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Optimization of Processing Parameters and Ingredients for Development of Healthier Ketogenic Patties Incorporated by Chickpea Hummus and its Quality Evaluation

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***Abstract*:**

The aim of this study was to obtain a ketogenic patties incorporated with Hummus having a healthier lipid profile and optimal cooking properties. It was evaluated on the effect of corn flour content and Rice flour content along with the Cauliflower mash on cooking yield, moisture and fat retention, peroxide value and dimensional shrinkage of cooked Ketogenic patties. The optimized Ketogenic patties were reheated in grill and microwave. Also, nutritional value, cooking properties, lipid profile, sensory evaluation, and product stability during frozen storage of optimized patties were determined. The physico chemical analysis of the patty reported that it was high in proteins and fats and low in carbohydrates. The developed ketogenic patties were analyzed for storage at 28ºC and -18ºC in two packaging materials viz. HDPE and aluminuim pouch. During storage study the microbial analysis and sensory analysis were reported of the developed ketogenic patties. The developed ketogenic patties were consumable at 28ºC for 3 days and it had 30 days of shelf life at -18ºC in HDPE packaging.

Keywords: Ketogenic Patties, Hummus, cooking properties, low carbohydrate, Peroxide value

1) INTRODUCTION

Fast food is a multi billion industry continuing to grow at a rapid pace in coming years. Fast food is often highly processed and prepared in an industrial fashion i.e., with standard ingredient, methodical cooking and production methods.(Nisa,2005) The term "burgers" originated from the word "hamburger" which presumably is a product which was conceived in the country Hamburg. Most of the European countries regulated that burgers should contain at least 80% meat and 20-30% of fat content. Burgers are also referred to as "patties" (Al –Mrazeeq et al., 2008; Ranken, 2000). A patty is a flattened, usually disc-shaped 9 serving of ground meat or meat alternatives. The meat alternative/meat is usually minced/finely chopped, compacted, shaped and cooked. Substitution of some ingredients with meat substitutes has been practiced among processed meat industries. This replacement is done due to several relationships such as for quality, health, economic or preferential purposes. Many food industries have replaced ingredients of animal origins with that of plants. (Hosein.H).

The majority of chronic diseases like diabetes, hypertension, and heart disease are largely related to obesity which is usually a product of unhealthy lifestyle and poor dietary habits. Appropriately tailored diet regimens for weight reduction can help manage the obesity epidemic to some extent. One diet regimen that has proven to be very effective for rapid weight loss is a very-low-carbohydrate and high-fat ketogenic diet. For decades, dietary fat was considered uniquely fattening due to its high energy density and palatability, leading to “passive overconsumption” relative to all carbohydrates. However, recent research underscores a biological basis for body weight control, by which the metabolic effects of food, more so than calorie content of specific foods or nutrients, determine body weight over the long term. According to the carbohydrate-insulin model of obesity the processed carbohydrates (e.g., most breads, rice, potato products, and added sugar) that replaced dietary fats during the low-fat diet era promote fat storage, increase hunger, and lower energy expenditure, predisposing to obesity and diabetes in susceptible individuals.fat diet era promote fat storage, increase hunger, and lower energy expenditure, predisposing to obesity and diabetes in susceptible individuals.(*The Journal Of Nutrition*,2019) A ketogenic diet primarily consists of high-fats, moderate-proteins, and very-low-carbohydrates. The dietary macronutrients are divided into approximately 55% to 60% fat, 30% to 35% protein and 5% to 10% carbohydrates. Specifically, in a 2000 kcal per day diet, carbohydrates amount up to 20 to 50 g per day. (Masood.*et al.*, 2020) A ketogenic diet could be an interesting alternative to treat certain conditions and may accelerate weight loss.

2) Materials and Methods

All raw materials were procured from local market of Kolhapur, Maharashtra, India.

2.1.1) Preparation of Chickpea Hummus

Soaking Chickpeas (12hrs)
↓
Germination (48hrs)
↓
Autoclaving
(at121 ^{0}C for 20mins)
↓
Grinding with sesame paste, lemon juice, garlic
↓
Storage

Fig. 1: Flow sheet for preparation of Chickpea Hummus (Doumani. *et al*, 2020)

2.1.2) Preparation of Cauliflower Mash

Washing
↓
Cutting
↓
Boiling
(at 121 ^{0}C for 8mins)
↓
Grinding
↓
Cauliflower Mash

Fig.2: Flow sheet for preparation of Cauliflower Mash with slight modification (Elmore, 2014)

2.1.3) Preparation of Ketogenic patties

Chickpea Hummus ↑ ↑ Cauliflower Mash

↓

Weighing Ingredients

↓

Mixing

(Rice flour, corn flour, green chillies, cumin powder, salt)

↓

Forming Patties

↓

Frying

(Shallow frying at 162 ^{0}C for 2mins)

↓

Heat Degrease

↓

Freezing

(-20 to -30 ^{0}C)

↓

Reheating

Fig 3: Flow sheet for Formulation of patty with slight modification (Willard.M, 1993)

2.2.1) Optimization of Control Sample

2.2.1.1) Optimization of control sample was carried out by combination of varying corn flour and potato proportion

Ingredients (gm)	**A_1**	**A_2**	**A_3**
Potato Mash	85	**80**	75
Corn flour	5	**10**	15
Salt	2.5	**2.5**	2.5
Green chilly	3	**3**	3
Cumin powder	2.5	**2.5**	2.5
Chat masala	2	**2**	2

Table 1: Optimization of corn flour and potato

In the above table optimization of control potato patty is carried out by varying potato and corn flour proportions. SampleA_1 contain highest amount of potato proportion i.e. 85gm and sample A3 contains lowest amount of potato i.e. 75gm. Sample A2 contains 80gm potato proportion. Amount of corn flour is highest in sample A3 i.e. 15gm and sample A1 contains 5gm corn flour. Sample A2 contains 10gm corn flour proportion. All other ingredients are kept constant in all samples.

2.2.1.2) Optimization of control sample was carried out by substitution of rice flour in corn flour

Ingredients (gm)	B_1	B_2	B_3
Potato Mash	80	**80**	80
Corn flour	10	**5**	0
Rice flour	0	**5**	10
Salt	2.5	**2.5**	2.5
Green chilly	3	**3**	3
Cumin powder	2.5	**2.5**	2.5
Chat masala	2	**2**	2

Table 2: Optimization of rice flour by substituting in corn flour

In the above table optimization of control sample is carried out by substituting rice flour into corn flour. Sample B1contain highest amount of corn flour i.e. 10gm and sample B3 does not contain corn flour proportions. Sample B2 contain 5gm of corn flour proportion. Amount of rice flour is highest in sample B3 i.e. 10gm and sample B1 does not contain rice flour proportion. Sample B2 contains 5gm rice flour. All other ingredients are kept constant in all samples.

2.2.2) Optimization of Ketogenic Patties

2.2.2.1) Optimization of ketogenic patties was carried out by varying Potato and Chickpea Hummus proportions

Ingredients (gm)	P_1	P_2	P_3	P_4	P_5
Potato Mash	80	60	40	**20**	0
Chickpea Hummus	20	40	60	**80**	100
Rice flour	5	5	5	**5**	5
Corn flour	5	5	5	**5**	5
Salt	2.5	2.5	2.5	**2.5**	2.5
Green chilly	3	3	3	**3**	3
Cumin powder	2.5	2.5	2.5	**2.5**	2.5
Chat Masala	2	2	2	**2**	2

. Table 3: Optimization of Chickpea Hummus

In the above table optimization of curry mix is carried out by varying Chickpea hummus and potato proportion. Sample P_1contains highest amount of potato i.e. 80gm and sample P_5does not contain potato. Sample P_2, P_3,P_4 contain 60gm, 40gm, and 20gm potato respectively. Amount of Chickpea Hummus is highest in sample P_5 i.e. 100gm and sample P_1 contains 20gm Chickpea Hummus proportion. SampleP_2, P_3, P_4 contain 40gm, 60gm, and 80gm Chickpea Hummus respectively. Other ingredients are kept constant in all samples.

2.2.2.2) Optimization of ketogenic patties was carried out by replacing Potato mash by Cauliflower mash proportions

Ingredients (gm)	Q_1	Q_2	Q_3	Q_4	Q_5
Chickpea Hummus	80	**80**	80	80	80
Cauliflower Mash	0	**20**	40	60	80
Rice flour	5	**5**	5	5	5
Corn flour	5	**5**	5	5	5
Salt	2.5	**2.5**	2.5	2.5	2.5
Green chilly	3	**3**	3	3	3
Cumin powder	2.5	**2.5**	2.5	2.5	2.5
Chat Masala	2	**2**	2	2	2

Table 4: Optimization of Cauliflower mash

In the above table optimization of curry mix is carried out by varying Chickpea Hummus and Cauliflower proportion. Sample Q_5 contains highest amount of Cauliflower i.e. 80gm and sample Q_1does not contain Cauliflower. Sample Q_2, Q_3, Q_4 contain 20gm, 40gm, and 60gm Cauliflower respectively. Other ingredients are kept constant in all samples.

2.3) Reheating ketogenic patties in Microwave:

Frozen Ketogenic Patties

↓

Microwave heating

(For 1 min at 600mW)

↓

Ready to eat

Fig.4: Reheating of Ketogenic Patties (Silva.F.A., *et. al.*, 2016)

2.4) Reheating ketogenic patties in Griller:

Frozen Ketogenic Patties

↓

Grilling

(For 3mins at 160^{0}C)

↓

Ready to eat

Fig.5: Reheating of Ketogenic Patties (Silva.F.A., *et. al.*, 2016)

2.5) Analytical measurements

2.5.1) Changes in Weight, Thickness and Diameter

Change in weight loss, Diameter loss and thickness loss has been measured according to the methods suggested by (Borry, 1980) and (Engle, 1975).The equation are as follows:

$$\% \text{ Weight loss} = \times 100 \quad \frac{\text{Weight before cooking (g)} - \text{Weight after cooking (g)}}{\text{Weight before cooking (g)}}$$

$$\% \text{ Diameter loss} = \times 100 \quad \frac{\text{Diameter before cooking (mm)-Diameter after cooking (mm)}}{\text{Diameter before cooking (mm)}}$$

$$\% \text{ Thickness loss} = \times 100 \quad \frac{\text{Thickness before cooking (mm)-Thickness after cooking (mm)}}{\text{Thickness before cooking (mm)}}$$

2.5.2) Thawing Loss

A Patty sample was frozen (24 h, -18 °C) and the thawing was completed when the internal temperature of the samples reached 25 °C. Thawing loss of each patty was measured as the difference between the initial weight (before freezing) and the final weight (after thawing) and was expressed as a percentage

$$\text{Thawing loss (\%)} = [(W1-W2)/ W1] \times 100$$

Where, W1 and W2 is the weight of patty before freezing and after thawing, respectively.

2.5.3) Liquid holding capacity

The ability of patty product to retain moisture was evaluated using the Choi *et al.* (2018) method with minor modifications. Briefly, approximately 1 g of patty was placed in a 15 mL centrifuge tube and centrifuged at 3,000rpm for 10 min at 4°C. The LHC was then calculated using the following formula:

$$LHC = (L2/L1) X100$$

Where, L_1 is initial weight of the sample, and L_2 is the weight of the sample after centrifugation.

2.5.4) Fat retention

The fat retention value represents the amount of fat retained in the product after cooking. Fat retention was calculated according to Murphy *et al*. (1975).The equation for fat retention (%) is as follows:

$$\text{Fat retention (\%)} = \frac{\text{(Cooked weight of patty)} \times \text{(Fat content per gram of cooked patty)}}{\text{(Uncooked weight of patty)} \times \text{(\% Fat content per gram of cooked patty)}} \times 100$$

2.5.5) Peroxide value

The peroxide value (POV) was determined according to the method of Sallam *et al.* (2004). The titration was continued against standard solution of sodium thiosulfate. POV was calculated by following equation and expressed as milli equivalent peroxide per kilogram of sample:

$$POV\ (meq / kg) = \{(S \times N) / W\} \times 100$$

Where "S" is the volume of titration (ml), "N" is the normality of sodium thiosulfate solution (N=0.01) and "W" is the sample weight (g)

2.5.6) Free fatty acid value

Free fatty acid (FFA) value was determined according to the method of Rukunudin *et al.* (1998). The sample (5 g) was dissolved with 30 mL chloroform using a homogenizer at 10,000 rpm for 1 min. After addition of five drops 1% ethanolic phenolphthalein as indicator to filtrate, the titration was continued with 0.01 N ethanolic potassium hydroxide solutions and FFA value was calculated as follows:

$$FFA\ (\%) = (mL\ titration \times Normality\ of\ KOH \times 28.2) / g\ of\ sample$$

2.5.7) Colour profile analysis

Colour measurement is done by using a Hunter colour measuring system and expressed in terms of L*, a*, b*, according to the Robertson, (1976). L* represents the lightness from white (100) to black (0). Red to green colour component was indicated by a* values and yellow to blue colour components was indicated by the b* values.

2.6) Sensory evaluation

The optimized Ketogenic patties were evaluated for their sensory characteristics namely appearance, taste, flavour and overall acceptability by a semi-trained panel member comprising of 10 panelists from faculty members and post graduate students of the department. The panelists were asked to record their observations on the sensory sheet based on a 9 point hedonic scale.

2.7) Microbiological analysis

2.7.1) Total plate count

Enumeration of total viable plate count of the samples was done in standard plate count agar medium, pH 7.0±0.1 by following pour plate technique. Plates were incubated at 37 °C for up to 24 hrs for enumeration of total viable aerobic count. Counting was done by using a bacteriological colony counter and all those plates yielding >25 and <250 bacterial colonies were taken into account (Sarkar *et. al.*, 2019).

2.7.2) Yeast and mould counts

Yeasts and moulds counts of the Ketogenic patties were made at similar time intervals as that of the total viable plate count by inoculating the appropriate dilution of the sample on Rose Bengal Agar Base, pH 7.2±0.1 and on incubating at 25 °C up to 24 hrs. Counting was done by using a bacteriological colony counter (Sarkar *et. al.*, 2019).

3) RESULTS AND DISCUSSION

3.1) Results of Physical parameters of patties

Table 5: Physical properties of patties

Sample	Cooking loss (%)	Thawing loss (%)	Liquid holding capacity (%)	Diameter (mm)		Thickness (mm)	
				D_b	D_a	T_b	T_a
Control	5.26±0.32	ND	78.94±1.00	60	59.2	8	7.8
Pre cooked	ND	ND	80.23±0.02	61	ND	8.1	ND
Cooked	4.73±0.33	ND	79.83±1.02	61	61.5	8.1	7.6
Reheated patties							
Microwaved	2.36±6.39	1.34±0.15	78.70±0.63	61	59.8	7.9	7.2
grilled	3.15±0.86	1.63±0.14	77.79±1.10	61	60.9	7.9	7.3

*Values are expressed as mean±standard deviation at $p<0.05$ (n = 3).

(Where, D_b=Diameter of patty before cooking, D_a=Diameter of patty after cooking, Tb=Thickness of patty before cooking, T_a= Thickness of patty after cooking, ND=not defined)

Cooking loss, Thawing loss, Water holding capacity, diameter and thickness of patties was recorded in above table. Of all the samples Microwaved patties seemed to had less cooking loss of about 2.36%.On the other hand when comparison was done between cooked ketogenic patty and control patty, control patty seemed to had more cooking loss of about 5.26% and cooked ketogenic patty had 4.73%.When the reheated patties were considered, Microwaved ketogenic patties has significantly less cooking loss of about 2.36% than grilled ketogenic patties which had 3.15% cooking loss. Control patties showed more cooking loss due to the presence of potatoes that absorbs more oil while frying. Whereas in reheated ketogenic patties the microwave radiations did not cause much damage to the original patties than the grilled ketogenic patties.

In thawing loss analysis of reheated patties, Microwaved ketogenic patties showed lower value than grilled ketogenic patties of about 1.34% and 1.63% ($p<0.05$)respectively. In this study, LHC was used as a measure of total water content loss in the patties. Cooked ketogenic (79.83±1.02,$p<0.05$) patties showed more water retention than control patties(78.94±1.00,$p<0.05$).Within reheated ketogenic patties, Microwaved (78.70±0.63,$p<0.05$) patties had higher water retention values than grilled patties (77.79±1.10,$p<0.05$),which possibly indicates a positive effect on the tenderness of the reheated ketogenic patties. As pre cooked ketogenic patties contented 80% Hummus and 20% Cauliflower, hence moisture retention was found to be more (80.23±0.02, $p<0.05$).

Further diameter and thickness before and after cooking of the patty was evaluated. Of all the samples, cooked ketogenic patty had more diameter gain (61.5mm) due to more oil absorption than control patties (59.2mm). When reheated patties were compared, microwaved patty was found to had more diameter loss (59.8mm)than grilled patty (60.9mm).While studying thickness of patties, it was seen that thickness loss was more in cooked ketogenic patties (0.5mm) than control patty(0.2mm).In reheated ketogenic patties Microwaved patty had more thickness loss (0.7mm) than grilled patty(0.6mm).

3.2) Results of Fat retention percentage in patties

Table 6: Fat retention percentage in patties

Samples	Weight of uncooked patty (g)	Weight of cooked patty (g)	Fat in uncooked patty (%)	Fat in cooked patty (%)	Fat retention (%)
Control	40	38	2.21	4.69	2.23
Precooked	ND	ND	ND	ND	ND
Cooked	38	36.2	2.76	5.21	1.98
Reheated Patties					
Microwaved	38	37.1	5.21	5.21	0.97
Grilled	38	36.8	5.21	5.21	0.96

(ND = Not defined)

The fat retention of all samples was calculated. Table 6 reveals the data of fat retention the patties. According to the data recorded control sample showed a maximum retention of fat due to the presence of potato which absorbs more oil while frying. Frying medium for control sample was sunflower oil which allows maximum exchange of fat between the frying medium and the food. The fat retention in the control sample was around 2.23%. Whereas in ketogenic cooked patties the fat retention was found to be 1.98%. The vast difference between fat retention of control patty and ketogenic patty was due to different frying medium. The frying medium for ketogenic patty was olive oil. It is high in antioxidant and fatty acids which makes it stable at above 150 ^{0}C. Hence the oil absorption for ketogenic patties was comparatively less as compared to control patty. The fat retention value for ketogenic patty was 1.98%. Furthermore in reheated patties there was significant thawing loss. Thus the reheated patties showed slight decrease in the fat retention value i.e. for microwave patty fat retention was 0.97% and for grill patty it was 0.96%.

3.3) Results of changes in some of the analytical properties of Patties

Table 7: Changes in some of the analytical properties of Patties after cooking

Samples	Trait	%for cooking loss
Control	Weight(g)	5.26±0.32
	Diameter(mm)	1.33±0.38
	Thickness(mm)	2.5±0.62
Pre cooked	ND	ND
Cooked	Weight(g)	4.73±0.33
	Diameter(mm)	0.80±0.37
	Thickness(mm)	6.17±0.65
Reheated patties		
Microwaved	Weight(g)	2.36±0.31
	Diameter(mm)	1.96±0.35
	Thickness(mm)	8.86±0.66
grilled	Weight(g)	3.15±0.31
	Diameter(mm)	1.77±0.34
	Thickness(mm)	7.59±0.67

*Values are expressed as mean±standard deviation of triplicate experiments at $p<0.05$ (n = 3). (ND = Not defined)

Table (7) shows the changes in the ketogenic patties before and after cooking. Frying by oil method has led to decline in the weight of patties as they were 5.26 and 4.73% for the samples control and cooked patties respectively. Reason for this is that raw materials like hummus and cauliflower in ketogenic patties lose significant amount of water while cooking. The losses are mainly occurring while dripping fluid on cooking. In reheated ketogenic patties, microwaved patty had (2.36±0.31%,$p<0.05$) more weight loss than grilled patty (3.15±0.31%,$p<0.05$).Whereas loss of diameter was found to be 1.33 and 0.80% in control and cooked ketogenic patty respectively. That was due to loss in weight and decrease in amount of water resulting into slight shrinkage in the patty. In reheated patties the diameter loss was very negligible, as it was 1.96 and 1.77% respectively. That was due to loss in weight and decrease in the amount of water, causing slight shrinkage in the patties. The change in the thickness of control and cooked patties was around 2.5 and 6.17% respectively. Those changes that took place were due to addition of binders like rice flour and corn flour, which caused withdrawal of constituting water. Similarly in reheated patties, the thickness loss was around 8.86 and7.59% for microwaved and grilled patties respectively.

3.4) Colorimetric analysis of Ketogenic patties

Table 8: Colorimetric analysis of Ketogenic patties

Sample	L*	a*	b*
Control	23.49±0.44	5.02±0.38	8.98±0.23
Pre cooked	50.38±0.12	3.54±0.52	8.21±1.33
Cooked	24.39±0.35	4.79±0.12	9.07±0.92
Reheated patties			
Microwaved	20.21±0.98	4.98±0.41	8.56±0.76
Grilled	18.32±1.33	5.02±0.33	8.13±0.61

*Values are expressed as mean±standard deviation of triplicate experiments at $p<0.05$ (n = 3).

Color changes in the patties evaluated are recorded in the table 10.Control patties had highest *L (23.49±0.44) and lowest *a and *b values i.e, 5.02±0.38 and 8.98±0.23 respectively. Similarly Cooked patties also had highest *L value (24.39±0.35) and lowest *a and b* value i.e, 4.79±0.12 and 9.07±0.92 respectively. In cooked patties highest L* value and lowest a* value was seemed to be clearly caused by presence of hummus and white color cauliflower. Amongst the reheated patties grilled patties had higher L* value i.e, 22.32±1.33 as compared to microwaved patties which had 20.21±0.98 L* value. It was seemed to be clearly due to high cooking loss in grilled patties, which lost a large amount of their liquid content. a* values in microwaved patties and grilled patties were 4.98±0.41 and 5.02±0.33 respectively. The b* values in both reheated patties were nearly equal i.e., in microwaved patty it was 8.56±0.76 and in grilled patty it was 8.13±0.39.The pre cooked patties the L* value was highest (50.38±0.12) due to presence of binders like rice flour and corn flour. It has lowest value of a* and b* value i.e, 3.54±0.52 and 8.21±1.33 respectively.

3.5) Results of proximate analysis of raw materials

Table 9: Proximate analysis of raw materials

Sr. No.	Parameter (%)	Cauliflower	Chickpea	Chickpea Hummus
1	Moisture	90.62±0.24	5.62±0.46	6.47±0.37
2	Ash	0.62±0.37	2.50±0.37	0.28±0.23
3	Protein	1.98±0.24	19.68±0.61	6.8±0.37
4	Fat	0.23±0.12	4.18±0.44	25.3±1.38
5	Carbohydrate	4.42±0.13	3.72±0.12	7.5±0.23

*Values are expressed as mean±standard deviation of triplicate experiments at $p<0.05$ (n = 3).

Table 9 gives the summary of the analysis of the raw materials such as cauliflower, chickpea and chickpea hummus. Percentages of crude protein in cauliflower, chickpea and chickpea hummus are1.98±0.24, 19.68±0.61,6.8±0.37% respectively. As a result Chickpea is a good source of protein. The fat percentage in cauliflower, Chickpea and chickpea hummus was 0.23±0.12, 4.18±0.44 and 25.3±1.38% respectively. The moisture content varied as 90.62±0.24, 5.62±0.46 and 6.47±0.37% in cauliflower, chickpea and chickpea hummus respectively. Hence moisture content in cauliflower was more as compared to chickpea and chickpea hummus. Carbohydrate percentage varied as 4.42±0.13, 3.72±0.12 and7.5±0.23% in cauliflower, chickpea and chickpea hummus respectively. The ash content was 0.62±0.37, 2.50±0.37 and 0.28±0.11% in cauliflower, chickpea and chickpea hummus respectively.

3.6) Result of Mineral analysis of Cauliflower, Chickpea and Chickpea Hummus

Table 10: Mineral analysis of Cauliflower, Chickpea and Chickpea Hummus

Sr. No.	Parameter (mg/100g)	Cauliflower	Chickpea	Chickpea Hummus
1	Potassium	1.68±0.24	718±0.23	228±0.62
2	Calcium	41.16±0.13	57±0.44	38±0.16
3	Magnesium	12.28±0.24	79±0.12	71±0.23
4	Iron	2.83±0.44	4.31±0.11	2.44±0.76
5	Zinc	1.86±0.25	2.76±0.24	1.83±0.44

6	Phosphorous	61.35±0.23	246±0.13	176±0.61

*Values are expressed as mean±standard deviation of triplicate experiments at $p<0.05$ (n = 3).

Mineral analysis evaluated of Cauliflower, Chickpea and Chickpea Hummus are recorded in the table 10.The mineral analysis of cauliflower revealed that it was rich source of phosphorous and calcium. Calcium and phosphorous content in cauliflower was found to be 41.16±0.13 and 61.35±0.23 (mg/100g) respectively. The mineral analysis of chickpea revealed that it was good source of potassium. It contained 718± 0.23(mg/100g) potassium. Similarly the mineral analysis of Chickpea hummus revealed that it was also good source of potassium. It contained 228±0.62 (mg/100g) of potassium.

3.7) Results of proximate analysis of Control and Ketogenic patties

Table 11: Proximate analysis of Control and Ketogenic patties

Sr. No.	Parameter (%)	Control	Ketogenic patty
1.	pH	6.69±1.33	6.08±0.93
2.	Moisture	61.01±0.23	63.69±0.11
3.	Ash	2.08±0.86	1.29±0.36
4.	Protein	3.12±0.12	16.56±0.51
5.	Fat	4.96±0.52	5.21±0.52
6.	Carbohydrate	28.83±0.11	13.25±0.38

*Values are expressed as mean±standard deviation of triplicate experiments at $p<0.05$ (n = 3).

The percentage compositions for pH, moisture, ash, protein, fat and carbohydrate of Control and Ketogenic patties are reported in Table 11.Control patty showed higher pH value (6.69±1.33) while ketogenic patty showed slightly lower pH value (6.08±0.93).The moisture content in both the patties was higher i.e, 61.01±0.23% and 63.69±0.11% for control patty and ketogenic patty. Ash content in the control patty and ketogenic patty was 2.08±0.86% and 1.29±0.36% respectively. The protein content in the ketogenic patty was higher due to presence of chickpea hummus. The protein content in ketogenic patty was found to be 16.56±0.51% whereas in control patty it was 3.12±0.12%. The fat percentage was also comparatively higher in ketogenic patty than control patty. The fat percentage was 4.96±0.52 and 5.21±0.52% in control and ketogenic patty respectively. Carbohydrates percentage was higher in control patty due to presence of potato into it. Control patty and keto patty content 28.83±0.11% and 13.25±0.38% of carbohydrates respectively. As a result ketogenic patty is a rich of protein and fat.

3.8) Results of Minerals analysis of Control and Ketogenic patties

Table 12: Mineral analysis of Control and Ketogenic patties

Sr. No.	Parameter (mg/100g)	Control	Ketogenic
1	Magnesium	19.28±0.17	8.76±0.66
2	Calcium	52.77±0.13	38.71±0.33
3	Potassium	278±0.38	3.15±0.29
4	Iron	1.12±0.23	1.31±0.75
5	Zinc	0.71±0.32	0.011±0.13
6	Phosphorous	139±0.75	63.09±0.32

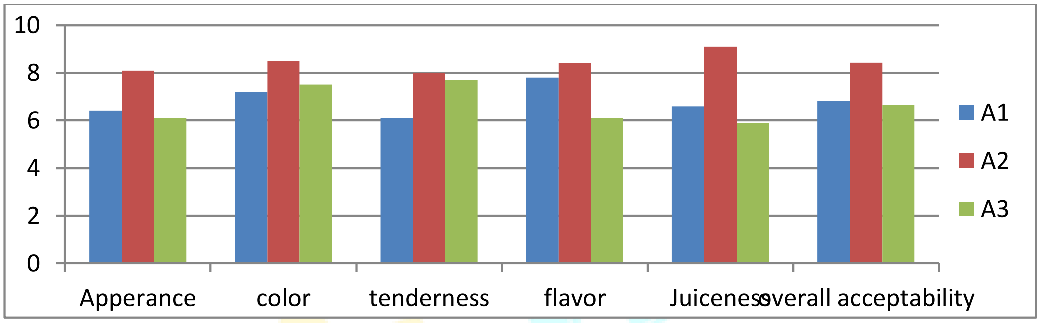
*Values are expressed as mean±standard deviation of triplicate experiments at $p<0.05$ (n = 3).

Mineral analysis of Control and ketogenic patties was determined and results were presented in the table 12.The mineral analysis revealed that control patty was a rich source of potassium (278±0.38 mg/100g), phosphorous (139±0.75 mg/100g), calcium (52.77±0.13 mg/100g)and magnesium (19.28±0.17 mg/100g) due to presence of tuberous root potato. It had considerable amount of iron (1.12±0.23 mg/100g) and zinc (0.71±0.32 mg/100g). The results also revealed that ketogenic patty was a good of phosphorous

(63.09±0.32mg/100g) and calcium (38.71±0.33 mg/100g). It had considerable amount of magnesium (8.76±0.66mg/100g) and potassium (3.15±0.29mg/100g). The ketogenic patty was a least source of iron(1.31±0.75mg/100g) and zinc(0.011±0.13mg/100g).

3.9) Results of sensory evaluation of prepared formulations

3.9.1) Sensory evaluation for optimization of corn flour and potato

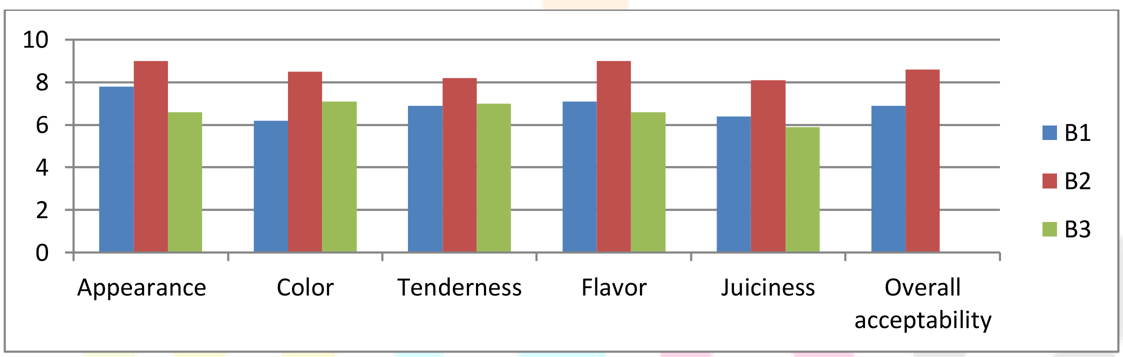


(Where, A_1 = Potato Mash: Corn flour; 85:5, A2= Potato Mash: Corn flour; 80:10, A_3=Potato Mash: Corn flour; 75:15)

Fig4: Sensory evaluation for optimization of corn flour and potato

Figure 4 illustrates the sensory evaluation for optimization of corn flour and potato. The 3 samples were prepared by shallow frying at 160 ^{0}C for 6mins till they get golden brown. The percentage of potato mash and corn flour varied. Hence it was observed that as potato mash percentage decreased and corn flour percentage increased the crust of the patty hardened. Therefore, sample A_2 was optimized as it contained 80% potato mash and 10 % corn flour which showed desirable characteristics with respect to appearance, color, tenderness, flavor and juiciness. The sensory score ranged from like very much to extremely like to the sample A_2. As a result sample A_2 was optimized which contained 80% potato mash and 10 % corn flour.

3.9.2) Sensory evaluation for optimization of rice flour by substituting in corn flour

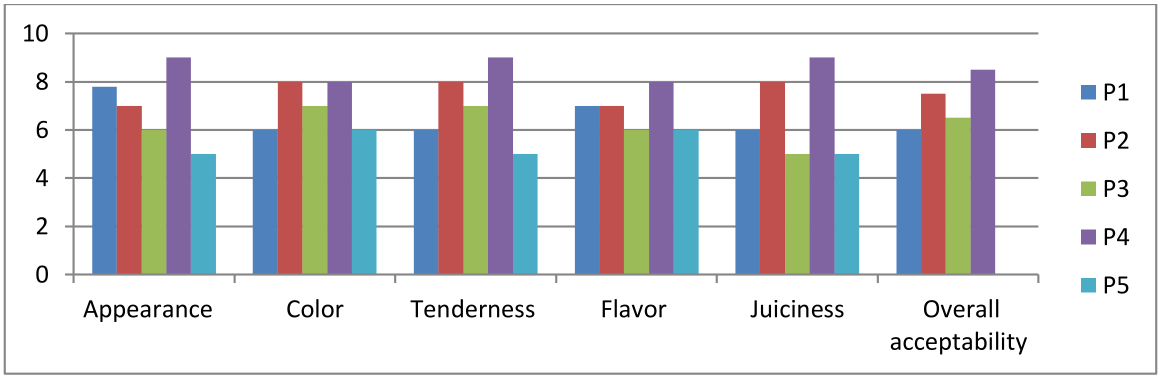


(Where, B_1 = Corn flour: Rice flour; 10:05, B_2= Corn flour: Rice flour; 05:05, B_3=Corn flour: Rice flour; 05:10)

Fig5: Sensory evaluation for optimization of rice flour by substituting in corn flour

Sensory evaluation for optimization of rice flour by substituting in corn flour is recorded in the figure number 5. Rice flour was substituted in 10% corn flour of optimized A_2 sample. 3 samples were prepared by shallow frying at 160 ^{0}C for 6mins till they get golden brown. Thus it was observed that as the rice flour percentage was increased the texture of patty turned out to be gummy rather than crunchy. Hence sample $B_2$was optimized which contained equal amount of rice flour and corn flour i.e. 5% corn flour and 5% rice flour.

3.9.3) Sensory evaluation for optimization of Chickpea Hummus

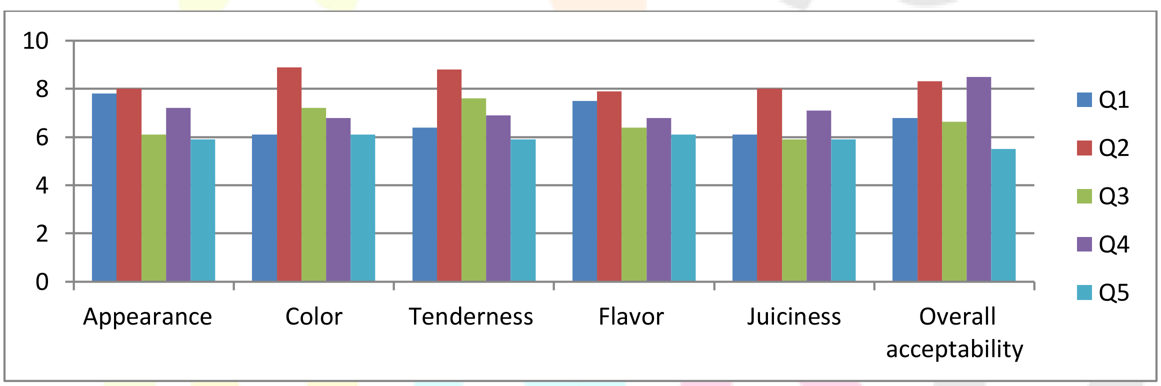


(Where, P_1= Potato Mash: Chickpea Hummus; 80:20,P_2= Potato Mash: Chickpea Hummus; 60:40, P_3=Potato Mash: Chickpea Hummus; 40:60 ,P_4= Potato Mash: Chickpea Hummus; 20:80,P_5=Potato Mash: Chickpea Hummus; 00:100)

Fig6: Sensory evaluation for optimization of Chickpea Hummus

Figure 6 illustrates the sensory evaluation for optimization of Chickpea Hummus. 5 samples were prepared by varying percentage of Potato Mash and Chickpea Hummus. The samples were shallow fried in olive oil at 175^{0}C for 7mins till they get yellowish brown. Hence according to sensory evaluation sample P_4 achieved maximum score amongst all samples. The score ranged from liked very much to extremely like. As a result sample P_4 was optimized that contained 20% potato mash and 80% Chickpea Hummus.

3.9.4) Sensory evaluation for optimization of Cauliflower Mash

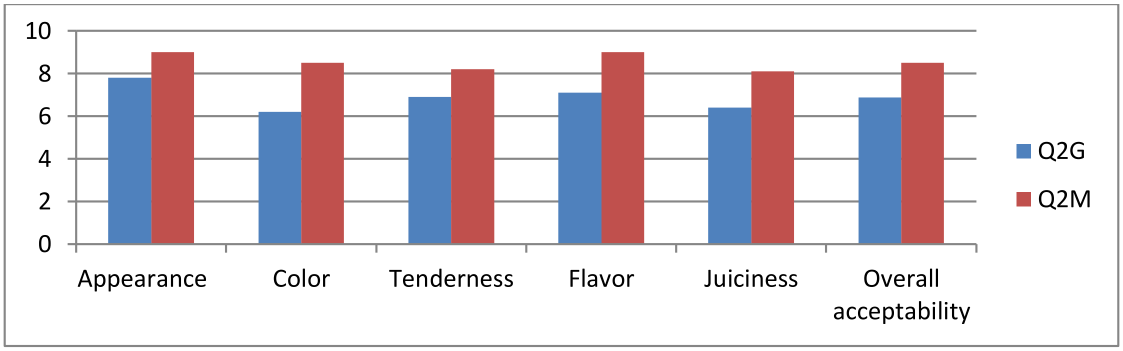


(Where, Q_1 = Chickpea Hummus: Cauliflower Mash; 80:00, Q2= Chickpea Hummus: Cauliflower Mash; 80:20, Q3=Chickpea Hummus: Cauliflower Mash; 80:40, Q_4=Chickpea Hummus Cauliflower Mash; 80:60, Q5=Chickpea Hummus: Cauliflower Mash; 80:80)

Fig7: Sensory evaluation for optimization of Cauliflower Mash

Sensory evaluation for optimization of Cauliflower mash is recorded in the figure 7. Samples were prepared by varying percentage of chickpea Hummus and Cauliflower. The samples were fried in olive for 7mins at 175 ^{0}C till get yellowish. According to sensory score sampleQ_2 received maximum score with respect to appearance, color, tenderness, flavor and juiciness. SampleQ_2 had desired crunchy texture, yellowish color and firm toughness (tenderness and juiciness). HenceQ_2 sample was optimized amongst all. It contained 80% Chickpea hummus and 20% cauliflower mash. The sensory score for sampleQ_2 varied from moderately like to like very much.

3.9.5) Sensory evaluation for Reheated patties



(Where, Q_{2G}=Grilled Ketogenic Patty, Q_{2M}=Microwaved Ketogenic Patty)

Fig8: Sensory evaluation for Reheated patties

Figure 8 illustrates the sensory evaluation for reheated patties. The optimized Q_2 sample was packed and sealed in HDPE and stored in Refrigerator (Samsung RT34M5538S8, 324L, Samsung Pvt.Ltd, India). The patties were further reheated in microwave (Model MS23K3513AK 23L Convection Microwave Oven, Samsung Electronics Co. Ltd., New Delhi India) and grill (Pacific PM-813 Electric Contact Grill, 2000v, India). According to the sensory evaluation sample Q_{2M} received maximum score which shows liked moderately.

3.10) Storage study of developed Ketogenic Patties

A definite shelf life is required for any perishable product to make it commercially marketable. The ketogenic patties were accessed for storage related changes. The ketogenic patties were packed in aluminuim pouch and HDPE. The packed products were stored at room temperature and at -18 ^{0}C for storage studies. Storage study was conducted for the period of 45days from 16thOctober 2021 to 2nd December 2021. Each packet of 15 gm was made. Out of that 6 samples were packed in aluminum pouches and 6 were packed in LDPE .The samples were evaluated at 15 days interval. The sensorial analysis of ketogenic patties during storage period includes organoleptic changes like colour and appearance, flavor, tenderness, juiciness and overall acceptability. Peroxide value and free fatty acid value was also determined during the storage study of the ketogenic patties. Microbiological analysis pertained to yeast and mould count and total plate count were known during storage period. Changes were analyzed up to 45 days at storage of room temperature with 15 days of intervals and the acceptance or rejection of developed product was done based on sensory score. The effect of storage period on sensory evaluation and microbial study was discussed in the following table.

3.10.1) Effect of storage on sensory attributes (score)* of ketogenic patties

Table 13: Changes in sensory attributes of prepared ketogenic patties packed in Aluminum pouch

Sensory attributes	Storage period (Aluminium pouch)					
	0	3	7	15	30	45
Appearance	7.8	7.18	6.23	5.02	4.1	3.70
Color	7.5	6.25	5.0	5.19	4.6	3.14
Tenderness	7.6	7.2	6.9	6.3	5.8	5.6
flavour	7.8	7.18	4.12	4.31	3.4	3.05
Juiciness	8.0	7.30	4.5	4.0	3.7	3.27
Overall acceptability	7.74	7.02	5.35	4.96	4.32	3.75

Table 14: Changes in sensory attributes of prepared ketogenic patties packed in HDPE

Sensory attributes	Storage period (HDPE)					
	0	3	7	15	30	45
Appearance	8.0	7.58	6.23	6.03	5.0	4.70
Color	8.0	7.65	6.02	6.10	5.0	4.84
Tenderness	7.8	7.51	7.2	6.91	6.2	6.1
flavour	7.8	7.18	5.18	5.83	4.7	3.25
Juiciness	8.0	7.45	6.45	6.15	4.9	3.72
Overall acceptability	7.92	7.47	6.21	6.20	5.16	4.52

3.10.1.1) **Color and appearance:**

The table 13 and 14 shows the sensory attributed of developed patty packed in Aluminium pouch and HDPE for a period of 45 days. It can be clearly seen that the sensory score for color and appearance gradually decreased from around 7.8 to 3.70 for patty packed in Aluminium pouch. Similarly the sensory parameters for patty packed in HDPE decreased from 8.0 to 4.70. The changes in the color and appearance of the patty may be attributed to the changes occurring in the patty during storage period. Therefore upto 45th day the color and appearance was 3.70 and 4.70 for appearance change and 3.14 and 4.84 for color change for the patties stored in aluminuim pouch and HDPE respectively.

3.10.1.2) **Tenderness:**

The table 13 and 14 illustrates the tenderness of the developed product packed in Aluminium pouch and HDPE. The tenderness was found to be 7.6 and 7.8 for the 1st day of developed patty packed in Aluminium pouch and HDPE respectively which was moderately liked. But this score gradually decreased to 5.6 and 6.1 upto 45th day of stored patty in aluminuim pouch and HDPE respectively which shows neither liked nor disliked. The tenderness of the patty hampered due to physical and chemical changes occurring upto 45th day of the storage period.

3.10.1.3) **Flavour**

The table 13 and 14 reveals the effect of storage on flavour of the patty. The flavour of the patty gradually decreased from 7.8 to 3.05 in Aluminium pouch and 7.8 to 3.25 in HDPE. Therefore this study indicated that the developed product is not good upto 45th day of storage period in both packaging material. The reduction in the flavour could be attributed to the lipid oxidation, liberation of fatty acids, increased in microbial load and loss of flavour volatiles from spices in the developed patties.

3.10.1.4) **Juiciness:**

The change in juiciness is also evaluated in the table 13 and 14. The sensory score of juiciness decreased from 8.0 to 3.27 upto 45th day when packed in aluminuim pouch. Similarly, it was also seemed to be decreased when packed in HDPE. The sensory score for HDPE packed patty changed from 8.0 to 4.9.The study indicates that upto 45th day of storage the juiciness of patty was slightly disliked in both the packaging material. This may be attributed to the evaporative loss of moisture from the developed product.

3.10.1.5) **Overall acceptability**

The table 13 and 14 reveals average overall acceptability of developed patty. Scores of overall acceptability showed gradually decreasing trend as the storage increased. The overall acceptability changed from 7.74 to 3.75 for the patties packed in aluminuim pouch for upto 45th day of storage which ranged from moderately liked to moderately disliked. Similarly for HDPE the score of overall acceptability changed from 7.92 to 4.95 which shows it is slightly disliked upto 45th day. Continuous decrease in overall acceptability might be due to the changes of decline in the scores of Color, appearance, Tenderness, Flavour and Juiciness.

3.10.2.1) Effect of storage on microbial quality of ketogenic patties at 28˚C (Room Temperature)

Table 15: Changes in microbial load*of ketogenic patties at 28˚C (Room temperature)

Microbial parameters	Storage period (Aluminium pouch)					
	0	**3**	**7**	**15**	**30**	**45**
Total plate count (cfu/g)	2.1×10^{2}	2.8×10^{3}	3.3×10^{4} (spoiled)	-	-	-
Yeast and mold (cfu/g)	ND	ND	ND	ND	ND	ND

Table 16: Changes in microbial load*of ketogenic patties at 28⁰C (Room Temperature)

Microbial parameters	Storage period (HDPE)					
	0	3	7	15	30	45
Total plate count (cfu/g)	2.2×10^{2}	2.3×10^{3}	2.3×10^{4} (spoiled)	-	-	-
Yeast and mold (cfu/g)	ND	ND	ND	ND	ND	ND

3.10.2.2) Effect of storage on microbial quality of ketogenic patties at -18˚C

Table 17: Changes in microbial load*of ketogenic patties at -18˚C

Microbial parameters	Storage period (Aluminium pouch)					
	0	3	7	15	30	45
Total plate count (cfu/g)	2.3×10^{2}	2.3×10^{2}	2.3×10^{2}	2.3×10^{2}	2.3×10^{2}	2.3×10^{2}
Yeast and mold (cfu/g)	ND	ND	ND	ND	ND	ND

Table 18: Changes in microbial load*of ketogenic patties at -18˚C

Microbial parameters	Storage period (HDPE)					
	0	3	7	15	30	45
Total plate count (cfu/g)	2.0×10^{2}	2.0×10^{2}	2.0×10^{2}	2.0×10^{2}	2.0×10^{2}	2.0×10^{2}
Yeast and mold (cfu/g)	ND	ND	ND	ND	ND	ND

3.10.2.1 Total plate count

Table 16 and 17 shows the changes in total plate count of ketogenic patties at room temperature. The TPC of ketogenic patties sample increased gradually from $2.2\times10^{2}$to 2.3×10^{4}cfu/ml for aluminuim pouch and 2.1×10^{2} to 3.3×10^{4}cfu/ml for HDPE during 7 days of storage period. After 7 days of storage period there was a rapid increase in the TPC which cannot be defined. A progressive increase in the TPC of the patties may be due to increase in moisture content of the sample with increase in storage period. Total plate count (Cfu /ml) of patties more than $1x10^4$Cfu/ml then the patties are reported as unsafe for consumption according to food safety standards (2011).As a result the Ketogenic patties can only be consumed within 3 days at room temperature.

The table 22 and 24 illustrates the changes in the total plate count of ketogenic patties at -18 ^{0}C packed in aluminuim pouch and HDPE. The total plate count was found to be at constant rate i.e for aluminuim pouch it was 2.3×10^2cfu/ml and for HDPE it was 2.0×10^2 cfu/ml for 45 days of storage period.

3.10.2.2) Yeast and mould count

The effect of Yeast and Mould count in Ketogenic patties during storage are presented in table 16 and 17 at room temperature. The table shows that the average initial YMC in Ketogenic patties was nil. These results conclude that hygienic conditions were maintained during preparation of Ketogenic patties. Similarly, at -18 ^{0}C the YMC was nil in both packaging material i.e., Aluminium pouch and HDDPE. Yeast and mould count (cfu /ml) of patties more than $1x10^3$ /ml cfu/ml is reported as spoiled by food safety standards (2011).

3.10.3.1) Effect of storage on physico chemical properties of ketogenic patties at room temperature packed in HDPE

Table 19: Changes in physico chemical properties of ketogenic patties at room temperature (28 ^{0}C)

Physico chemical properties	Storage period (days)					
	0	3	7	15	30	45
Peroxide value (meq/kg)	0.89±0.18	1.1±0.10	4.68±0.28	12.2±0.43	21.1±0.15	22.3±0.29
Acid value(mg/g)	0.21±0.26	2.34±0.11	3.87±0.57	4.14±0.13	4.93±0.19	5.9±0.33

*Values are expressed as mean±standard deviation at $p<0.05$ (n = 3).

The peroxide value and acid value in the ketogenic patties are evaluated during storage period. Table 19 reveals the peroxide value and acid value during storage of the patties at room temperature. The peroxide value is useful method to determine the early stages of fat oxidation and the product is considered rancid when PV of 20-40 meq / kg is reached (Economou *et. al*., 1991). The ketogenic patties showed gradual significant increase in the peroxide value with advancement of storage period. The increase in peroxide value in ketogenic patties was not significant upto 3 days. After 30 days the ketogenic patties may be termed as rancid due to high peroxide value at room temperature.

The high free fatty acid values are due to triacylglycerol hydrolysis that takes place upon release of water from the patty. The patty had desirable amount of free fatty acids upto 3 days. The acid value gradually increased from 7th day to 45th day of storage leading to oxidative instability, increased acidity and gave rise to off flavor formation in the patties at room temperature.

3.10.3.2) Effect of storage on physico chemical properties of ketogenic patties at -18^{0}C packed in HDPE

Table 20: Changes in physico chemical properties of ketogenic patties at -18^{0}C

Physico chemical	Storage period (days)

properties	0	3	7	15	30	45
Peroxide value meq/kg	0.89±0.22	0.97±0.34	1.5±0.20	1.7±0.98	2.1±0.35	3.2±0.11
Acid value(mg/g)	0.21±0.51	0.27±0.67	0.3±0.79	0.35±0.38	0.4±0.19	0.81±0.18

*Values are expressed as mean±standard deviation at $p<0.05$ (n = 3).

The peroxide value and acid value of patties store at -18 ^{0}C are recorded in the table 20. The study reveals that there was not significant increase in the peroxide value of the patties at -18 ^{0}C. This was due to frozen state of patty. The fatty acids in the patty were crystallized at -18 ^{0}C. Similarly, the acid value of patty under frozen condition did not show any gradual change.

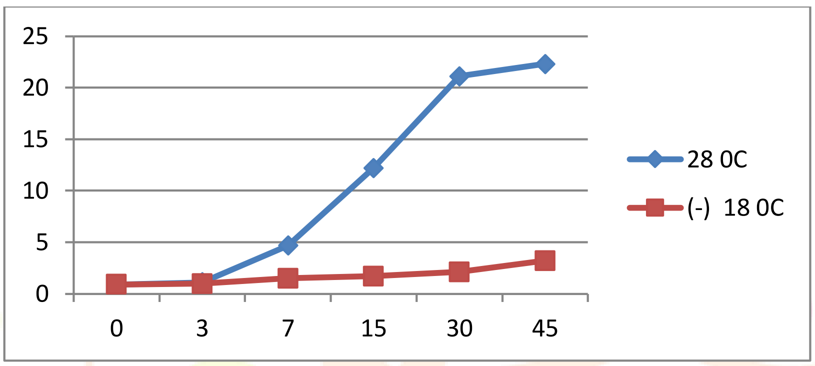


Fig 9: Changes in peroxide value at 28^{0}C and -18^{0}C

The figure 18 shows the graphical results of change in peroxide value at 28^{0}C and -18^{0}C. There was significant increase in peroxide value at 28^0 C after 3 days. This may be due to the exposure of free fatty acids to the oxygen. The graph clearly reveals the gradual increase in the peroxide after 7th day at 28^{0}C. This may be due to a large amount of fat oxidation which led the patty to be rancid. Furthermore, at -18^{0}C the peroxide value was considerably less due to crystallization of free fatty acids. Hence the peroxide value of ketogenic patties in frozen state was less as compared to the values at 28^{0}C.

4.0) Conclusions

Thus, it can be concluded that the developed ketogenic patties can be used as alternative for regular burgers patties which mostly includes patties made from potato, beef, chicken and fish. These burger patties are basically termed as fast foods as they are rich in carbohydrates which may result into serious problems like obesity, heart diseases, PCOS, Diabetes type II etc. Whereas the developed ketogenic patties are low in carbohydrate, high in protein and high in fat product. Hence the calories are obtained from protein and fat and less from carbohydrates. The developed ketogenic patties can be consumed by health conscious people those who are keen to lose weight by eating clean foods.

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