International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

# Design of Affordable 3D Food Printer for Customized Chocolate Making, Health and Nutrition.

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**A B S T R A C T**

3D food printing is an expanding field in food science and technology. This technology utilises edible materials like chocolate to create culinary creations layer-by-layer. Such applications include intricate decorations, customised chocolates for dietary needs, and the exploration of textures and flavours. This is an affordable 3D food printer designed to provide rural communities with greater access to earning a living from it. This technology has the potential to transform home cooking, redefine dining experiences, and address global food challenges.

**Keywords:** 3D Food Printing, Edible materials, Culinary arts, personalised nutrition, food technology.

## 1. Introduction

3D food printing has brought a revolutionary leap to culinary technology. It changes how we perceive, create, and consume food. This cutting-edge innovation combines principles of additive manufacturing with the realm of gastronomy to allow for the construction of edible creations layer by layer. This introduction explores the origins and mechanics of 3D food printing.

### Origin and Evolution

The origins of 3D food printing can be traced back to the more widespread field of 3D printing, also known as additive manufacturing. First developed with non-edible purposes, applications of 3D printing found their way to various industries-from aerospace to healthcare. The idea of printing gradually evolved through exploration by researchers with the possibility of using edible materials in the printing process. The fusion of technology and culinary arts gave birth to 3D food printing, a groundbreaking convergence that continues to evolve.

### Mechanics of 3D Food Printing

At its core, 3D food printing works much like traditional 3D printing, but the materials are edible, such as chocolate and sugar. The process typically nbegins with a digital model or design that is then translated into a series of precise instructions for the printer. As the printer layers on successive layers of edible material, intricate and customised shapes begin to take shape. Improvements in nozzle technology, material formulation, and printing precision contribute to the artistry achievable with 3D food printing.

## 2. Structure

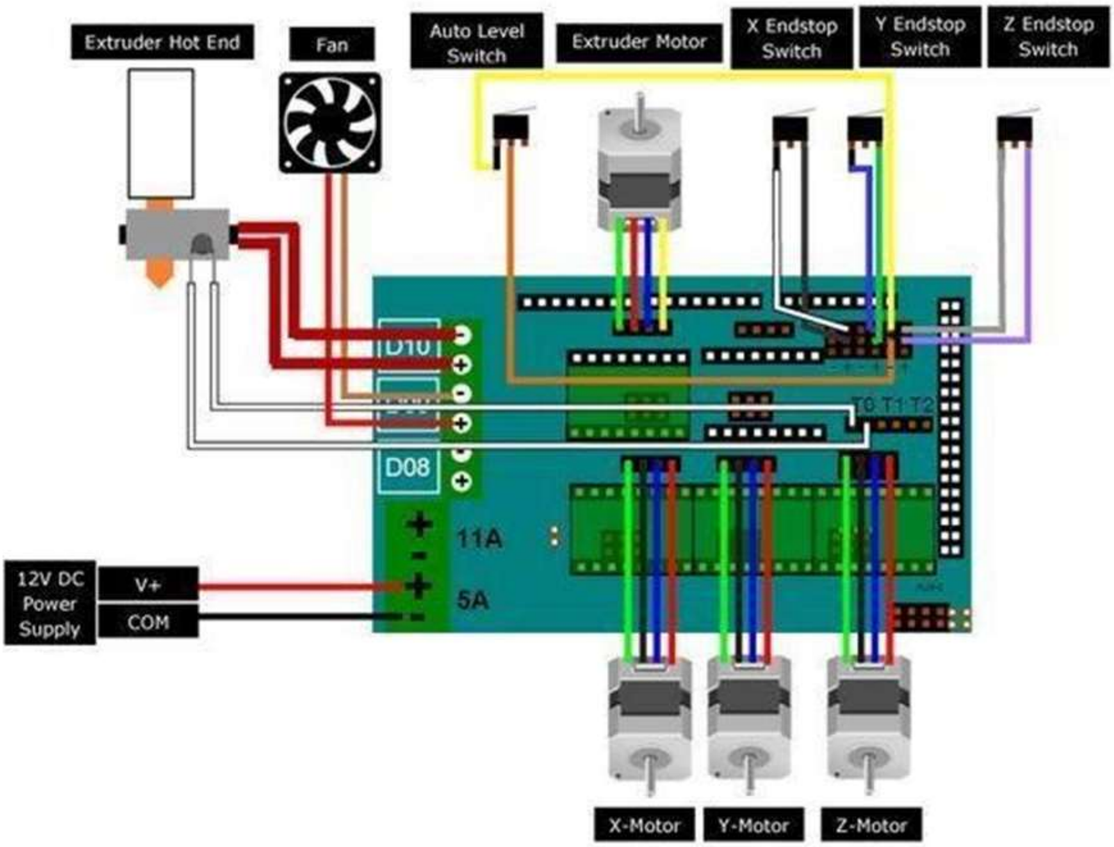



Fig 1.1: Circuit diagram

As shown in the circuit diagram, the project consists of the components and their connections in this 3D printer wiring diagram are as follows:

- **Auto Level Switch:** This switch is used to automatically level the print bed to ensure a flat surface for printing.
- **Extruder Motor:** This motor drives the filament through the extruder, pushing it towards the hot end.
- **X, Y, and Z Endstop Switches:** These switches are used to define the physical limits of the printer's movement along the X, Y, and Z axes.
- **X, Y, and Z Motors:** These stepper motors control the movement of the print head along the X, Y, and Z axes.
- **Power Supply:** This provides the necessary power for all the components of the printer.
- **Control Board:** This is the brain of the printer, responsible for controlling all the components and executing the printing process. It typically has connectors for the motor drivers, end-stop switches, and other components.

**Overall Function:**

The control board receives instructions from the computer and coordinates the movement of the print head, the extrusion of filament, and the heating of the hot end to create the desired 3D object.

## 3. Methodology:


The given flow chart outlines the various steps involved in the process of building a 3D food printer. The first step, defining project objectives, forms the foundation of the project, as it involves extensive planning and research to determine the feasibility of the project. The next step involves the literature review that is required to know more about the existing technology of the food printers. After the literature review, material selection takes place where the component materials are selected. Then, the hardware design is made, once the design is ready, various components are collected, and then assembly takes place, where they are put together to form the final product. Next, the Food safety measures are taken care of, that is, all the materials and components are checked to see if they are safe to be used for food. After completion, the system undergoes extensive testing to ensure that it functions as intended.

### *3.1 Working:*

The process begins by turning on the switch, which activates the power supply and initiates the operation of the 3D food printer. Then, connect the printer to the laptop and open the Ultimaker application. Using the Ultimaker applications, we can trigger the end switches by bringing the stepper motors X, Y & Z to their minimum position. While doing this, the stepper motors should be kept off.

While keeping the stepper motors off, we have to remove the extruder from the frame and fill it with chocolate as per our requirement. Once the extruder is filled with chocolate, place it back in the frame. Now, we have to select the design we want to print from the Ultimaker application and proceed with printing through the ultimate application.

Once the printing is started, the extruder prints the design we've selected on the aluminium bed. The aluminium bed consists of two Peltier modules, one is used for heating the chocolate and the other one is used for cooling it. As the chocolate gets printed on the bed, the Peltier module helps it to cool and freeze it to the shape it has been printed. This saves the cooling and setting time of the chocolate.

## 4. Components used:

**PSU or Power Supply Unit:** The Power Supply Unit (PSU) supplies power to all the electronic components in the printer. This unit is a transformer and rectifier that steps down AC power and converts the lower-power AC to DC. A PSU is connected directly to the motherboard, which then directs the power to all the relevant components. Upgrading a PSU is often required if new components are added to the 3D printer that has higher power requirements. Take care not to replace the PSU without first confirming that the motherboard can handle the increased power.

Fig 4.1: Power Supply Unit

**Motherboard or Controller Board:** This is the main hub to which all of the electronic parts of the 3D printer are connected. The key parts of a 3D printer motherboard are given below:

- Software used: ULTIMAKER
- Connectors
- Stepper motors Drivers
- Communications

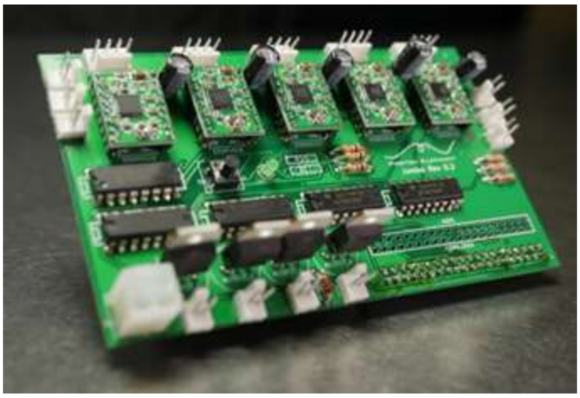


Fig 4.2: Motherboard

**Frame**: The frame of a 3D printer is where all the different mechanical 3D printer parts are connected, including the motherboard. The frame is made mainly from aluminium and plastic.

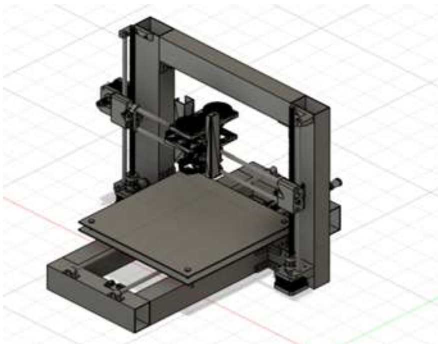


Fig 4.3: Frame

**Extruder:** As the motor rotates, the gear-1, which is attached to it, also rotates and transmits power to the pinion, which in turn transmits power to gear-2, which is attached to a piston and cylinder arrangement. When the piston moves downwards, the chocolate is extruded from the cylinder. The material used is food-grade plastic.

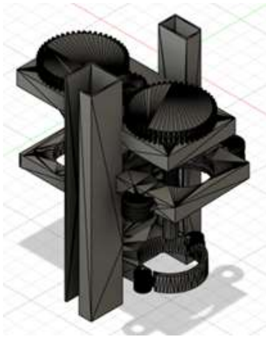
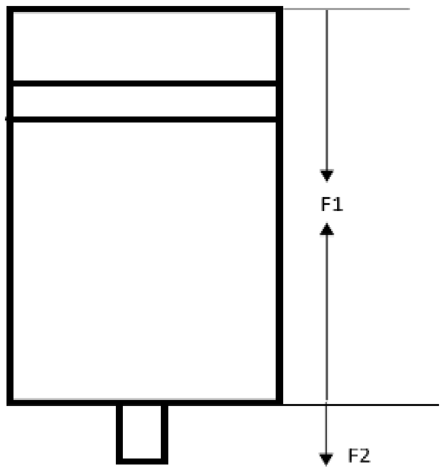


Fig 4.4: Extruder

**Four Stepper Motors:** Stepper motors are required to provide precise control over movement and positioning. They work by rotating in small, accurate steps, making them ideal for applications requiring exact motion. 3 Stepper motors control the movement of the print head and the build platform along the X, Y, and Z axes to ensure precise placement of material. The fourth Stepper motor is used to control the movement of the piston in the extruder.

***DESIGN CALCULATIONS***




F=πr4ΔP/8L eqn 5.1

F1=F1+F2 eqn 5.2

F1= πr4ΔP/8L

F2 =Will be neglected because the force acting too small. F=F1+F2

F2 =0

F1= $8\times\mu\times Q\times((L/r) + (L\ (\text{small pipe}) \times r^2/r^4(\text{small pipe})) + \pi\times \text{pfinal}\times r^2$ eqn 5.3

$=8\times17\times4.07\times10^{-3}\times((0.19/0.036+0) + \pi\times100\times0.036^2$

= 3.32N

T=F×r eqn 5.4

=3.32×0.036

=0.1195Nm

By the above torque, we have selected standard stepper motor NEMA 17, which is 0.411 N-m, which is near to the above value of torque.

We have viewed the specification of the NEMA 17 stepper motor, which generates a power of 11.5 kW

**Calculation of Gears.**

Gear is used for the different raw materials

**Given**: N1=3000rpm, d2=25mm, d1=85mm, Z1=8

1. i = d1/d2 eqn5.5

= 85/25

=3.4

i = n1/n2

3.4= 3000/n2 n2=880 RPM

2. n1/n2 = z1/z2 eqn5.6

3000/880 = z2/8 z2 = 27.25

by referring to the standard no. of teeth from the data handbook z2 = 32

3. Torque on gear eqn5.7

mt = [P×9550/n2] × Cs

$= [11.5 \times 9550/880] \times 1.25$

$= 156$ Nm

4. Power

$P=2\pi N2T/60000 \times CV$ eqn 5.8

$=2\times\pi\times880\times156/60000\times1.25$

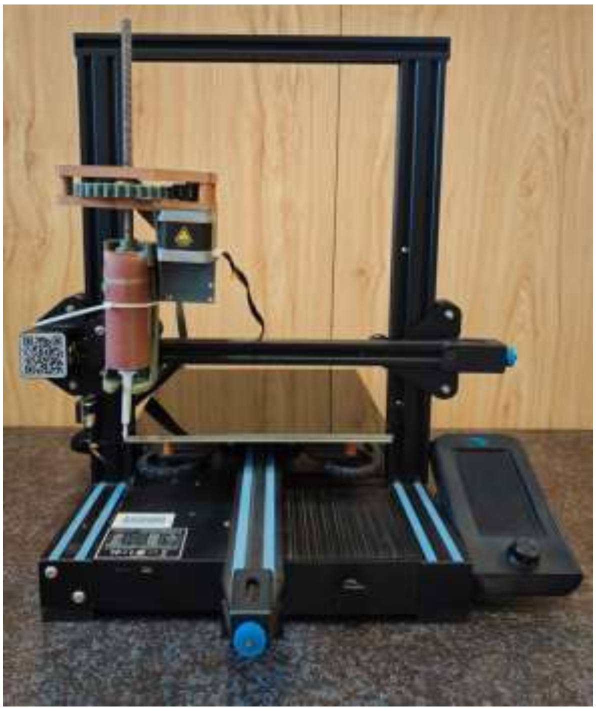
$=11.50$ KW

***4.1 Existing system:***

Existing 3D food printers demonstrate the capabilities and possibilities of the technology. Consumer-focused companies like Natural Machines offer products like the Foodini, which can prepare a wide range of dishes from fresh ingredients. Other companies, such as Choc Edge, focus on specialised materials, like chocolate, to create intricate and artistic works. Research institutions and food tech startups are also working on innovative 3D food printing technologies. There are printers for specific applications, such as making customised nutrition for individuals with special dietary needs or the development of sustainable and plant-based food alternatives. The existing 3D food printers show that this technology is a game-changer in how we produce, consume, and experience food.

## 5. Results:

- In Elevating overall efficiency, 3D food printing is indeed revolutionising the food industry by enhancing efficiency in several ways
- 3D food printers can operate continuously and produce food items quickly and consistently.
- This can lead to faster production times and increased efficiency in food manufacturing processes
- 3D food printing allows for the creation of customised meals tailored to individual dietary needs and preferences.
- This means that food can be designed to meet specific nutritional requirements, which is especially beneficial for people with dietary restrictions or health conditions.
- Traditional food manufacturing processes often result in significant waste due to overproduction and the need for uniformity in product shapes and sizes.
- 3D food printing minimises waste by producing only what is needed, and it can create complex shapes that might not be possible with conventional methods



## 6. Conclusion:

In conclusion, 3D chocolate printing offers an attractive blend of culinary creativity and technological innovation. With precise control over layer deposition, intricate designs can be brought to life, promising a delightful and customisable experience for chocolate enthusiasts and bakers. It helps with livelihood for rural people as it is affordable and easy to use. People with specific dietary needs can use this 3D food printer to customise their chocolates according to their needs with intricate designs.

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