Development of Vegan Meat from Palymrya Sprouts and Investigation of Temperature Using IoT-Based Sensors in Packaging

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Abstract

Plant-based meat alternatives are food products made from plant-based ingredients that aim to imitate the taste and texture of meat. Due to high fiber content, palmyra sprouts are able to curb hunger and prevent overeating. Demand for veganism can be managed by palmyra sprout vegan meat. To that developed product, Temperature is an important factor in determining the shelf life of a product. Deviation in temperature profile can result in growth or survival of microorganisms, which cause spoilage of food. Temperature fluctuations can be determined using temperature indicators. Unlike other traditional TTIs, which only provide a visual indication of the elapsed time and temperature, an IOT based temperature monitoring system can transmit data wirelessly to a remote monitoring system, allowing for real time monitoring and tracking of temperature and time conditions during storage and transport. An IoT-based TTI typically consists of a sensor that measures temperature and time, a microcontroller that processes the data, and a wireless communication module that transmits the data to a remote monitoring system. The data can be accessed and analyzed using a web-based interface or a mobile app, providing a convenient and user-friendly way to monitor temperature and time conditions for perishable goods.

Keywords: Palmyra sprout, vegan meat, temperature, remote, tracking, sensor.

1. Introduction

As of recent years, India ranks first in the world with nearly 122 million palmyra (*Borassus flabellifer)*. There are many palm trees found in Andhra Pradesh, Tamil Nadu, Bihar, and Orissa, but more palms are found in the southern half of the country as shown in figure 1.1. Palmyra has a great deal of economic potential and every part of them is useful in one way or another. Due to widespread utilization of its parts, such as trunk, nuts, and flesh, the palmyra palm is a miracle plant[4]. The shelf life of many food products depends on the temperature changes, any fluctuation may lead to spoilage of food, mainly high moisture foods like meat and its alternatives.

In order to solve these problems, Temperature monitoring system is developed for the transportation of our newly developed food product (palmyra sprout vegan meat).[9]This system will help in quick and easy transfer of data at any remote locations. Interchange of gases Carbon dioxide, carbon mono-oxide of any product can also be detected along with Humidity level. To begin with, Vegetables are cooked along with this product to give a whole instant meal. Researchers appear to be quite interested in this subject because there is now no viable alternative for meat, which is more plant based, and takes less time for the preparation, easy storage and sustainability than meat. This study gives comprehensive information on the Temperature system which affects the new product in order to provide appropriate solutions and as part of waste management.[3] Palmyra sprouts are widely accessible in the market and are used seasonally to manufacture vegan meat that is ideal for cooking after reaching the consumer.

In continuation with introduction, IOT temperature monitoring systems can be used to ensure that perishable goods are stored at the correct temperature during transportation and storage.[2] This can help prevent spoilage and foodborne illnesses.[8]

2. Related Work

Meat substitutes are culinary items that are manufactured from plant-based ingredients or from other non-meat sources but are intended to taste and feel like meat. Today's market offers a wide choice of meat substitutes. Since more individuals are turning to plant-based meals for ethical, environmental, or health reasons, meat replacements have grown in popularity.This system enables food businesses to ensure that their products are stored and transported at the correct temperature, which is essential for food safety and quality. Wireless temperature sensors are placed in food storage and transportation containers to monitor the temperature of the food.[5] The sensors communicate with a central hub, which collects and analyzes the data. Humidity level depends on the temperature changes. Gas release and temperature are closely related in food, as temperature can affect the rate and extent of gas release from food products.[1] Initially developed with only temperature and humidity sensors. [7]

3. Methodology Preparation of Palmyra Powder:

Palmyra sprouts are collected from local markets of Sathyamangalam. Palmyra sprouts are washed to remove dust and mud from the surface of the skin. Then it is peeled and sliced into thin slices for blanching. Blanching is done by immersing yam slices in hot boiling water at the temperature of 70°C for about 5-6 minutes. Then weighed and placed in the tray for drying. Trays are placed in the cabinet dryer for 5 hours at the temperature of 80°C. Initial weight of the Palmyra sprouts are 200g and the final constant weight obtained as 61g.The sample is monitored at the specific interval to ensure uniform drying. The powder produced by cabinet drying gives brighter color. The sample is then powdered using a mixer grinder. The powder is sieved using a sieve shaker to obtain fine powder. The particle size of the powder is 180 μm and 250 μm. The obtained powder is stored in low density polyethylene zip lock bags for further processing. Samples are homogenized in different compositions of materials with high pressure.

Aqueous Extraction:

Below chart (Figure 1 Process flow of aqueous extraction) gives a glimpse on the process carried out for the reduction of bitterness in palmyra powder.

Fig. 1. Process flow of aqueous extraction

Proximate Analyses of Palmyra Sprout Powder

Determine the crude protein content by the Kjeldahl method. This involves digestion of the sample with concentrated sulfuric acid and the measurement of the resulting ammonia by titration. Determine the crude fat content by the Soxhlet method. This involves extraction of the sample with an organic solvent, followed by evaporation of the solvent and weighing the residual fat.[6] Determine the crude fibre content by the acid and alkali digestion method. This involves digestion of the sample with acid and alkali, followed by washing and drying to isolate the fibre. Determine the ash content by incinerating the sample at a high temperature until all organic matter has been burned off. The residue is then weighed and expressed as a percentage of the original sample weight. [10] Once the above steps have been completed, the proximate composition of the Palmyra sprout sample can be calculated as follows which is shown in table

4. Experimental Results

Preparation of Vegan Meat:

The preparation of vegan meat can vary depending on the specific type of meat substitute you wish to create. Here is a general overview of the process: choose a protein source: There are several plant-based protein sources to choose from, such as palmyra sprout powder.[11] Select binding agents: Plant-based binding agents can include wheat gluten. This ingredient helps to bind the protein source and give it a meat-like texture. Corn lecithin as an emulsifier Preparation method: Seitan is prepared by kneading wheat gluten with water and palmyra powder and seasoning to make a dough, steaming it at 60 degree Celsius as shown in the figure 2. Keep in mind that making vegan meat substitutes from scratch can be time-consuming, and can be a more convenient and time-saving alternative.

Fig. 2. Experimental procedure for the preparation of vegan meat

Fig. 3 The visible spoilage difference in three temperatures after 10 days (a) Room temperature (b) Freezer (-10 degree Celsius) (c) Refrigeration temperature (7 degree Celsius)

(a) (b) (c)

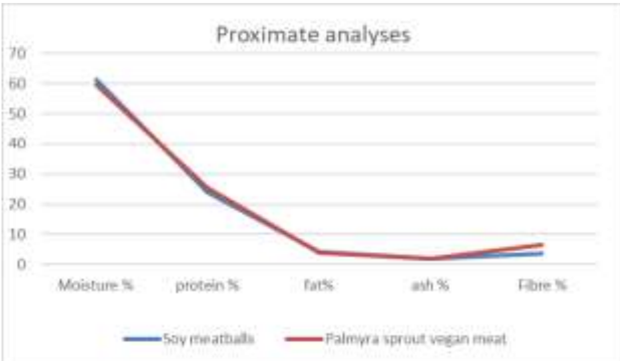
Microbial Results

A 10-gram sample of the vegan meat product is taken and homogenized in 90 mL of sterile diluent solution to create a 10^-1 dilution. From the 10^-1 dilution, a 1 mL sample is transferred to a sterile plate, and serial dilutions are made up to 10^-6. 0.1 mL of each dilution is then spread onto agar plates using a sterile spreader. The agar plates are then incubated at a suitable temperature (e.g. 35-37°C) for 24-48 hours, depending on the test method. After incubation, the colonies on the agar plates are counted. Let's say that we count 45 colonies on the 10^-4 dilution plate.

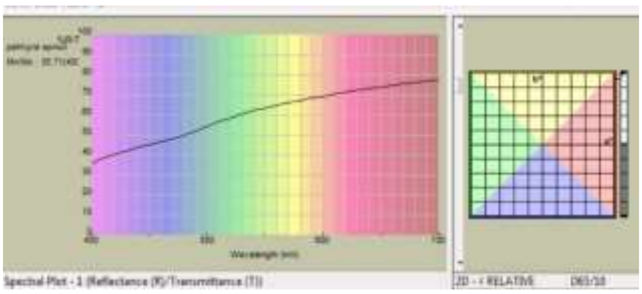
To calculate the TPC, we need to account for the dilution factor. In this case, the 10^-4 dilution corresponds to a 10^4-fold dilution of the original sample. So, we multiply the colony count by the dilution factor to get the TPC per gram of vegan meat. TPC = (45 colonies) x (10^4 dilution factor) / (10 grams of sample) = 4.5 x 10^4 CFU/g

Proximate analysis	Soy meatballs	Palmyra sprout vegan meat
Moisture %	61.28	59.48
protein %	24.09	25.52
fat%	4.29	3.85
ash %	1.82	1.95
Fibre %	3.8	6.44

(a)



(b)



(c)

PROXIMATE COMPOSITION	SAMPLE %
MOISTURE	8.66
FAT	0.07
CRUDE FIBER	7.34
PROTEIN	6.7
ASH	1.24
WATER ACTIVITY (a_w)	0.54

(d)

DAYS	MEAT	STORAGE	COLOUR	FLAVOUR	TENDERNESS	JUICINESS	TEXTURE	OVERALL
0	C	FREEZER	8.33 ± 0.51	8.66 ± 0.51	7.66 ± 0.51	8.16 ± 0.75	8.33 ± 0.51	8.66 ± 0.51
		FRIDGE	7.66 ± 0.51	8.16 ± 0.75	7.33± 0.51	8.33 ± 0.51	8.33 ± 0.51	8.33 ± 0.51
		R T	8.33 ± 0.51	8.66 ± 0.51	7.66 ± 0.51	8.16 ± 0.75	8.33 ± 0.51	8.66 ± 0.51
	NP	FREEZER	8.6	8.2	8.8	8.2	8.8	8.52
		FRIDGE	8.4	8	8.2	7.8	8	8.08
		R T	8.6	8.6	8.6	8.6	8.6	8.6
3	C	FREEZER	7.66 ± 0.51	7.50 ± 0.54	7.50 ± 0.54	7.66 ± 0.51	7.83 ± 0.40	7.50 ± 0.54
		FRIDGE	7.50 ± 0.54	7.66 ± 0.51	7.66 ± 0.51	8.00 ±0.63	8.00 ±0.63	7.50 ± 0.55
		R T	6.33 ± 0.51	6.50 ± 0.63	6.83 ± 0.41	6.66 ± 0.54	5.83 ± 0.51	6.50 ± 0.41
	NP	FREEZER	8.2	7.8	7.6	6.6	8.6	7.76
		FRIDGE	7.8	7.6	6.6	6.6	8.6	7.44
		R T	8.4	7	7.4	6.8	8.6	7.64
6	C	FREEZER	7.66 ± 0.51	7.50 ± 0.54	7.50 ± 0.54	7.66 ± 0.51	7.83 ± 0.40	7.50 ± 0.54
		FRIDGE	7.66 ± 0.51	7.66 ± 0.51	7.33± 0.52	8.00 ±0.63	8.00 ±0.63	7.50 ± 0.55
		R T	6.33 ± 0.51	6.50 ± 0.63	6.83 ± 0.41	6.66 ± 0.54	5.83 ± 0.51	6.50 ± 0.41
	NP	FREEZER	7.6	6	6.2	6.2	7.6	6.72
		FRIDGE	6.6	6.6	6	6	6.6	6.36
		R T	7.6	6	5.8	5.6	6.6	6.32
9	C	FREEZER	7.73 ± 0.51	7.50 ± 0.54	7.66 ± 0.51	7.33± 0.52	7.50 ± 0.54	7.33± 0.55
		FRIDGE	7.00 ± 0.63	7.66 ± 0.51	7.66 ± 0.52	7.16 ± 0.41	7.66 ± 0.52	7.33± 0.54
	NP	FREEZER	6.6	6.2	5.4	5.4	6.8	6.08
		FRIDGE	5.4	5.4	5.2	5.2	5.8	5.4
		R T	5.8	5.2	5.2	5.2	5.4	5.36
12	C	FREEZER	6,50 ± 0.54	7.00 ± 0.63	6.66 ± 0.51	7.33± 0.51	7.33± 0.54	7.33± 0.41
		FRIDGE	7.00 ± 0.63	7.50 ± 0.54	7.66 ± 0.51	7.16 ± 0.40	7.50 ± 0.54	7.00 ± 0.51
	NP	FREEZER	6.2	6.2	5.4	5.4	6.8	6
		FRIDGE	4.8	5.4	5.2	5.2	5.8	5.28
		R T	4.2	5.2	5.2	5.2	5.4	5.04
15	NP	FREEZER	4.8	4.4	4.2	3.6	5.8	4.56
		FRIDGE	4.6	4.4	3.8	3.6	4.2	4.12
		R T	4	3.4	3.2	3	3.4	3.4

(e)

Fig. 4. Proximate analysis (a) Comparison with soy meat balls(b) graph of the comparison (c) Color interpretation (d) Proximate analyses of powder (e) Sensory scores of control and developed vegan meat

Programming Code:

```
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);
#define BLYNK_PRINT Serial
 #include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <DHT.h>
//foodqualitytest2023@gmail.com
//foodqualitytest@23
char auth[] = "izTISVHWAkq5lpAHSZIn-KFwzhTh2_59";
char ssid[] = "IOT";
char pass[] = "IOT12345";
#define DHTPIN D3
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);
#define S0 D8
#define S1 D7
#define S2 D6
#define S3 D5
#define SIG A0          // Decimal places of the sensor value outputs int sensor1;
int sensor2;
```

```
BlynkTimer timer;
void setup()
{
pinMode(S0,OUTPUT);
pinMode(S1,OUTPUT);
pinMode(S2,OUTPUT);
pinMode(S3,OUTPUT);
pinMode(SIG, INPUT);
Serial.begin(9600);
dht.begin();
Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
lcd.init();
lcd.backlight();
lcd.setCursor(0,0);
lcd.print(" FOOD QUALITY ");
lcd.setCursor(0,1);
lcd.print(" MONITORING IOT ");
delay(3000);
lcd.clear();
}
void loop()
{
Blynk.run();
// Channel 0 (C0 pin - binary output 0,0,0,0)
digitalWrite(S0,LOW); digitalWrite(S1,LOW); digitalWrite(S2,LOW);
digitalWrite(S3,LOW);
sensor1 = analogRead(SIG)/4;
// Channel 2 (C1 pin - binary output 0,1,0,0)
digitalWrite(S0,LOW); digitalWrite(S1,HIGH); digitalWrite(S2,LOW);
digitalWrite(S3,LOW); sensor2 = analogRead(SIG)/4;
int h = dht.readHumidity(); int t = dht.readTemperature();
if (isnan(h) || isnan(t)) {
Serial.println("Failed to read from DHT sensor!"); return;
}
Serial.println(t);
Serial.println(h);
Serial.println(sensor1);
Serial.println(sensor2);
Blynk.virtualWrite(V0, t);
Blynk.virtualWrite(V1, h);
Blynk.virtualWrite(V2, sensor1);
Blynk.virtualWrite(V3, sensor2);
if(sensor1>100 || sensor2>100 || t>36)
```

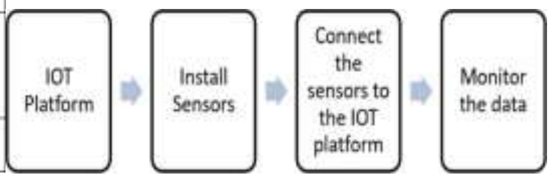
```
{
String a="Food Expired "; Blynk.virtualWrite(V4, a);
}
else
{
String a="Food Wellgood ";
Blynk.virtualWrite(V4, a);
}
}
void lcd_decimal3(unsigned char col,unsigned char row,int val)
{
unsigned int val1,val2,val3,v; val1=val/100;
v=val%100; val2=v/10; val3=v%10;
lcd.setCursor(col,row);
lcd.write(val1+0x30);
lcd.setCursor(col+1,row);
lcd.write(val2+0x30);
lcd.setCursor(col+2,row);
lcd.write(val3+0x30);
}
```

Output for the Temperature Monitoring **System**

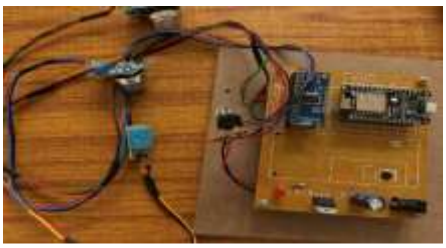
The following figure 5: Results of IOT based wireless temperature monitoring system (a) Parameters of sensors (b) Flow process (c) Implemented output (d) Food quality check

	DHT11SENSOR	MQ7 SENSOR	MQ135 SENSOR
RH	20 – 80 %	Less than 95%	
Temperature	-15 to 50degree Celsius	-20 to 50 degree Celsius	Operating temperature: -20 to 50degree Celsius Storage Temperature:-20 to 70 degree Celsius
Detectable range of gas		20 to 2000 ppm	10 to 1000 ppm

(a)



(b)



(c)

(d)

5. Conclusion

Now a days Fibre-rich veganism has a wide range of scopes and benefits. A diet high in fibre can promote regular bowel movements, prevent constipation, and reduce the risk of digestive disorders such as diverticulitis and haemorrhoids. High-fibre foods can help to promote feelings of fullness, which can reduce overall calorie intake and support weight loss goals. Fibre has been shown to lower cholesterol levels and reduce the risk of heart disease, making it an important part of a heart-healthy diet. Foods high in fibre can slow down the absorption of sugar in the bloodstream, which can help to prevent blood sugar spikes and dips. A high-fibre diet has been linked to a reduced risk of colorectal cancer, as well as other cancers such as breast, ovarian, and prostate cancer. Overall, a palmyra vegan meat that is high in fibre can provide a wide range of health benefits and support a healthy and sustainable lifestyle.

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