation or complexity, from the smallest atoms to a population of animals or people. Modern technology has not attempt to address the limitations of the automatic stirring of poorly soluble food which has the tendency to sediment during feeding the experimental animals. This calls for intermittently agitation of the feeding bottle to overcome the problem of blocking the teat of the bottle and hinder the flow of the poorly soluble food/drug when the animals suck from the feeding bottle. The reason is that most of the homogenizers are not simple and automated. In this work a mini auto-homogenizer bottle was designed and used to feed the experimental animals to give a dose of solution through integration with an Arduino Uno microcontroller board and mini servo motor. This device stirred efficiently and it can be used for all kinds of poorly soluble foods.

Introduction

Homogenization as a process of achieving homogeneity through a product by particle size modification. The equipment used is called homogenizer which is categorised into three, namely; ultrasonic pressure homogenization, pressure homogenization and mechanical homogenization (. The equipment used is called homogenizer which is categorised into three, namely; ultrasonic pressure homogenization, pressure homogenization and mechanical homogenization. Homogeneity is a concept relating to the uniformity in a substance. Homogeneous material has a uniform composition and that of heterogeneous lacks uniformity in its properties. This concept is applicable at every level of sedimentation or complexity, from the smallest atoms to a population of animals or people.

A large scale substance may be homogeneous, compared to being heterogeneous on a smaller scale within the same substance .Animals have been used in research to understand basic biology, as ‘models' for studying human biology and disease, and as test subject for the development and testing of drugs, vaccines and other biological substances (antibodies, hormones) to improve and advance human health (Greek et al, 2010).Such studies are carried out with the aim of producing artificially in the laboratory, a condition in an animal that may resemble the human equivalent of a medical disease or injury. Through this means, scientists have been able and continue to discover and quantify the impact of a treatment or assess the toxicity of a chemical leading to innovative ways to treat and cure diseases and illnesses (Nails *et a*l, 2009). It said that due to the enormous advantages that the use of isolated organ or cell culture has over whole animal, attention has been turned to their use in similar studies. However, it has been shown that certain studies are best carried out in whole animals and therefore the use of whole animals in research still remains relevant (Murphy,1991).

Administering of substances to laboratory animals is often a critical component of the experimental design. Several substances may be administered including infectious disease agent, therapeutics, pharmacologic agents, electrolytes and other fluids among others. Giving of substances directly into the mouth admixed in diet or other foodstuffs or by or gastric or nasogastric gavages is a common practice in animal medicine and research. The oral route is economical, convenient and relatively safe as some animals can be trained to co-operate voluntarily depending on the compound being administered. Achieving homogeneity with the help of a homogenizer will ensure that mixed solutions are given or administered to the laboratory animals instead of its sediments (Turner et al, 2011) Factors to consider for delivery of substances to laboratory animals are numerous and include the route of delivery as well as solution preparation for the delivery of the substance that cannot be delivered in a solid or particulate state (Lapidus et al, 1998). The essence of this intermittent agitation was to get the soluble foods to mimic the form in which it is often taken by humans. The current work therefore seeks to design a feeding bottle homogenizer that could intermittently agitate solutions with the tendency to sediment during its administering processes feeding animals for a research purpose.

However, the tendency for some substances administered as soluble foods sediment, when left standing for a while, will impede the consumption of the material or food by the animal and this might affect the growth of the animal due to the lack of some nutrients needed but it is in the sediment food. The existing homogenizers do not consist of auto-homogenizer or a mechanism of that sort to accomplish or achieve the periodic agitation of soluble food. Currently, those available are of high speed or pressure and the most widely used are the blenders, food processor, laboratory homogenizer (Mindak et al, 2014). The designed auto-homogenise feeding bottle in this research will eliminate the need for human hand in stirring agitation of the bottle to get its contents well mixed and therefore make the substance administration process less laborious. Additionally, late hours or night administration or feeding of animals will be achieved with ease. The auto homogenize bottle in this work helps to administer uniform doses of poorly soluble foods or drugs solutions to laboratory animals at all times.

Materials and Method

Materials

Table : List of components

S/n	Item/Material	Description/ Specification	Quantity
1	Plastic Bottle	500ml	2
2	Arduino uno board		1
3	Servo motor		
4	Wires (jumper/others)	-	Various
5	Stainless steel rods & slaps/flap	-	Various
6	USB Cable	-	2
7	9v DC Battery	-	1
8	Laptop PC with Arduino software (IDE) installed	-	1
9	Wooden cage	-	Various

Arduino Uno Microcontroller Board

Arduino Uno is a microcontroller board developed on the ATmega328P microcontroller. It has 14 digital input/output pins, 6 analog inputs, a 16

MHZ quartz crystal, a USB connection, a power jack, an in-circuit serial programming (ICSP) header and a reset button. Six (6) of the I/O pins can be used as pulse width modulation (PWM) outputs. The board can be programmed with the Arduino Software (IDE). The ATmega328 on the board is already pre-programmed with a bootloader that allows uploads of new code to it without any external hardware programming. Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode, digital Write and digital Read functions. The pins operate at 5 volts; can provide or receive 20mA as recommended operating condition. However, each pin has an internal pull-up resistor (disconnected by default) of 20-50kΩ as a fail-safe measure; but a maximum of 40mA must not be exceeded to avoid permanent damage to the microcontroller.

Table : Main technical specification of Arduino Uno microcontroller board

Main Characteristic	**Value/Range**
Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20Ma
DC Current for 3.3V Pin	50Ma
Flash Memory	32KB (ATmega328P) [0.5KB used by bootleloader]
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHZ
Length	68.6 mm
Width	53.4 mm
Weight	25g

Table 3: The technical specification and operating condition of servo motor

Main Characteristic	Specification
Rated Voltage	5.0V
Operating voltage	2.2 – 6V DC
Rated current	90Ma
Rated load	Counter weight
Rated speed	7,500 rpm
Rotation	CW (clockwise)
Motor position	All positions
Operating conditions	-30 - 70 °C, ordinary humidity
Mechanical noise	50db (A) max.
Insulation resistance	1MΩ min.
Mass	2.30g.

Pulse Width Modulation (PWD) in Arduino Board

The output pins send a current to any device connected to them, such as a motor or a light bulb. Unlike pins used for input, there are only two possibilities for the voltage: 5V or 0V. Gradually changing the speed of a motor requires a continuous change in voltage, which is not possible with any ordinary output pins. Hence the Arduino's special output pins dedicated to pulse width modulation. Instead of ranging over many voltages, the voltage rapidly changes from 0V to 5V. Essentially, PWM simulates a gradual change from one voltage to another, allowing for anything connected to the pin to also vary along a continuum. For example, if 5V are being outputted one fifth of the time, this is known as a 20% duty cycle, and the simulated voltage is one fifth of 5V (i.e. 1V). A function built into the Arduino, analog Write (), allows a program to make use of the PWM function simply by plugging in a value ranging from 0 to 255, with the latter being the maximum possible voltage (a continuous output of 5V).

Specifications of Servo Motor

Through the control line the servo motor is controlled, using a yellow or white wire. The signal pulse width is sent to the Servo control wire to determine how the motor will move, either clockwise or anticlockwise. The figure below shows how different pulse widths correspond with different position of the motor. Pulse Width, when is less than 1.5ms the motor will move to the 0 positions and hold and the Pulse Width of 1.5ms the motor will rotate to the 90-degree position. Finally, when the Pulse Width is greater than 1.5 ms gives a motor rotation to the 180 position.

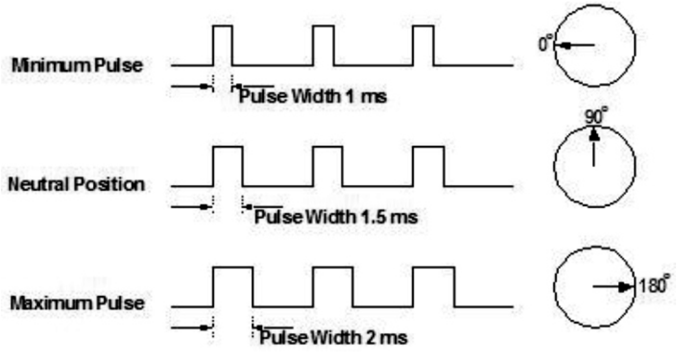

Figure : Pulse charts (PWM) in Arduino using the analog Write () function.

The motor hold at the desired position until the signal is sent to move and it is done in this application using the Arduino 1.0 coding software to write to one of the Arduino UNO's 5 PWM output pins. The PWM output pins on the development board can be written to with different pulse widths which are used to control the motor.

Figure 2: Photo of the servo motor

Design and Construction

The device is made up of hardware and software; as well as components to make it stir effectively.

Hardware Configuration

The device is made up of hardware and software; as well as other components to make it to run.

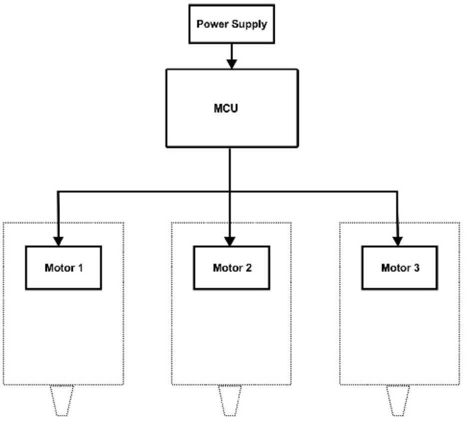

Figure : Block diagram for hardware connection of various units.

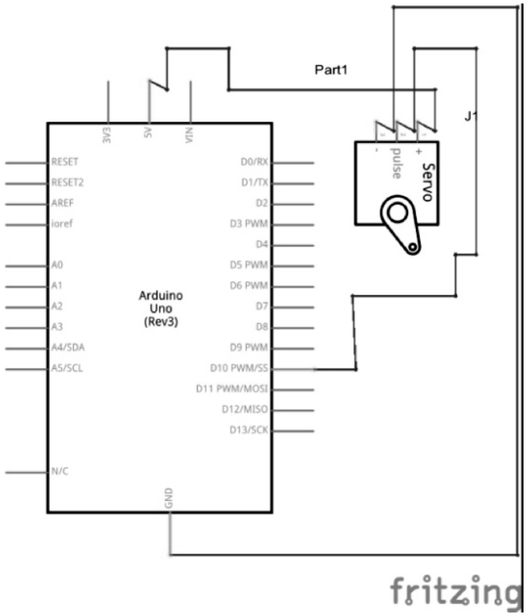

Figure4: Circuit diagram for the hardware.

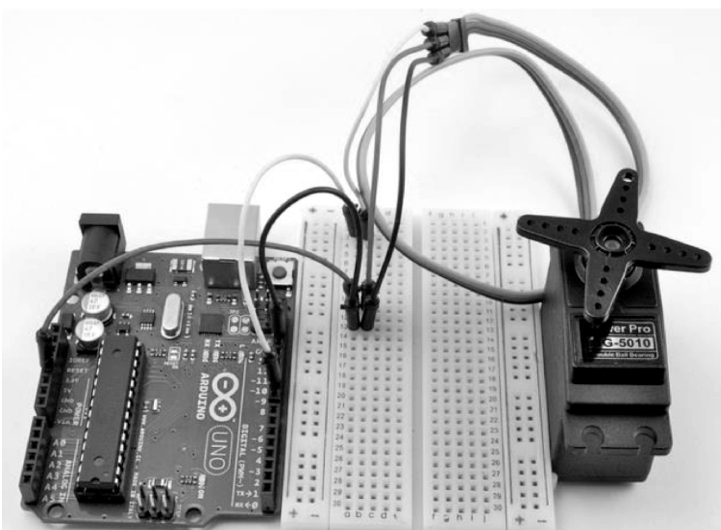

Figure : Photo of electronic hardware connection.

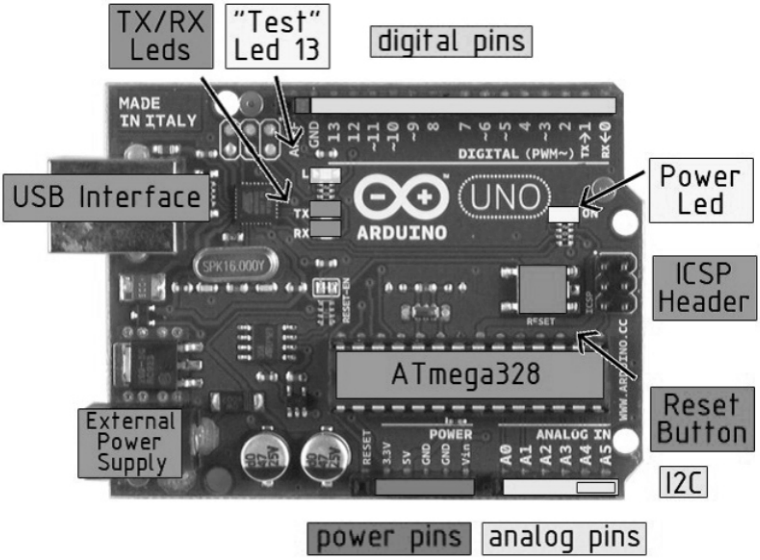

Figure 6: The Arduino Uno microcontroller board

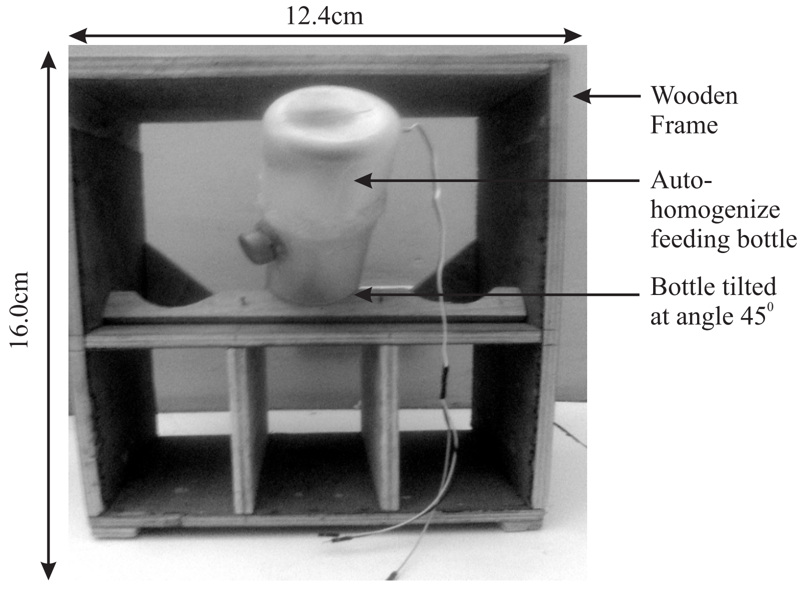

Figure : Photo of wooden frame holding homogenising feeding bottle.

Software Configuration

The finished source code was downloaded into the memory of Arduino Uno board via a USB cable. Figure and Appendix A show the flow chart and source code respectively.

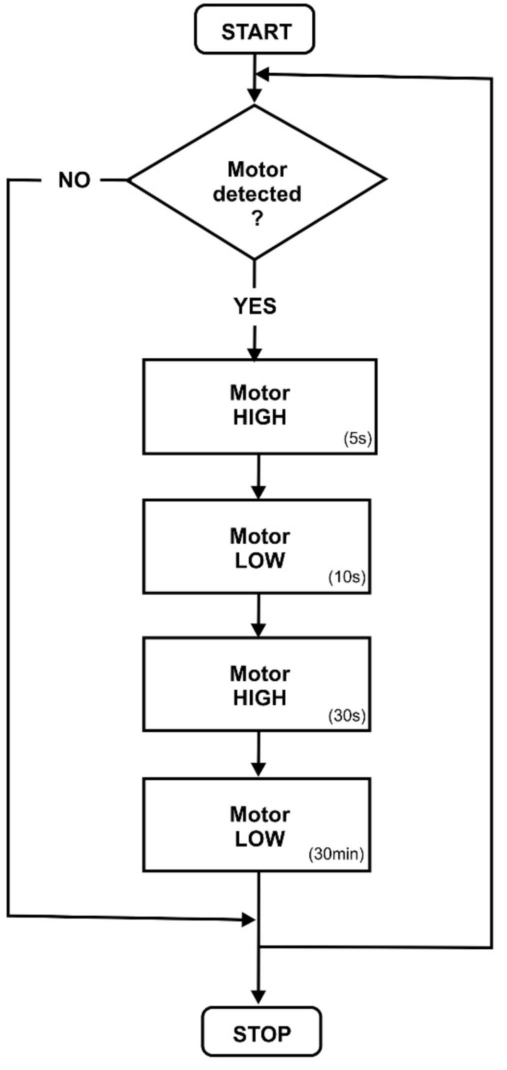

Figure 8: Flow chart for device operation.

Testing and Evaluation

The testing and evaluation for the system was done in the laboratory to monitor its performance and reliability of homogenising of solution. A 400ml food solution is prepared into the auto homogenizing feeding bottle and tilted at an angle of 45^{o} in a supporting wooden structure.

Operation and Function of the Device

The designed device was constructed properly with a plastic bottle consisting of two chambers; the motor chamber and the solution chamber. Within the solution chamber there is a stirrer which does the stirring. There is a junction separating the motor chamber from the solution chamber. It has a jumper wire that connect the bottle to the microcontroller and an input which is the opening. The auto-homogenize bottle has a cork covering the bottle with a long teat of about five centimetres (5cm). The Arduino UNO controls using the code to make the shaft coupled to the motor to successfully stir the liquid. The Servo motor is controlled with an Arduino UNO development board using the software and the hardware approach. The connections are properly done resulting in the running of the Servo motor causing continuous movements as coded. A shaft is coupled to the motor that can be used for stirring different liquid foods. Once Arduino Uno receives the pulse, it uses the coded to operate the motor causing solution to be stirred at different time interval. The delay time was kept constant at 30min with variable volume. At the volume of 100ml, the device function was moderate due to the low level slightly below the stirrer.

Results and Discussion

Results

The Feeding Device

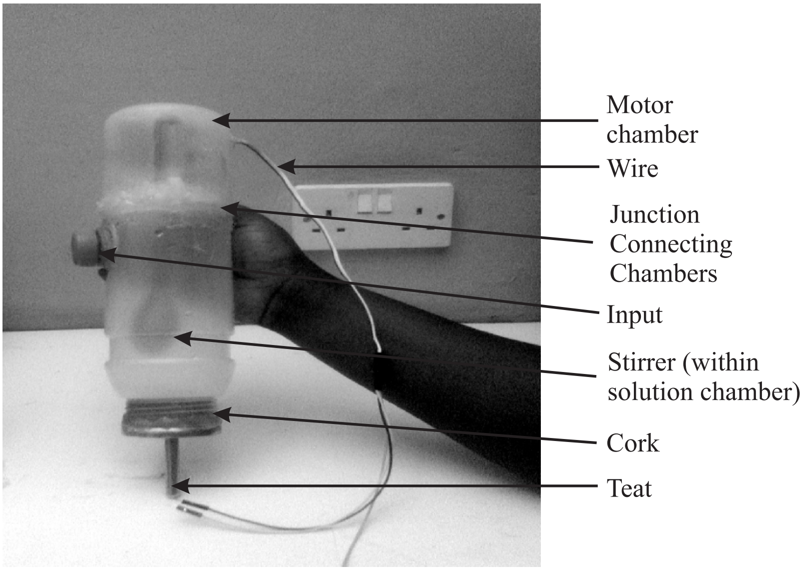

Figure 9: **Photo of the homogenize bottle (device).**

The Output of Evaluation

Table 4: The output of homogenizing bottle.

Fluid Volume /ml	Delay (settling) time/min	Active motor rotation	Effective fluid mixing
500	30	Yes	Yes
400	30	Yes	Yes
300	30	Yes	Yes
200	30	Yes	Yes
100	30	None	None

Figure 10: Photo of small animals feeding on the auto-homogenize feeding bottle

Figure 11: Photo of small animals sucking from non-homogenize bottle

Table 5: Output of homogenizing and non-homogenizing bottle feeding.

Day	Weight of animal	Homogen-ize bottle(1) weight	Non Homo-genize bottle(1)	Homogen-ize bottle(2) weight	Non Homo-genize bottle(2)	Homogen-ize bottle(3)	Non Homo-genize bottle(3)
1	160	160.3	160.0	161.3	160.5	162.1	160.8
2	150	150.8	150.2	151.0	150.8	151.9	151.0
3	180	180.2	180.1	181.1	180.5	182.0	180.9
4	190	190.2	190.1	190.9	190.5	191.6	190.7
5	190	190.3	190.1	191.2	190.6	192.1	190.8
6	170	170.7	170.0	171.0	170.5	172.5	171.0
7	140	140.5	140.1	141.0	140.7	142.0	140.9

Discussion

The table 4 showed how active and effective the auto-homogenizing bottle has worked in mixing the solution at various volume at constant time of 30minutes. In figure 11, the animals were crowded around tip of the device each trying to feed from it. It also showed clearly from table 5, the increase in weight of the animals as a result of the auto-homogenizing bottle feeding compared to the non-auto-homogenizing feeding bottle.

Conclusion

The device was constructed with an appropriate timing circuit on the microcontroller for the motor control. It was tested for control delivery to eliminate the stress of the researcher and frequently agitating the feeding bottle. This help to make regular homogenization practicable at all time. The device is light in weight, small in size and friendly to the user. The device is easily transportable. Those animals feeding from the device showed an increase in weight.

References

Sokpor, G., Addai, F.K., Gyasi, R.K., Bugyei, K.A., Ahenkorah, J. And Hottor, B. (2012) Voluntary ingestion of natural cocoa extenuated hepatic damage in rats with experimentally induced chronic alcoholic toxicity. Functional foods in health and disease, 2(5):169.

Greek, R. & Shanks, S. (2009) Animal Model in Light of Evolution. Boca Raton, FL: Brown Walker Press.

Murphy, H. C. (1999) The use of whole animal versus isolated organs or cell culture in research. Transaction of the Nebraska Academy of sciences, XVIII: 105-108.

Turner, P.V., Brabb, T., Pekow, C. and Vasbinder, M. A. (2011) Administration of substance to laboratory animals: Routes of administration and factors to consider. Journal of the American Association for Laboratory Animal Science, 50(5): 600-613.

Alchibald B. (2009) Evolving products in the homogenization field. America Biotechnology Laboratory.

Allen V, Povich G.N, Ansel's H.C. (2004) Ansel's Pharmaceutical Dosage Forms and Drug Delivery System. 260-263.

Robinson J.R, (1987) Controlled drug delivery. 2^{ND} ed. Marcel Dekker, 4-15.

Lipidus H, Lordi N.G (1998) Studies on controlled Release Formulations. Journal of Pharmaceutical Science.1998; 57:1292-1301

Mindak, R., Jacobs, M., Capar, G., Cunningham, C. (2014) Elementary Analysis Manual for Food and Related Products. *FDA U.S. Food and Drug Administration*. Pp 2-4

Jack J. (2008) Robotic Platform 1kg Motor Controller Timing Research. *Motor Controller Timing Research*.