RECIPE OPTIMIZATION OF CHICKEN MEAT BALL

By: Sudarshan Gosai

B. Tech (Food) (2073-2077)

TU Registration Number: (5-2-0008-0021-2016)

Class Roll Number: 14

Address: Rapti sonari -3, Banke

Gmail: sudarshangosai321@gmail.com

Mobile: 9868247054

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by

Sudarshan Gosai

Department of Food Technology

Central Campus of Technology

Institute of Science and Technology

Tribhuvan University, Nepal

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A dissertation submitted to the Department of Food Technology, Central Campus of Technology, Tribhuvan University, in partial fulfillment of the requirements for the degree of B. Tech. in Food Technology.

by

Sudarshan Gosai

Department of Food Technology

Central Campus of Technology, Dharan

Institute of Science and Technology

Tribhuvan University, Nepal

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Tribhuvan University

Institute of Science and Technology

Department of Food Technology

Central Campus of Technology, Dharan

Approval Letter

This *dissertation* entitled *Recipe Optimization of Chicken Meatball* presented by Sudarshan Gosai has been accepted as the partial fulfillment of the requirement for the B. Tech. degree in Food Technology.

Dissertation Committee

1. Head of the Department ____________________

(Mr. Basanta Kumar Rai, Prof.)

2. External Examiner ____________________

(Mr. Raj Kumar Rijal, Chief, FTQCO.)

3. Supervisor ____________________

(Mr. Devraj Acharya, Asst. Prof.)

4. Internal Examiner ____________________

(Mr. Arjun Ghimire, Asst. Prof.)

5. RMC Member ____________________

(Mr. Basanta Kumar Rai, Prof.)

December 28, 2021

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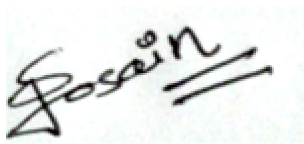

Sudarshan Gosai

Abstract

The basic raw materials for chicken meatball preparation were brought from local market of Dharan. The recipe for ingredients was extracted from previous study and Response Surface Methodology (RSM) was employed to optimize the level of addition of fat, water and yangben in the range of 0-20%, 0-15% and 0-5% respectively. The effect of these process variables was studied on responses processing yield, fat and jelly separation and water holding capacity of meatball while other parameters were kept constant. Twelve formulations produced by design expert which was also subjected to sensory evaluation to obtain optimum product in terms of aroma, color, blood taste, yangben taste, texture, juiciness and overall acceptability.

From the sensory evaluation the product prepared with sample E (0% water, 20% fat, 0% yangben), G (6.42% water, 8.57% fat, 5% yangben) and I (10.74% water, 6.25% fat, 3% yangben) were found to be significantly ($P < 0.05$) superior at 5 % level of significance in terms of flavor, tenderness, juiciness and overall palatability. From the physiochemical analysis the product prepared with sample G having 8.57% lard, 5% yangben, 6.43% water was found to be significantly ($P < 0.05$) superior at 5% level of significance in terms fat and jelly separation, processing yield, water holding capacity. Sample G was selected as best optimized sample for further analysis because it shows maximum desirability on sensory and physiochemical analysis. The processing yield, fat and jelly separation and water holding capacity of optimized sample i.e. sample G was found to be 92.16%, 1.16% and 81.37% respectively. Physico-chemical and sensory analysis of meatball samples showed that increase in percentage of yangben processing yield as well as WHC of the product increases and fat and jelly separation decreases. Physico-chemical and sensory analysis of meatball samples showed that WHC, processing yield and fat and jelly separation increases with the increase in percentage of water and fat (lard).

Contents

Acknowledgements .... **iv**

Abstract .... **vi**

List of Figures .... **xii**

List of Tables .... **xiii**

List of Abbreviations .... **xiv**

1. Introduction **1-5**

1.1 General introduction 1

1.2 Statement of the problem 2

1.3 Objectives 2

1.3.1 General objective 2

1.3.2 Specific objectives 2

1.4 Significance of the study 3

1.5 Limitation of the work 3

2. Literature review **4-32**

2.1 Historical background 4

2.. Chicken meat 4

2.2.1. Introduction 4

2.2.2. Parameters of chicken meat quality 6

2.2.3. Health benefits of chicken meat 7

2.3 Chemical composition chicken meat 9

2.4 Nutritional value 12

2.4.1 Energy 12

2.4.2 Protein 12

2.4.3 Fat and cholesterol 13

2.4.4. Moisture 14

2.4.5 Vitamins 14

2.4.6 Minerals..15

2.5 Gross composition of chicken..16

2.6 World broiler meat trade and production..17

2.7 Functional characteristics..17

2.7.1 Water holding capacity (WHC)..17

2.7.2 Emulsifying capacity (EC) 17

2.7.3 Myofibriller fragmentation index..18

2.8 Yangben 18

2.8.1 Introduction 18

2.8.2. Uses of Lichens (yangben) 19

2.8.3 Yangben as natural binders 21

2.9 Corn flour..21

2.10 Fat (lard) 23

2.11 Sensory attributes..23

2.12 Technology of meat balls..24

2.12.1 Ingredients..24

2.13 Quality attributes of meatballs..28

2.13.1 Appearance....29

2.13.2 Flavor/aroma....29

2.13.3 Texture and tenderness....29

2.13.4 Juiciness....30

3. Material and methods 33-40

3.1 Materials....33

3.1.1 Meat....33

3.1.2 Corn starch flour....33

3.1.3 Yangben....33

3.1.4 Oils....33

3.1.5 Salt....33

3.1.6 Other ingredients....34

3.2 Equipment....34

3.3 Methods of meatballs making....34

3.3.1 Recipe formulation different recipes.....34

3.3.2 Flowchart for preparation of meatball....37

3.3.3 Mincing and mixing....37

3.3.4 Fisting....37

3.3.5 Frying....38

3.3.6 Cooling....38

3.3 Sensory evaluation....38

3.3.1 Hedonic rating....38

3.3.2 Statistical analysis 38

3.4 Chemical analysis 39

3.4.1 Moisture content..39

3.4.2 Crude fat..39

3.4.3 Crude protein..39

3.5.4 Ash content..39

3.4.5 Crude fiber..39

3.5 Processing yield 40

3.6 Water holding capacity 40

3.7 Fat and jelly separation 40

4. Results and discussion 41-64

4.1 Proximate composition of raw material..41

4.1.1. Proximate composition of chicken meat. 41

4.1.2 Proximate composition of yangben..43

4.2 Effect of process variable on properties of chicken meatball..44

4.2.1 Effect of process variables on sensory attributes of chicken meatball..........44

4.3 Optimization of yangben, pig fat (lard) and water for the preparation of chicken. 50

4.3.2 Solution with expected response..51

4.4 Evaluation of responses 55

4.4.1 Fat and jelly separations..55

4.4.2 Processing yields..57

4.4.3 Water holding capacity..60

4.5 Optimization study ... 62

4.6 Proximate analysis of sensory optimized product ... 63

4.7. Cost evaluation ... 64

5. Conclusion and recommendations ... 65

5.1 Conclusion ... 65

5.2 Recommendations ... 65

6. Summary ... 66-67

References ... 68-74

Appendices ... 75-85

Color plates ... 86-90

List of Figures

Figure No.	Figure	Page No.
3.1	Flowchart for preparation of chicken meatball ………………………… ...	37
4.1	Mean sensory score for appearance of meatball………………………....	46
4.2	Mean sensory score for taste of meatball……………………………………	47
4.3	Mean sensory score for texture of meatball…………………………………	48
4.4	Mean sensory score for juiciness of meatball……………………………….	49
4.5	Mean sensory score for overall acceptability of meatball …………………..	50
4.6	Solution 1 with expected response………………………………………....	53
4.7	Solution 2 with expected response………………………………………..	54
4.8	Overlay plot for all responses as a function of water, pig fat (lard) and yangben in meatball…………………………………………………………………	55
4.9	Response surface plots for fat and jelly separation as a function of water, pig fat (lard) and yangben in meatball………………..………………………………	57
4.10	Counter plot for fat and jelly separation ………………..…..…………………	58
4.11	Counter plot for processing yield as a function of water, pig fat (lard) and yangben in meatball………………………………………………………	60
4.12	Counter plot for WHC as a function of water, pig fat (lard) and yangben in meatball………………………………………………………….…….…....	62

List of Tables

Table No.	Title	Page no.
2.1	Chemical composition of chicken meat…..…...........................	11
2.2	Amino acid content of raw chicken meat………………… …...	12
2.3	Lipid content of raw chicken meat………………………......	13
2.4	Vitamins content per 100 g…………………………...……..	14
2.5	Minerals content (mg/100 g)…………………….…………...	15
2.6	Gross composition of chicken meat………………...…….…	15
2.7	Chemical composition of pig fat (lard)…………………….…...	22
3.1	Amount of constant ingredients……………………..………	34
3.2	Constrains setting for optimization……………..…….….…..	35
3.3	Different recipe of samples…………………...…………..….	36
4.1	Proximate composition of chicken meat………………………..	43
4.2	Proximate composition of yangben……………………………	44
4.3	Different recipe of samples……………………..………..…..	45
4.4	Responses of experimental plan with formulation………..…...	53
4.5	Proximate composition of sensory optimized product……..…..	63

List of Abbreviations

Abbreviations	Full form
ANOVA	Analysis of variance
CCT	Central Campus of Technology
RSM	Response Surface Methodology
WHC	Water Holding Capacity
PY	Processing Yield
FAO	Food and Agriculture Organization

PART I

Introduction

1.1 General introduction

A meatball is ground meat rolled into a small ball, sometimes along with other ingredients, such as corn flour, minced onion, salt, MSG and seasoning. Meatballs are cooked by frying, baking, steaming, or braising in sauce. There are many types of meatballs using different types of meats and spices. The term is sometimes extended to meatless versions based on vegetables or fish (Rohman *et al.*, 2011). A meatball is ground meat rolled into a small ball, sometimes along with other ingredients, such as corn starch flour, minced onion, ginger garlic paste and seasoning. Meatballs are cooked by frying, baking, steaming, or braising in sauce. There are many types of meatballs using different types of meats and spices. The term is sometimes extended to meatless versions based on vegetables or fish. Only those meatballs with high nutritional value, good textural properties, acceptable flavor and taste profiles are preferred by consumers. Studies have shown that textures appears to be the most important characteristics of meatballs and consumers prefers harder texture (Yılmaz, 2005).

There are different types of ingredients used in meatball such as meat, spices, salt, MSG, yangben, fat and binders. The use of binder in meat industry is popular to bring about significant improvement in organoleptic properties of product. Binders have a macromolecular structure that have the capacity to form matrices to retain aroma and nutrients along with entrapment of large amount of water released during thermal processing to prevent exudation. Especially in ground meat products like meatball they are used to bind water and fat to stabilize meat emulsion. The Yangben in fact is the best water and fat binder in the minced meat due to its ability to form gel upon heating (Rankovic and Kosanic, 2015).

Yangben is itself an important traditional food served and eaten with Pork and/or blood locally called as *faqsa*. Besides it has a technological significance like binding property in product like *sargayangma* which is also considered an important traditional cuisine in Rai and Limbu community. The binding property of yangben is comparable to that of egg albumin which is one of the most used binders in food industry. So, yangben can be alternative to egg albumin in many cases (Limbu *et al.*, 2018). However, the expected result in product is found to be affected by type of muscle used and proportion of binder used in the product. Extensive research regarding the optimum amount of yangben to get the desired result in a particular product is not found yet. The water holding capacity of yangben was also found to be significantly affected by pH and fibrinogen concentration also (Adhikari, 2018)

1.2 Statement of the problem

Meatball is getting popularity nowadays all over the world. In context of Nepal meatball is getting popularity day by day. Various kinds of meatball are already present in food market, but their formulation and processing are not standardized and technical. Lack of research and development is the main problems for the promotion. The main problem is cost optimization for the marketing of meatballs. The main problem for the shelf life of meat ball is due to lipid oxidation and rancidity. The main problems it is unable to stabilize meat emulsion. In meatball the fat and water unable to bind so binders are used. But there are so many chemical binders are used which is not better for healthy purposes. So natural binder yangben is used as binding agent in meat products.

1.3 Objectives

1.3.1 General objective

The general objective of the dissertation work was to recipe optimize of chicken meat ball.

1.3.2 Specific objectives

The specific objectives of the dissertation work were to:

- Prepare meatball of different formulations given by experiment design.
- Measure the processing yield, fat and jelly separation and water holding capacity of the samples.
- Conduct sensory analysis of prepared samples.
- Optimize the recipe from RSM (Response Surface Methodology) and sensory analysis.
- Perform different physicochemical analysis of optimized product

1.4 Significance of the study

Chicken meat is cost effective in context of Nepal. Moreover, due to its low fat content, the meat is relatively easy to prepare and require less cooking skills. Likewise yangben can also be easily available in the market. Yangben can be traditionally prepared by cooking in ash water. Present work helps to develop low cost product which will be sustainable in the market. New product development plays significant role giving completely different taste, aroma, flavor, and appearance. So it is, helpful for the development of nutritionally dense and quality meat product. Product with Consistent quality thus helps in its commercialization. Thus, giving the new product a sort of life style foods, which can be further, accelerated when they become a part of the menu in fast food restaurants and companies. Future work can be taken as reference materials and will be useful for further research.

Yangben can be used in ground meat products like meatballs to bind water and fat to stabilize meat emulsion. Yangben is rich in carbohydrate and serves to bring about many textural and physicochemical changes in the meatball like final product. Binders play important role in meatball manufacturing with reducing the rapid use of commercial chemical binders and encourage people to use organic binders for hygienic and healthy purpose. Yangben is a rich source of iron and proteins of high nutritional and functional quality. Yangben also aids in improving the meatball's functional qualities. It improves water retention and processing yield while reducing fat and jelly separation.

1.5 Limitations of the work

Following were the limitations of the present study:

- Comparative study of binding capacity of yangben and different commercial binders was not performed.
- The parameter tenderness was not examined in relation to distinct sensory qualities.

PART II

Literature review

2.1. Historical background

The history of the meatball is obscure and early recipes are rare. Though many culinary inventions have been recorded decisively, no one is sure where the meatball originated. The meatball is a mysterious staple in food history, as no one really knows where and how the first meatball originated. The most commonly accepted theory is that meatballs come from Persia. In Persia, there is a food called “Kofta” which has many variations of preparation but essentially means, “pounded meat”. Based on their shape, ingredients and preparation, most trust this is where our traditional meatball derived. In the earliest of times, meatballs were made from leftover meat that was pounded, chopped finely, shredded by hand or prepared in a way that could be rolled into a small ball. Since most meatballs were made from leftover meat, it’s safe to assume that some of the earliest recipes have not been recorded as they were prepared for the common folk (Ghimire, 2018).

In the 1800’s, the Oxford English Dictionary defined them as “any combination of raw or cooked meat shaped into balls.” With such a broad definition, all cultures had room to create their very own staple recipe. Some of the earliest records of meatballs are in countries along the trade routes. It seemed everyone had their own version but the dish was essentially the same. Because of this, meatballs tie nations together. The main differences were the ingredients used. Regions played a big part in the components. For instance, China had an abundance of pork and therefore made plenty of pork meatballs while early ambitious Roman eaters enjoyed peacock, pheasant and rabbit meatballs (Vandendriessche, 2008).

2.2. Chicken meat

2.2.1. Introduction

Chicken meat is considered as an easily available source of high-quality protein and other nutrients that are necessary for proper body functioning. In order to meet the consumers’ growing demands for high-quality protein, the poultry industry focused on selection of fast-growing broilers, which reach a body mass of about 2.5 kg within 6-week-intensive fattening. Relatively low sales prices of chicken meat, in comparison to other types of meat, speak in favor of the increased chicken meat consumption. In addition, chicken meat is known by its nutritional quality, as it contains significant amount of high-quality and easily digestible protein and a low portion of saturated fat. Therefore, chicken meat is recommended for consumption by all age groups (Bell *et al.*, 2002).

The technological parameters of chicken meat quality are related to various factors (keeping conditions, feeding treatment, feed composition, transport, and stress before slaughter, etc.). Composition of chicken meat can be influenced through modification of chicken feed composition (addition of different types of oils, vitamins, microelements and amino acids), to produce meat enriched with functional ingredients (n-3 PUFA, carnosine, selenium and vitamin E). By this way, chicken meat becomes a foodstuff with added value, which, in addition to high-quality nutritional composition, also contains ingredients that are beneficial to human health (Aho, 2002).

Throughout the world, poultry meat consumption continues to grow, both in developed and in the developing countries. In 1999, global production of chickens reached 40 billion, and by 2020 this trend is expected to continue to grow, so that poultry meat will become the consumers' first choice. Fresh chicken meat and chicken products are universally popular. This occurrence can be explained by the fact that this meat is not a subject of culturally or religiously set limitations, and it is perceived as nutritionally valuable foodstuff with low content of fat, in which there are more desirable unsaturated fatty acids than in other types of meat. More importantly, quality poultry products are available at affordable prices, although their production costs may vary. If referring to overall consumption of all types of meat, poultry meat consumption takes one of the leading places in all countries throughout the world. Such good rating of poultry meat is influenced by many factors, such as short fattening duration, excellent space utilization, high reproductive ability of poultry, excellent feed conversion, satisfactory nutritional value of poultry meat and relatively low sales prices (Jayasena *et al.*, 2013).

The quality of broiler meat is affected by a number of factors, as follows: fattening system, duration of fattening, hybrid and sex, feeding treatment, handling before slaughter, freezing of carcasses, storage time, etc. It should be emphasized that nowadays poultry is fattened in an intensive way, so the stress is an inevitable factor, and the feed, with increased content of microalgae and vegetable and fish oils used to enrich poultry products with desirable fatty acids, is susceptible to oxidation. The same as designed poultry feed mixtures with increased microalgae or oil content, poultry products (meat and eggs) enriched with omega-3 fatty acids are also subjected to oxidation. In order to reduce oxidation in poultry feed, it is necessary to supplement it with some antioxidants, such as selenium or vitamin E. Such chicken meat is considered as “functional food”, as it has the increased content of bioactive substances, which positively influences consumers’ health. The most common bioactive substances used to enrich chicken meat are conjugated linoleic acid (CLA), vitamins, microelements, amino acids, microalgae and oils rich in omega-3 PUFA (polyunsaturated fatty acids) (Yeung and Morris, 2001).

The aim of this research was to present the nutritive value of chicken meat, as well as to assess the influence of different fattening system factors that determine the meat quality. Furthermore, the aim was to elaborate the possibility of enriching the meat with omega-3 fatty acids, carnosine and selenium, and to point out the benefits that consumption of enriched chicken meat has on human health (Bell *et al.*, 2002).

2.2.2. Parameters of chicken meat quality

When considering nutritional aspects, poultry meat is good for consumers because it is rich in protein and minerals, and contains a small amount of fat with high portion of unsaturated fatty acids and a low cholesterol level. Changes in consumers’ lifestyle in developed countries have influenced the meat market by changing the demand and supply of certain types of meat, which the food industry used as an advantage to market so called “fast food” and more recently also “functional food”. In both food groups, chicken meat is highly represented (Le Bihan-Duval *et al.*, 2008).

This growing demand for poultry meat influenced the scientists to create chickens of fast-growing genotypes, which have good feed conversion, better carcass formation (higher portion of breast meat and less abdominal fat), lower mortality, etc. However, all of these positive changes in new chicken genotypes cause greater stress, and many researchers point out that this fast growth of chickens resulted in histological and biochemical modifications of muscle tissue. The researches proved that selection of fast-growing chickens had negative effects on some meat quality parameters: reduced water holding capacity of meat, poor cohesiveness in cooked meat, appearance of pale, soft, exudative (PSE) meat, that is, of dark, firm, dry (DFD) meat. In addition to the mentioned factors, the available literature states that parameters of chicken meat quality are affected by the keeping system and duration of chicken fattening, feeding treatment and sex of chickens, pre-slaughter handling, transport to slaughterhouse (Le Bihan-Duval *et al.*, 2008).

An important factor for consumers when deciding on the purchase of meat is its appearance, therefore, in this chapter are described some technological features such as color, pH value, drip loss, cooking loss and water holding capacity (WHC), that have a direct impact on meat appearance. Consumers connect the color of meat with its freshness. The color of meat can be determined visually or using instruments (colorimeters). For the visual evaluation of the meat color, it is necessary to have trained panelists, who evaluate the appearance of meat by using the hedonic scale (Kralik *et al.*, 2018).

The instrumental determination of meat color is more efficient and the methods of reflection or extraction are used to quantify the amount of pigment. The color of foods can be defined as the interaction of a light, an object, an observer and the surroundings of the food. Recently, the International Commission on Illumination described how background can influence the appreciation of color. Instruments used for evaluation of meat color by reflection method are colorimeters, for example, CR Minolta 300 or 400 that work on the principle of meat color comparison in regard to standard color values. The International Commission on Illumination lists three values: CIE L*, a* and b*. CIE L* indicates lightness, where values range from 0 (black) to 100 (white). The value of CIE a* shows redness while CIE b* indicates yellowness. Negative a* and b* values indicate the appearance of green and blue color of the meat (Perez, 2008).

2.2.3. Health benefits of chicken meat

It is important to mention that chicken with skin contains 2–3 times more fat than chicken without skin, so it should be eaten without skin to ensure the intake of high-quality protein without extra calories and fat. When compared to red meat, the main advantage of white chicken meat is in its low caloric value and a low portion of saturated fat, so consumption of white chicken meat is recommended to people who want to reduce the fat intake, as well as to people suffering from heart and coronary diseases. When compared to cholesterol content, white chicken meat does not differ much from other types of meat, however, if considering other benefits (more protein, less total fat, less saturated fat and less calories), it has better nutritional quality and therefore, it is recommended for consumption to anyone who takes care of diet and health. High protein content makes chicken meat an ideal foodstuff for all consumers who need high-quality, easily degradable protein (athletes, children, the elderly) (Jiang and Xiong, 2016).

Average daily requirement (AR-average requirements) of adults for protein is 0.66 g/kg body weight (BW), while young children and athletes' needs are twice as high (1.12 g/kg body weight). Pregnant women's needs for protein are considerably higher and they depend on the pregnancy trimester, by increasing to an additional 23 g/day for the third pregnancy trimester. Because of all stated above, chicken meat is recommended as a rich source of high-quality protein in human nutrition. Chicken meat contains low collagen levels, which is another positive characteristic. Collagen is a structural protein that reduces meat digestibility, so chicken meat is easier to digest than other types of meat (Pereira and Vicente, 2013).

Chicken meat is also a good source of some minerals and vitamins. When compared to red meat (except for pork meat), it contains more calcium, magnesium, phosphorus and sodium. Content of iron is almost the same as in pork. Iron is necessary for creation of hemoglobin, for prevention of anemia, as well as for normal muscle activity. Calcium and phosphorus are important for healthy bones and teeth. Sodium is an electrolyte, and magnesium is important for normal synthesis of protein and proper muscle activity. Out of the total content of vitamin in chicken meat, niacin (vitamin B_3) is contained in highest portion, and content of vitamins A and B_6 is also higher than in other types of meat. Niacin is very important for proper metabolism of carbohydrates and for energy creation. It is also important for healthy skin, hair and eyes, as well as for nervous system. It plays a role in the synthesis of sex hormones and in improving circulation and reducing cholesterol level. Niacin is often used as an additional therapy in patients that take drugs for lowering of blood lipids. In this case, it is scientifically proven that niacin affects the increase of high density lipoprotein (HDL) cholesterol level, but it does not affect the improvement of cardiovascular disease state. When niacin is taken as an independent therapy, it reduces the development of cardiovascular diseases, and lowers the mortality associated with cardiac or cardiovascular diseases. The chronic lack of niacin in the organism causes pelagic disease, which is characterized by uneven skin pigmentation (skin redness), gastrointestinal disorders (diarrhea) and brain function disorder (dementia). In light of the above mentioned, chicken meat is considered as convenient, affordable and acceptable source of basic nutrients, vitamins and minerals necessary for proper body functioning (Bender, 1992).

In present times, emphasis is put on importance of chicken meat consumption for maintaining and reducing body weight. It is known that the intake of dietary protein is effective in reducing body weight, so the chicken meat is often a part of the diet aimed to reduce body weight, because of its high protein and low fat content. The studies have shown that weight loss was higher in people who consumed low calorie meals rich in protein in comparison with low calorie meals with low protein content. This is due to the fact that protein provides a greater sense of satiety, so that people consume less calories during the day, thus reducing the intake of carbohydrates (Haug *et al.*, 2011).

Chicken meat is considered as desirable foodstuff in prevention of cardiovascular diseases. Saturated fat, cholesterol and heme iron, which is more contained in red than in white meat, are very important factors in development of atherosclerosis, cardiovascular diseases, hypertension and in increase of blood cholesterol. According to the data of Bernstein, by replacing meals with red meat with white chicken meat, the risk of cardiovascular disease occurrence can be lowered by 19%. The authors assumed that this was a consequence of fewer intakes of heme iron and sodium, and of more polyunsaturated fatty acids in meals. Therefore, chicken meat, as a source of protein, could be a significant factor in reducing risks of cardiovascular disease development. There has been recently a lot of evidence on how the lifestyle has been influencing the increase or the decrease of disease risk occurrence, such as diabetes (Gregory *et al.*, 2013).

2.3. Chemical composition chicken meat

Among the flesh foods, poultry meat is economical, quick and easy to prepare and serve and have a number of desirable nutritional and organoleptic properties. It occupies an important position in our diet from the nutritional and comprises an important part today's health o acids. Poultry protein readily digestible.it is slow in calories, a good source both saturated and unsaturated fatty acids including certain essential fatty acids. The meat fibers of poultry are tender and easy to digest. Poultry meat is rich in both water and fat soluble vitamins and in minerals (Bogosavljevic-Boskovic *et al.*, 2010).

Poultry meat is good source of niacin, which is immediately concerned, in several metabolic reactions. Lack of this vitamin causes a disease called pellagra. Poultry meat is also moderately good source of riboflavin, thiamine that is needed for various body activities. Due to absence carbohydrates chicken meat can be an ideal food for diabetic patients, as well as a help shed fat from body. Because of its richness in protein, it can help in solving the malnutrition problem. Besides supplying of energy and giving the body building factors, poultry meat also provides a factors, which regulate the function of body and protect it against injury and disease (Hassanin *et al.*, 2017).

Poultry meat present in the diet also contributes to various minerals like sodium, magnesium, calcium, iron, phosphorous, sulfur, chlorine and iodine. These minerals are necessary for different body tissue such as constituents of bones and teeth, constituent of body cells of soft tissues such as muscle (Hassanin *et al.*, 2017).

The chemical composition of poultry meat as follows:

The chemical composition of various poultry meat is given in the Table 2.1.

Table 2.1 Chemical composition of various poultry meat (g/100 g)

Ingredients	All classes light Meat without skin		Fryer		Roaster	
	Raw	Roasted	Raw	Fried	Raw	Roasted
Water	73.7	63.8	75.7	53.3	63	53.5
Energy (Kcal.)	117	166	124	249	239	290
Protein (g)	23.4	31.6	18.6	30.7	18.2	25.2
Fat (g)	1.9	3.4	4.2	11.8	17.9	20.2
Carbohydrate (g)	0	0	0	0	0	0
Ash (g)	1	1.2	0.8	1.3	0.9	1.1
Calcium (mg)	11	11	12	13	10	10
Phosph.(mg)	218	265	201	254	176	220
Iron (mg)	1.1	1.3	1.9	2.3	1.6	1
Sodium (mg)	30	64	0	0	0	0
Potassi.(mg)	320	411	0	0	0	0
Vit-A (I.U)	60	60	730	820	920	960
Thiamine (mg)	0.05	0.04	0.07	0.07	0.08	0.08
Riboflavin (mg)	0.09	0.10	0.38	0.57	0.19	0.22
Niacin (µg)	10.7	11.6	5.6	9.1	6.7	7.4

Source: Watts (2004)

2.4 Nutritional value

2.4.1 Energy

A 100 g serving of baked chicken provides 859 KJ of energy, which is 9% of recommended daily intake for women and 8% of RDI for men. Chicken is a nutrient dense food in that many nutrients, including proteins, zinc, iron, magnesium, riboflavin and niacin contribute more to their respective RDI than the percentage contribution for energy. The positive correlations exist with the fat and energy content such that as the fat content increases there is corresponding rise in energy. Poultry meat is low in calories to other nutrient present. So it's a good foodstuff for weight control diet, convalescents and old people who are not physically active.it helps to reduce calories intake but also helps to keep other nutrient require in proper balance. Broiler contains 151 Kcal./100 g (Kik, 1962).

2.4.2 Protein

Chicken is an excellent source of protein. A typical 100 g serving of baked chicken provides 49% of the RDI for men and 60% of the RDI for women. The broiler meat contains more protein than red meats. Shah (1956) reported that cooked poultry meat contains 25-35% of protein, excluding edible viscera. It contains high quality protein, is easy digest and contains all essential amino acids presently known to be required in human diets (Kralik *et al.*, 2001). Amino acid content was shown Table 2.2.

Table 2.2 Amino acid content

Amino acid	Value (%)
Lysine	7.5
Valine	1.8
Arginine	5.92
Tryptophan	0.8
Leucine	6.6
Isoleucine	4.1
Histidine	3.69

Source: Millares and Fellers (1949)

2.4.3 Fat and cholesterol

In one of the analytical program carried, the total fat content in the cooked portion ranged from 0.9-17 per 100 g edible portion. Stir–fried skinless breast fillets had the lowest fat content and casseroled chicken wings had the highest fat content (17 g/100 g). Generally, breast portions has the lowest fat content, followed by the thigh portions and then the drumstick, with chicken wings having the highest fat content. Removing the skin from the chicken portion considerably lowered the overall fat content. Little differences was noted in the fat content when comparing the equivalent baked and casseroled chicken cuts. As a general trend, the cholesterol content increases in the chicken portion as the fat content increased. The cholesterol content ranged from 165 mg/100 g esp. with breast portion having lowest cholesterol levels, followed by the thigh portions, then the drumsticks with chicken wings having the highest cholesterol levels. Poultry meat contains a higher proportion of unsaturated fatty acids and then the fats from the red meats, but less than fats and oils from vegetable origin. It contains less cholesterol (Barroeta, 2007). Lipid content (% total lipids) of raw chicken meat is shown in the Table 2.3.

Table 2.3 lipid content (% total lipids) of raw chicken meat

Lipid types	% of total lipids
Phospholipids	48
Natural lipids	52
Cholesterol (mg per 100 g)	60

Source: Sharma and Wani (1995)

2.4.4. Moisture

Moisture less occurred unevenly among the different chicken portions, with smaller portions producing the greatest percentage moisture loss. Due to the moisture loss, the concentration of many of the nutrients increased during cooking despite partial destruction of certain heat labile nutrient loss in the drained juices. The edible portion of chicken broiler contains about 71 to 72.2% moisture (Kralik *et al.*, 2001).

2.4.5 Vitamins

A 100 g serving of baked chicken is excellent source of niacin equivalent, providing more than 100% of the RDI for women and 71% RDI for men. Chicken is also good source of riboflavin and a moderate source of vitamin E. A correlation exists between the amount of fat % in the chicken portion and the concentration of the fat soluble vitamins: as the fat content increases in the tissue there is a corresponding rise in fat soluble vitamins. Vitamin A and E are present in larger concentration in the skin and separable fat than in the lean tissues. The vitamins folate was measured for the first time. Small amounts of folate were detected in the lean raw components of the chicken, with the thigh portion containing the largest amount (14 mg/100 g) (Barroeta, 2007). Vitamins content per 100 g is shown in Table 2.4.

Table 2.4 Vitamins content per 100 g

Vitamins content per 100 g	
Vitamin A	730 IU
Thiamin (B_1)	0.07 mg
Riboflavin (B_2)	0.38 mg
Niacin	5.6 mg

Source: Sharma and Wani (1995)

2.4.6 Minerals

Mineral content per 100 g is shown in Table 2.5.

Table 2.5 Minerals content (mg/100 g)

Minerals	Content (mg/100 g)
Calcium	5.8
Phosphorous	407
Iron	0.7
Sodium	46
Potassium	248
Magnesium	29
Sulphur	268

Source: Sharma and Wani (1995)

2.5 Gross composition of chicken

Gross composition of chicken meat is shown in Table 2.6.

Table 2.6 Gross composition of chicken meat

		Lean meat (%)	Fat (%)	Skin (%)	Inedible (%)
Whole chicken	Raw	54	5	11	27
	Baked	57	2	8	30
Chicken breast	Raw	64	5	9	20
	Baked	66	2	7	23
Chicken drumstick	Raw	57	1	8	31
	Baked	52	1	8	36
Chicken thigh	Raw	47	10	11	29
	Baked	52	3	3	32

Source: Chang (2007)

2.6 World broiler meat trade and production

Total 2003 broiler meat exports by major exporting countries are forecast to return to record levels of 5.6 million tons, up 4%from the 2002 estimate. The top 4 exporting countries are expected to dominate export markets due mainly to availability of supplies, price competitiveness, and for the EU, increased subsides. For 2003, broiler meat imports by major countries are forecast at 4.5 mil tons, up 2% from the 2002 estimate. China, the EU, japan, Mexico, Russia and soudi Arabia are expected to account for more than 80% of imports (Davis *et al.*, 2013)

2.7 Functional characteristics

2.7.1 Water holding capacity (WHC)

Among the functional parameters, the inherent ability of the meat to hold its own water and its ability to bind with water added to it separately or as a constituent present in non-meat additives in a product formulation is the most important factor in deciding suitability of the meat for processing into products. It is directly related to emulsion stability and juiciness of the meat products. Poor water holding capacity in raw poultry meat results in diminished visual appeal and inferior palatability traits for consumers as well as reduced ingredient retention, protein functionality and product yields for processors. Broiler breast muscles are comprised of nearly 100% fast- twitch glycolytic muscle fibers making them particularly susceptible to undergoing a rapid postmortem pH decline and exhibiting inferior WHC characteristics. Postmortem muscle pH and protein denaturation are considered the main determinants of WHC in meat (Bowker and Zhuang, 2015).

2.7.2 Emulsifying capacity (EC)

The amount of myofibriller proteins present in meat and their ability to emulsify added fat is an important criterion for emulsion stability and better product characteristics in terms of binding and texture. Emulsifying capacity at pH 7.0 was greater than at normal pH and pH 5.0, although the amount of salt soluble protein was not always greater. pH was more important in emulsifying capacity than was percent of salt soluble protein extracted from meat tissues. Emulsifying capacity of 45 ml oil/2.5 g meat was recorded in chilled meat from 3 month old chicken meat (Kijowski *et al.*, 1982).

2.7.3 Myofibriller fragmentation index

The amount of myofibrils in meat that gets fragmented by application of mechanical forces determines the texture of the meat product. More the fragmentation of myofibrils, tender will be product texture. The Myofibriller Fragmentation Index (MFI) is a measure of myofibriller protein degradation. This was highly related to shear force and sensory tenderness ratings and negatively correlated to lean color. Tenderness was highly and positively correlated with MFI and indicates the amount of myofibriller proteolysis that has occurred. The MFI was observed to be 67.5 in four month old chicken meat. The chicken meat from old had a higher myofibriller fragmentation index compared to the meat from young chicken. Animal age has been shown to have more influence on tenderness attributes than sex of the animal. MFI was negatively correlated with the shear force value of the chicken meat (Kulkarni *et al*., 1993).

2.8 Yangben

2.8.1 Introduction

Yangben are the symbiotic organisms, usually composed of a fungal partner, the mycobiont and one or more photosynthetic partners, the photobiont, which is most often either a green alga or cyan bacterium. The nature of the Yangben symbiosis is widely debated. However, the most researchers refer lichen as a classical case of mutualism where all the partners gain benefit from the association. Alternatively, they are also regarded as an example of controlled parasitism because the fungus seems to obtain most of the benefit and the photobiont may grow more slowly in lichenized state than when free living (Nash, 1996).

Usually in the association both partners have benefit. The mycobiont has two principle roles: to protect the photobiont from exposure to extreme sunlight and dessication and to absorb mineral nutrients from the underlying surface or from atmosphere. The photobiont also performs two major roles: to synthesize organic nutrients from carbon dioxide and in the case of cyanobacteria, to produce ammonium from N_2 gas by nitrogen fixation (Devkota *et al.*, 2017).

Lichens are distributed worldwide and are the pioneer groups of organism that initiate vegetation in the bare area. They have both algal and fungal properties and produce nalkane, unusual betaine ether glycerol-lipids, and saturated, unsaturated, branched and halogenated fatty acids. Many different bioactive secondary metabolite have also been isolated from different lichen species which have been used in different field of sciences (Adhikari, 2018).

About 13,500 to 17,000 species of lichens extend from the tropics to the polar region. In Nepal, 471 species of lichens have been reported, of which 48 species are endemic. The components of lichen flora are governed by altitudinal variation and growth forms also vary accordingly. In Nepal very little research have been done in lichen till now and most of the known ones were recorded by foreigner (Adhikari, 2018).

Some Ramalina species of lichen are used as food in some Central and South Eastern Asian countries. Though the lichen flora of Nepal is complex one, those collected from Dhankuta, Taplejung and Terathum district were identified as *Parmelia nepalensis*, *Usnea thomsonii*, *Ramalina farinacea*, *Ramalina subfarinacea*, *Ramalina conduplicans* etc. In Nepal, Rai and Limbu communities use them as traditional food usually mixed with other dishes. It is also called Jhyau, Tarey or Jhulo while Rai, Limbu and Sherpa call it yangben (Adhikari, 2018).

Some species of lichen after being chemically analyzed for food value were found to be rich in carbohydrate, fat, crude fiber and minerals with comparable content of carbohydrate and protein with that of rice. If mixed with food they provide sufficient amount of minerals and other nutrients. The high Fe, Ca and riboflavin content of species *Usnea, Parmelia, Ramalina* and *Peltigera* make them potentially valuable food supplements (Adhikari, 2018).

2.8.2 Uses of lichens (yangben)

Lichens are the important part of nature and are useful to human beings in many ways. Among hundreds of them, the most important ones can be mentioned as:

1) As food

Lichens have been widely used as food for centuries. However some species are mildly toxic, a few are poisonous and most are indigestible in their raw form. The complex carbohydrates difficult to break down in human digestive tract make them poorly digestible. So, they are prepared in the way that improves their digestibility as well as delicacy. The best known lichen polysaccharides are lichenan, isolichenan and galactomannan which are important when it comes to functionality in meat products (Nash III). The fibrous plant substances rich in non-cellulosic polysaccharides were found to have good water holding capacity. The content of soluble non-cellulosic polysaccharides of such fiber rich plant stuffs was found to be positively correlated to water holding capacity by (Devkota *et al.*, 2017).

This broadens the application of yangben in food industries where such functionality is desired

- Blood curry: Rehydrated yangben is mixed with blood (especially pork) and then it is cooked

- Pork curry: Rehydrated yangben is cooked with pork meat and delicious dish is prepared which resembles the character of meat

- Egg curry: It is prepared by frying the rehydrated yangben with egg.

- Vegetable curry: Yangben is also consumed by cooking it alone in karahi without mixing with any food and taken as vegetable curry with meal (Limbu *et al.*, 2018).

2) The most important environmental role of lichens is their use as bio indicators. The sensitivity of particular lichen species to a broad spectrum of environmental conditions, both natural and unnatural makes them an important biological indicator for pollution (Huneck and Yoshimura, 1996).

3) The genus Usnea is most commonly used as medicine due to presence of usnic acid which is used as antibiotic and anti-inflammatory substance (Crampton, 2017). Besides, some species of *Letharia, Ramalina, Cetraria, Cladonia* etc. are also used as traditional medicine in many parts of the world (Huneck and Yoshimura, 1996).

4) Many species of lichen are used for making wool and fabric dyes. Many colors are possible and it depends on the species of lichen and the extraction process used. The most common example is litmus, which is a mixture of dyes extracted from specific lichens, especially *Rosella tinctoria* (Nash, 1996).

5) They are used as ingredients in perfumes and deodorants. *Evernia prunastri* and *Pseudevernia furfuracea* are used for such purpose (Nash, 1996) .

6) The most of the lichen secondary metabolites have wide biological action like antioxidant, antiviral, antipyretic, analgesic and antitumor action which make them suitable candidate for various pharmaceutical purposes (Nash, 1996) .

2.8.3 Yangben as natural binders

The use of binder in meat industry is popular to bring about significant improvement in organoleptic properties of product. Binders have a macromolecular structure that have the capacity to form matrices to retain aroma and nutrients along with entrapment of large amount of water released during thermal processing to prevent exudation. Especially in ground meat products like meatball they are used to bind water and fat to stabilize meat emulsion. The Yangben in fact is the best water and fat binder in the minced meat due to its ability to form gel upon heating. The binding property of yangben is comparable to that of egg albumin which is one of the most used binders in food industry. So, yangben can be a alternative to egg albumin in many cases. However, the expected result in product is found to be affected by type of muscle used and proportion of binder used in the product. Extensive research regarding the optimum amount of yangben to get the desired result in a particular product is not found yet (Ofori and Hsieh, 2012). The water holding capacity of yangben was also found to be significantly affected by pH and fibrinogen concentration (Adhikari, 2018)

2.9 Corn flour

Corn starch, corn flour or maize starch or maize is the starch derived from the corn (maize) grain(Anon, 1828). The starch is obtained from the endosperm of the kernel. Corn starch is a common food ingredient, used in thickening sauces or soups, and in making corn syrup and other sugars. It is versatile, easily modified, and finds many uses in industry as adhesives, in paper products, as an anti-sticking agent, and textile manufacturing. It has medical uses, such as to supply glucose for people with glycogen storage disease. Like many products in dust form, it can be hazardous in large quantities due to its flammability. When mixed with a fluid, cornstarch can rearrange itself into a non-Newtonian fluid. Cornstarch is used as a thickening agent in liquid-based foods (e.g., soup, sauces, gravies, custard), usually by mixing it with a lower-temperature liquid to form a paste or slurry. It is sometimes preferred over flour alone because it forms a translucent, rather than opaque mixture. As the starch is heated, the molecular chains unravel, allowing them to collide with other starch chains to form a mesh, thickening the liquid (Starch gelatinization). It is usually included as an anticaking agent in powdered sugar (10X or confectioner's sugar). Meatballs with a thin outer layer of cornstarch allow increased oil absorption and crispness after the latter stages of frying (Jais and Rashid, 2017).

Corn starch, sometimes referred to as corn flour, is a carbohydrate extracted from the endosperm of corn. This white powdery substance is used for many culinary, household, and industrial purposes. In the kitchen, corn starch is most often used as a thickening agent for sauces, gravies, glazes, soups, casseroles, pies, and other desserts. Corn starch can be mixed into cool or room temperature liquids and then heated to cause a thickening action. Corn starch is often preferred to flour as a thickener because the resulting gel is transparent, rather than opaque. Corn starch is also relatively flavorless compared to flour and provides roughly two times the thickening power. Corn starch can be substituted at half the volume of flour in any recipe that calls for flour as a thickening agent (Rouf Shah *et al.*, 2016).

Corn starch can also be used to coat fruit in pies, tarts, and other desserts before baking. The thin layer of corn starch mixes with the fruits' juices and then thickens as it bakes. This prevents pies and other desserts from having a watery or runny texture. Corn starch is also used as an anti-caking agent. Shredded cheese is often coated with a thin dusting of corn starch to prevent it from clumping in the package. The corn starch will also help absorb moisture from condensation and prevent a slimy texture from developing (Wet, 2006).

2.10 Fat (lard)

Lard is semisolid white fat product obtained by rendering the fatty tissue of the pig. It is distinguished from tallow, a similar product derived from fat of cattle and sheep. Lard fat contain 38-43% of total saturated and 56-62% of total unsaturated fat. A different property of lard is given in Table 2.7.

Table 2.7 Different property of lard

Parameters	Value
Food energy	3770 KJ
Melting point	30-45 ℃
Smoke point	121-218 ℃
Specific gravity	0.917-0.938
Iodine value	45-75
Acid value	3.4
Saponification value	190-205

Source: Maw *et al.* (2003).

Lard can be rendered by steaming, boiling, or dry heat. The culinary qualities of lard vary somewhat depending upon origin and processing method; if properly rendered, it may be nearly odorless and tasteless. It has high saturated fatty acid content and no trans-fat. At retail, refined lard is usually sold as paper wrapped blocks (Maw *et al.*, 2003).

2.11 Sensory attributes

The physical, chemical and functional quality of meat is highly related to its sensory characteristics. The sensory attributes of meat products vary with characteristic change in their constitution in meat. Visual assessment is one of the key criteria in the sensory evaluation of foods. The appearance of food products may affect their perception by other senses, sometimes giving a false picture of their quality. A true assessment of such sensory attributes as aroma, taste, tenderness, and juiciness, which are components of the overall linking of food, without the use of instrumental methods is feasible only by blind people. Scores given by the sensory panel allowed the conclusion that the most desirable poultry meat was BM of broiler chicken and capon, followed by guinea flow. Lower scores were given by the panelists to meat of water fowl (goose, duck), whereas the lowest ones were assigned to cooked ostrich meat one of the beat method for sensory analysis is hedonic rating test. The coded samples of the meatballs were sensorial evaluated while still warm for appearance, flavor, texture, juiciness, taste and overall palatability on 9 point hedonic scale. The panelists were given instruction to give 9 points to extremely like and 1 points to the extremely disliked point sample. The coded samples were randomly presented. For the above hedonic rating test, semi trained panelist of B.Tech 4th year and teachers of Central Campus of Technology was taken. Before sensory evaluation, instructions were given to panelists. They were asked to give maximum scores for its purple brown color. For texture and taste, they were instructed to give marks as they like. The various parameters tested were appearance, texture and tenderness, taste, flavor and overall palatability (Yin *et al.*, 2011).

2.12 Technology of meat balls

2.12.1 Ingredients

2.12.1.1 Meat

Meatballs can be made from all types of meat. It can be made either from one type of meat or combination of different types of meat such as all chicken, all buffalo meat and all fish meat and from combination of different meat at various proportion . In meatball most desired are the lean muscles having less connective tissue. Thus meat pieces of relatively uniform size, trimmed of connective tissues are given first priority but second quality meat having partially trimmed off connectives are also used. The different animal tissue will vary in moisture to protein ration, lean to fat ratio. Approximately 60% of total protein is myofibriller composed mainly of myosin and actin, which combine to Form actomyosin during onset of rigor-mortis. When choosing raw material particular attention should be paid to its origin, composition and pre- treatment. The composition and quality of meat differs with animal species. The differences affect the water holding capacity pH, color, flavor and tenderness of meatball (Hoogenkamp, 2004).

There is also a significant difference in meat quality between breeds of different species as well as same species. Like myoglobin concentration of same muscle may vary which affects the color of the final product. Similarly the proportion intramuscular fat may vary which also affects the flavor and juiciness of the final product. With increase in age the concentration of intramuscular fat increases meat becomes darker and tougher. thus with the change in meat quality tenderness juiciness and color of meat ball do change. Generally good nutrition increases the level of intramuscular fat thus affects the juiciness of the meat ball i.e. juiciness increases. Another aspect of nutrition on meat quality the composition of the forage can lead to flavor variation. The pH of the meat depends on the glycogen content and glycolytic activity resulting in increase or decrease in glycolytic activity. After slaughter glycogen of the muscle is converted into lactic acid fall in pH from an initial value of 6.3 to 7.3 to about 5.4 to 5.8 at rigor-mortis. Electrically stimulated muscles hasten the process of rigor and subsequently a quick drop of pH (Hoogenkamp, 2004).

When animals stress immediately prior to slaughter the muscle glycogen released into blood stream and after slaughter is rapidly broken down to lactic acid and produce pale soft and exudative meat. The meat has low pH, has reduced water-holding capacity whereas DFD meat caused by long-term stress before slaughter or starvation has normal or increased water holding capacity and pH of meat greater than 6. Both the DFD and PSE meat has poor meat flavor too. The meat with pH greater 6 usually has good water holding properties (i.e. less cooking loss) and retains it native color when heated at pH greater than 6 has fixation effects on color attributes (Hoogenkamp, 1997).

The freezing causes certain damage to the muscle fibers and protein denatures which causes drip loss from meat. Also during thawing after freezing, there is a loss of characteristics. In addition, it has been found that hot boned meat tends to have its own antioxidative properties and thus taste and rancidity of hot meat is better than chilled meat. Post rigor storage/treatment (ageing) if meat is associated with both tenderization and increased water holding capacity as the myofibriller system decrease. Cold and thaw shortened meats are very tough, has low water holding capacity as demonstrated by the large amount of drip loss (Savic, 1985).

2.12.1.2 Seasonings

According to FDA, spices have been defined by the food and drug administration aromatic vegetable substances used for the seasoning of food. They are true to man and from them no portion of volatile oil or other flavoring principle has been removed. Seasoning is a comprehensive term applied to blends of spices, which may or may not contain other ingredients such as onion, garlic, MSG, salt and sugar. The various seasoned salts (onion salt, garlic salt and celery salt are seasoning salts as are chilli powder and curry powder). The meat industry uses a whole black pepper in several meat items. Very often some other form of spices is used with whole spices for flavor strength and uniformity of flavor, but whole spices usually do not compete with other form of spices (Anjaneyulu *et al.*, 2007).

2.12.1.3 Ground spices

Since the beginning of the recorded history ground spices have been used extensively to seasoned foods but more recently other forms of spicing have become well recognized Because of some desirable characteristics. In addition to ground spices the food processing Industry use considerable quantities of soluble spices and essential oils and to a lesser extent, aromatic chemical compounds. Of great importance are the ground spices which are used widely specially in meat, Bakery and caned products. Ground spices are available in wide range of particle sizes varying from cracked spices (pepper) to very finely milled spices averaging 10 to 50 microns. Many methods of grinding spices are commonly used but the factor, which determines method for particular spices include grinding rate, Power requirement and the amount of heat generated and transferred to the ground spice. The amount of heat and aeration determine to a large extent, the loss of volatile constituents during the grinding operation. Some of the very oily spices such as nutmeg are difficult to grind to a fine mesh size with conventional grinding technique (Anjaneyulu *et al.*, 2007).

2.12.1.4 Soluble spices

Soluble spices are made by mixing spices extractives from one or number of spices with a soluble carrier such as sucrose, dextrose, salt or MSG. Either the volatile oil from distillation or the oleoresin from solvent extraction or both are mixed with a soluble carrier in approximately the same concentrations as they occur in nature. Since the characteristics flavor comes from both volatile oil and oleoresin in most spices, a blend of both fractions will result in soluble spice with a truer flavor than when either is the sole source of spice flavor. Spice extractives also been mixed with non - soluble carrier such as dehydrated onion and garlic, other spices and occasionally with drying agent such as calcium silicate (Anjaneyulu *et al.*, 2007).

2.12.1.5 Spice oils

Spice oil includes the essential oil and non- volatile fraction known as oleoresin. Essential oils are commonly used in pickle and to a limited extent to catsup. The food manufacturer has four form of spice flavor with which to season his products; ground spices, soluble spices, essential and aromatic chemicals (Anjaneyulu *et al.*, 2007).

2.12.1.6 Flavor

Ground spices are usually very good unless they are exceptionally old or have picked up off-flavor during storage. Ground spices are considered the most stable of these four forms of spice but exposure to air and light can cause considerable loss of flavor in storage, especially in very finely ground material. Soluble spices can be very good, providing the essential oil and or the oleoresin are of good quality. These can vary as much as a ground spices but since they are compounded, there is ample opportunities for standardizing the flavor. Soluble spices can be much more uniform than ground spices. For soluble spices sucrose, dextrose and MSG is better carrier than salt. Essential oil can be good but the addition of oleoresin usually improves the flavor, making it resemble the original spice flavor more closely. They are used in occasion to extend essential oils as cinnamic aldehyde in oil of cassia. These react much the same as essential oil but often-cinnamic aldehyde will change to a mixture having a bitter almond taste (Anjaneyulu *et al.,* 2007) .

2.12.1.7 Salt

Salt is a non-meat ingredients added to meatballs. Salt which decreases water activity reduces microbial growth in most instances increases self-life and improves flavor. In sufficient concentration, salt inhibits microbial growth as the result of the increasing osmotic pressure of the medium of the food, which is also reflected in lowering the water activity. Some bacteria are inhibited by concentration as low as 2% and these microorganisms are referred to as salt tolerant. Many of the micrococci and bacillus Species are examples. Salts serves as a preservatives by retarding bacterial growth thereby functioning as bacteriostatic rather than bactericidal agent. Bacteriostatic effectiveness is dependent on brine concentration in the comminuted meat products (Anjaneyulu *et al.*, 1989).

2.12.1.8 Phosphates

Food grade phosphates are used in additives in many phases of meat packing industries. Among their functions are moisture retention emulsification and sequestration role as Well as participation in the curing and preservation of meat color, flavor and tenderness. The phosphates used are sodium tri polyphosphates, for cured meats phosphates are usually added to the pickling solution, which is injected or soaked into the meat. Phosphates, which reduces moisture loss during processing and improve firmness. 3% fats are generally used for the processed meat product such as sausage (Anjaneyulu *et al.*, 1989).

2.13 Quality attributes of meatballs

The buyer may define quality of foods as the composite of those characteristics that differentiate individual units a product and have significant in determining the degree of acceptability of the unit. Thus overall quality of the good product not should be, analyzed for its components attributes, each of which should be measured and controlled independently (Hsu and Chung, 1998).

Meatballs, patties, sausage like meat products have their typical characteristic and basic knowledge of their important attributes is necessary for sensory evaluation. The important meat attributes to be assessed are appearance (color) flavor, juiciness, texture and tenderness. Knowledge of these attributes is of prime importance (Hsu and Chung, 1998).

Warm meatballs (after frying) are used to evaluate the above attributes. The quality of the fried/cooked products varies markedly with the type of heat treatment and time of frying. Although flavor color and texture are all important quality attributes of cooked meats but it is well established that texture factor usually indicates the method of cooking is paramount importance and this quality (Hsu and Chung, 1998).

2.13.1 Appearance

Surface structure and the overall shape of the comminuted meat have an important bearing on their appearance. Degree of doneness is appearance parameters seen in hamburger. Consumers relate color to determine doneness in cooked meat patties (Hsu and Chung, 1998).

2.13.2 Flavor / aroma

Flavor is a complex sensation comprising mainly of odor and taste, odor being more important. It is sensed collectively by the oral and olfactory and senses. There are four basic tastes viz. sweet, salty, sour and bitter. For sound odor perception, the sample should be smelled first, followed by tasting. Of all the attributes, flavor has a profound effect on overall acceptability of meat product (Naveena *et al.*, 2006).

The flavor of meat and meat products is affected by many factors such as species, age, sex, pH, condition of storage, method of cooking and ingredient added in the processed added. Meat flavor, like aroma, is very difficult to evaluate and describe. It is hard to separate these two characteristic since many of the flavor properties are really the result of odor sensations. When the odor effect is reduced or removed, meat flavors are extremely difficult to distinguish. The flavor of the raw meat is weak, salty and blood like; the true meaty flavor develops during cooking. The nature and intensity of meat flavors depend in part on the type, length of time and temperature of cooking (Sharma and Wani, 1995).

2.13.3 Texture and tenderness

Claus *et al.* (1990) defined the texture as the attribute of substance resulting from a combination of physical properties perceived by the sense of touch, sight and hearing. The physical properties include size, shape, number, nature and continuation of constituent elements. Thus, texture encompasses all properties of food, which are perceived by kinesthetic and tactile senses in mouth example tenderness, density, granular structure, fragility, humidity etc. (Chen and Rosenthal, 2015).

Categorized the textural components of animal foods as mechanical characteristic which relate to the reaction of the food to stress example, hardness, brittleness, gumminess, chewiness, elasticity and cohesiveness etc. Geometrical characteristics, which relate the shape, size and orientation of particles with meat e.g. Coarseness, grittiness, fibrous, cellular, etc. and other characteristics which relate to moisture and fat perception of meat e.g. greasiness, oiliness, watery, dry, moist etc. The degree of tenderness may be evaluated as the number of chews required masticating the sample (Claus *et al.*, 1990)

2.13.4 Juiciness

Meat juiciness is an attribute having two organoleptic components. The first one is impression during initial chews, because of rapid release of meat fluid, the second being the sustained juiciness due to stimulatory effect of fat on salivation. A good quality meat is juicier than poor quality due to higher content of intramuscular fat. Fresh frozen meat with high ultimate pH is quite juicy (Winger and Hagyard, 1994).

The degree of shrinkage on cooking is inversely proportional to the juiciness of meat. Juiciness and tenderness are closely related to meat attributes. Overall acceptability of a meat product is not the sum average of all the eating quality attributes. This is so because some attributes influence the overall acceptability of the product as compared to others. Juiciness in meat product is largely determined by combined effect of fat, moisture and salt (Warner, 2017).

2.13.4.1 Water binding in meat products

The batters of meat products are complex colloidal suspension of meat and fat particles partially extended with solubilized proteins. Myosin is the primary constituents responsible for binding of water and fat particles. Manufacturing meat products with proper textural properties is related to the functionality of the muscle proteins in three dimensional matrixes. Formation of this matrix in sausage batter is due to interaction between protein-water, protein-protein and protein-lipid. Proteins are the major structural 37 components in the system; they combine and develop the structure by binding water and fat. Various proteins are added to emulsion type sausage batter to balance the quality and quantity of protein. With processing, functionality, nutritional value and cost (Honikel, 1983).

2.13.4.2 Mechanism of water binding in meat

Proteins in the meats must bind water and fat and form a firm, elastic gel. The WHC of meat product is affected by pH, temperature, ionic strength, extent of muscular and connective tissue disruption and other factors. The amount of water held is affected by the commination. Comminution process can be considered as effective, if the maximum amount of proteins is released from myofibrils. During physical disruption of muscular tissue at ionic strength above 0.6, intense fiber swelling was observed with myosin polymerization and solubilization. Efficient communition of lean muscle tissue must disrupt membranes and sarcolemma release myofibrils and myofilaments and to accelerate swelling and extraction of myofibriller proteins .Extraction of myosin and actomyosin accelerated by the presence of sodium chloride and phosphates increase proteinwater interaction and water binding (Honikel, 1983).

During comminuition a local increase in temperature to 400℃ and higher at edge of knife blades can decrease WHC of sausage batter. Meat pre-blending increased the level of protein extraction and improved water and fat binding properties. grinding and comminution increases WHC of meat as a result of increasing the number of polar groups available for binding water molecules a decrease in water binding capacity of sausage batter is possible if the time after comminution and heat treatment is prolonged and the binding temperature is too high. The reason for WHC decreased is the change in PH. Because of fast microbial growth of lactobacilli and micrococcus that are predominant in sausage batter, water-binding capacity could decrease markedly. The pH of sausage batter can drop notably within a few hours as a result of accumulation of acids, especially if sugar was added (Honikel, 1983).

In comminuted meat, a lower level of water was released by pressure. The rapid drop in pH in pale soft and exudative (PSE) meat leads to a reduction of WHC; it is recognizable from the wet, watery cut surface of the meat. Consequently, PSE meat has a poor functionality specially water retention in CMP (Hsu and Yu, 1999).

2.13.4.3 Effect of sodium chloride and phosphates on water binding in meat product

The physical and the chemical properties of the meat proteins are influenced by ionic strength. The studies of the influence of various salts showed that protein functionality is dependent on the balance of interactions between protein, water and salt. The capacity of the meat proteins to retain water is affected by the ionic strength of the medium. As the concentration of neutral electrolytes is reduced, the WHC is increased. The effect of sodium chloride on the WHC of meat is utilized in the manufacturing of sausage batters and during the curing of meat. Salt not only increases WHC but also liberates the proteins of the myofibrils (salt soluble proteins) they can function as emulsifier. The increase in WHC on the addition of NaCl is considered to be related to binding of chloride ions to the myofibriller and the sarcoplasmic proteins. Proteins can retain more water if chloride ions are bound to proteins (Knipe *et al.*, 1985).

The effect of NaCl and pH on WHC can be explained by the changes in the electrical charges of the myofibriller and sarcoplasmic proteins. The ability of the meat to hold water is greatest during the few water after slaughter (hot meat), and it rapidly declines to the minimum level after 24 h. The effects of the phosphates on proteins include increased pH and ionic strength and inter action with proteins that cause dissociation of actomyosin by pyrophosphates (Kijowski *et al.*, 1982).

2.14 Sensory analysis

Sensory methods can be loosely separated into two groups: discriminant methods and descriptive methods. Simple models of difference tests rest on a number of assumptions, and not only are they not very good at showing that samples are the same; they are not good at detecting small differences. Quantitative Descriptive Analysis was developed from the Flavor Profile Method, and used an interval scale with emphasis on statistical evaluation of results. A variation of descriptive analysis is Free-Choice Profiling, where data are normally examined by generalized Procreates analysis. Initial suspicion of the results has been overcome by more rigorous testing of their reliability. Time-intensity measurement is a special case of descriptive analysis, where a single characteristic is tracked as it changes over a period of time (Piggott *et al.*, 1998).

PART III

Materials and methods

3.1 Materials

3.1.1 Meat

Fresh chicken meat was purchased from the local market of Dharan. Different parts of chicken meat was separated and trimmed. Further trimmings obtained lean meat with minimal connective tissue. Chest part of chicken meat was used for preparation of meatball.

3.1.2 Corn starch flour

Corn starch manufactured by Trishul Ancillary products and packaging Murli, Birgunj was purchased from the local market of Dharan.

3.1.3 Yangben

Terhathum provided us with raw yangben. It grows on the trunks of trees such as chiraito and utis, among others. The head component of the yangben was split using a scissor after it had been collected. Yangben was cleaned and dried after being cooked in ash water. It was then ground and used into the mixture.

3.1.4 Oils

Cello sun flower oil manufactured by Bagmati Oil Industries was purchased from the local market of Dharan. Which is cholesterol free and sometimes sunflower oil was found adulterated with rapeseed oil.

3.1.5 Salt

Aayo iodised salt manufactured by salt trading corporation, Kathmandu was purchased from the local market of Dharan.

3.1.6 Other ingredients

The MSG and chilli powder was weighed out as required. Garlic (fresh), ginger (fresh), onion (fresh), black pepper was finely grounded in an electric grinder and weighed. All ingredients were purchased from the local market.

3.2 Equipment

There was different equipment used during preparation of chicken meatball which is shown on Appendix B.

3.3 Methods of meatballs making

3.3.1 Recipe formulation of different recipes

Recipe formulation was done by using Design Expert design expert @V.11 (by STAT-EASE Inc., USA). In recipe fat, water and yangben (fat=0-20%, water=0-15% and yangben=0-5%) were varied. Recipe of fat and water was given (Ghimire, 2018) and recipe of yangben was given by (Adhikari, 2018). The amounts of other ingredients were kept constant for all the formulation of samples which is given by (Ghimire, 2018). The amount of constant ingredient for all formulation is given below in Table 3.1.

Table 3.1 Amount of constant ingredients

Ingredient	Amount (g)
Meat	250
Corn flour	25
Salt	5
Black pepper	1.5
Ginger garlic paste	25
Onion	50
Chilli powder	1.5
MSG	0.75

Source: Ghimire (2018)

3.3.2 Constraints for setting goal in Design Expert

Constrains helped to set the goals for the optimization of yangben, pig fat (lard) and water for the preparation of chicken meatball and we get predicted data with maximum desirability and their overlay plots given by design expert. We have three constraints out of which water (A) was set between 0-15, fat between 0-20 and yangben between 0-5.

Table 3.2 Constrains setting for optimization

Low Limit		Constraint		High Limit
0	≤	A:water	≤	15
0	≤	B:fat	≤	20
0	≤	C:yangben	≤	5
		A+B+C	=	20

Different recipes were formulated. Recipe formulation was done by using Design Expert @V.11 (by STAT-EASE Inc., USA). The variation made in the formulation was in the proportion of yangben, pig fat (lard) and water incorporation. The amount of other ingredients was kept constant for all the formulation of samples. The coding of different formulations for analysis was done as shown in Table 3.3

Table 3.3 Different recipe of samples

samples	Component 1	Component 2	Component 3
	A:water	B:fat	C:yangben
A	5	10.36	4.63
B	2.81	12.99	4.18
C	2.73	12.27	5
D	15	3.803	1.19
E	0	20	0
F	4	11.5	4.5
G	6.43	8.57	5
H	3	12	5
I	10.74	6.25	3
J	6.17	9.83	4
K	12.17	5.82	2
L	0	0	0

3.3.2 Flowchart for preparation of meatball

Flowchart for preparation of meatball is shown in Fig. 3.1.

Chicken meat (Lean meat)

↓

Preliminary treatment (washing, trimming, cutting)

↓

Mincing with pig fat lard up to 20% (Through 3 mm plate)

↓

Fine chopping to recipe

↓

Addition of corn flour, water, spices and grinded yangben according to recipe

↓

Mixing uniformly

↓

Kneading and fisting till cohesive and good binding mass results forming of meatballs

↓

The meatballs on the wire mesh were deep-fried in frying pan containing oil under gas flame. The frying temperature was in the range l75±10°C. The frying time taken was 4±1 min

↓

Cooling, Packaging and Storage

Fig. 3.1 Flowchart for the preparation of meatball.

Source: Ghimire (2018)

3.3.3 Mincing and mixing

The lean chicken meat was taken and minced through meat mincer (3 mm plates). Minced meat was used for making meatball according to recipe formulation.

3.3.4 Fisting

The weighed minced meat, starch and seasonings with phosphate or without phosphate was mixed uniformly for making meatball. Then the batter was mixed properly and fisted manually for about 10-15 min so that the protein released from minced meat adhere all the ingredients together.

3.3.5 Frying

The meatballs on the wire mesh were deep-fried in frying pan containing oil under gas flame. The frying temperature determined by using digital thermometer was in the range l75±10°C. The frying time taken was 4±1 min. The color of meatball after frying was purple brownish in color.

3.3.6 Cooling

The products after frying were allowed to cool up to room temperature (27℃).

3.3 Sensory evaluation

The fried samples of the meatball were sensorial evaluated through hedonic rating test while still warm.

3.3.1 Hedonic rating

The coded samples of the meatballs were sensorial evaluated while still warm for appearance, flavor, texture, juiciness, taste and overall palatability on 9 point hedonic scale. The panelists were given instruction to give 9 points to extremely liked and 1 points to the extremely disliked point sample. The coded samples were randomly presented. For the above hedonic rating test, semi trained panelist of B.Tech 4th year and teachers of Central Campus of Technology was taken. Before sensory evaluation, instructions was given to panelists .They was asked to give maximum scores for its purple brown color. For texture and taste, they were instructed to give marks as they like. The various parameters tested were appearance, texture and tenderness, taste, flavor and overall palatability. Differences in the quality were determined by statistical analysis according to Ranganna (1986).

3.3.2 Statistical analysis

Sensory data was processed using Genstat Release 12.1 (2009) and MS Excel (2010) for ANOVA at 5% level of significance and charts respectively. Also, design expert @V.11

(by STAT-EASE Inc., USA) was used to analyze data other than sensory analysis data in optimization of the maturation. MS- Excel was also employed for the general graph and radar diagram construction.

3.4 Chemical analysis

3.4.1 Moisture content

The moisture content was determined by using hot air oven method 10 g. of the grinded sample was spread over the petri-dish and placed in hot air oven previously set at 103 ±20°C (Ranganna, 1986).

3.4.2 Crude fat

The crude fat of the raw chicken meat, yangben, corn flour and meatball was determined after extracting fat by Soxhlet extraction apparatus, using petroleum ether (Ranganna, 1986).

3.4.3 Crude protein

Crude protein was determined by estimating nitrogen content in the sample and multiplied by Kjeldahl factor 6.25 according to Ranganna (1986).

3.5.4 Ash content

Ash content of the meat was determined according to KC and Rai (2007). 10 g of sample was taken in crucible and the sample was charred over a low Bunsen flame to volatilize as much of organic matter. The crucible was then transferred to a muffle furnace set at 500°C for 3-4 h.

3.4.5 Crude fiber

The crude fiber content of the product was determined by recovering the ash free residue after sequential treatment sample with 1.25% sulphuric acid and 1.25% sodium hydroxide each under standard conditions. The ash that came along with the residue was removed by ashing in ash less filter paper (Ranganna, 1986).

3.5 Processing yield

According to (Kowale, 2008) for processing yield (%) of meatball, sample weight of meatballs before and after cooking was noted. The processing yield was calculated as percentage weight of cooked meatballs to weight of raw meatballs (KC and Rai, 2007).

Processing yield (%) is given as:

$$\text{Processing yield} = \frac{\text{Wt. of batter after cooking}}{\text{wt. of batter before cooking}} \times 100\%$$

3.6 Water holding capacity

For determining the WHC, 500 mg weighed minced meat sample was placed between the centers of two weighed filter papers. The filter papers were kept over a rigid, flat surface and Processing covered by PE sheet above and below it and pressed by 2.81 kg weight for 5 min. The meat flake after pressing was weighed. The filter paper was dried and weighed.

WHC (%) is given as:

$$\text{WHC} = \frac{\text{Actual weight of meat flake}}{\text{Sample weight}} \times 100\%$$

Where, actual weight of meat flake = weight of meat flake after pressing + subtraction of weight of filter paper before and after pressing.

3.7 Fat and jelly separation

For determination of fat and jelly separation the procedure given by was Kowale (2008) followed. Fat and jelly separation measure the stability of canned, meat batter or sausage batter. Its value indicates the quality of meat products. The meatball in beaker is heated at boiling temperature and liquefied fat and jelly separated determined. Fat and jelly separation is expressed in %.

$$\text{Fat and jelly separation (\%)} = \frac{\text{wt. of fat and jelly}}{\text{wt. of meat ball}} \times 100\%$$

PART IV

Results and discussion

Chicken meatball incorporated with yangben and pig fats (lard) and water according to formulation were prepared in the lab of CCT. For each different formulation chicken meat was minced calculated amount of chicken meat, yangben and pig fat were mixed and chopped in a bowl chopper. Necessary spices were also weighed and mixed in the chopper with the batter. Different formulations were prepared according to Design Expert version central composite design of response surface methodology was used for optimization of yangben, pig fat (lard) and water for the preparation of chicken meatball. Here 12 samples were prepared and subjected for sensory evaluation with respect to appearance, aroma, texture, juiciness and overall acceptability and functional properties such as fat and jelly separation, processing yield and water holding capacity.

4.1 Proximate composition of raw material

In the preparation of yangben incorporated chicken meatball, yangben and chicken meat are the major raw materials. They were analyzed for their physico-chemical composition.

4.1.1. Proximate composition of chicken meat.

Chicken meat was collected from local market of Dharan and analyzed in the laboratory for physiochemical composition. The chemical composition of chicken meat is presented in the Table 4.1.

Table 4.1 Physico-chemical composition of chicken meat

Parameters	Value
Moisture content (%)	71.77±0.67
Crude protein (% db)	20.04±0.83
Crude fat (% db)	3.43±0.55
Ash (% db)	2.25±0.63
Carbohydrate (% db)	0.84±0.44
WHC (% db)	75.67±4.92
pH	5.93±0.30

[The values in the table are the mean of the triplicates ± standard deviation.]

From the proximate analysis of meat, moisture content, protein, fat, ash content, WHC and pH were found to be 71.77%, 20.02%, 3.43%, 2.25%, 75.67% and 5.93 respectively. The values so obtained for moisture content, crude protein, crude fat and ash content were respectively slightly different then the result obtained by (Lonergan *et al.*, 2003). According to (Lonergan *et al.*, 2003) for moisture content, crude protein, crude fat and ash content were 72.6%, 23.4%, 2.9 and 1.8% respectively. According to (Watts, 2004) for moisture content, crude protein, crude fat and ash content were 72.6%, 23.4%, 2.9 and 1.8% respectively. The analysis showed that the meat used was of good quality in terms of water holding capacity i.e. 0.757. According to (Subba, 2010), a ratio of > 0.5 is regarded as good and < 0.4 as poor. A large number of factors affect carcass meat quality. These include: the animal itself, including breed or breed crosses, age, frame size, sex, age, and weight at slaughter, diet, management (production system, exercise, weather etc.), stress, pre-slaughter condition and slaughtering (Fletcher, 2002).

4.1.2. Proximate composition of yangben

The ash processed yangben was used for the preparation of meatball whose proximate composition is given in Table 4.2.

Table 4.2 Proximate composition of yangben

Parameters	Value
Moisture (%)	12.67 ± 0.31
Protein (% db)	9.97 ± 0.57
Fat (% db)	2.37 ± 0.25
Carbohydrate (% db)	70.96 ± 0.67
Crude fiber (% db)	11.87 ± 0.14
Ash (% db)	4.16 ± 0.28

[The values in the table are the mean of the triplicates ± standard deviation.]

The values obtained are in dry basis. According to Dhungana *et al.* (2004) the respective values for species yangben were 18.18% moisture, 6.37% protein, 2.63% fat, 14.28% crude fiber, 4.3% ash and 75.02% carbohydrate on dry basis. According to (Chaffey, 2014) moisture, carbohydrate and ash content of lichen range 65-67%, 2-10% and 3-10% respectively on wet basis. The slight difference in physico-chemical composition was due to the species as the yangben contain mixture of species mainly *Parmelia, Ramalina* and *Usnea.* Thus, the proximate composition varies from species to species (Kunwar *et al.*, 2010).

4.2 Effect of process variable on properties of chicken meatball

4.2.1 Effect of recipe on sensory attributes of chicken meatball

Sensory data was processed using Genstat Release 12.1 (2009) and MS Excel (2010) for ANOVA at 5% level of significance and charts respectively. The variation made in the formulation was in the proportion of yangben, pig fat (lard) and water incorporation. The amount of other ingredients was kept constant for all the formulation of samples. All the prepared samples of meatball were subjected to sensory analysis for aroma, color, taste, texture, juiciness and overall acceptability. Only 12 samples of meatball were subjected to sensory evaluation. The coding of different formulations for sensory analysis was done as shown in Table 4.3.

Table 4.3 Different recipe of samples

Samples	Component 1	Component 2	Component 3
	A:water	B:fat	C:yangben
A	5	10.36	4.63
B	2.81	12.99	4.18
C	2.72	12.27	5
D	15	3.80	1.19
E	0	20	0
F	4	11.5	4.5
G	6.42	8.57	5
H	3	12	5
I	10.74	6.25	3
J	6.16	9.83	4
K	12.17	5.82	2
L	0	0	0

4.2.1.1 Effect of formulation on appearance (color)

The mean sensory scores for appearance of twelve samples with their standard deviation are given in Appendix C. The statistical analysis showed that there was significant effect ($p<0.05$) of fat, yangben and water variation on aroma at 5% level of significance.

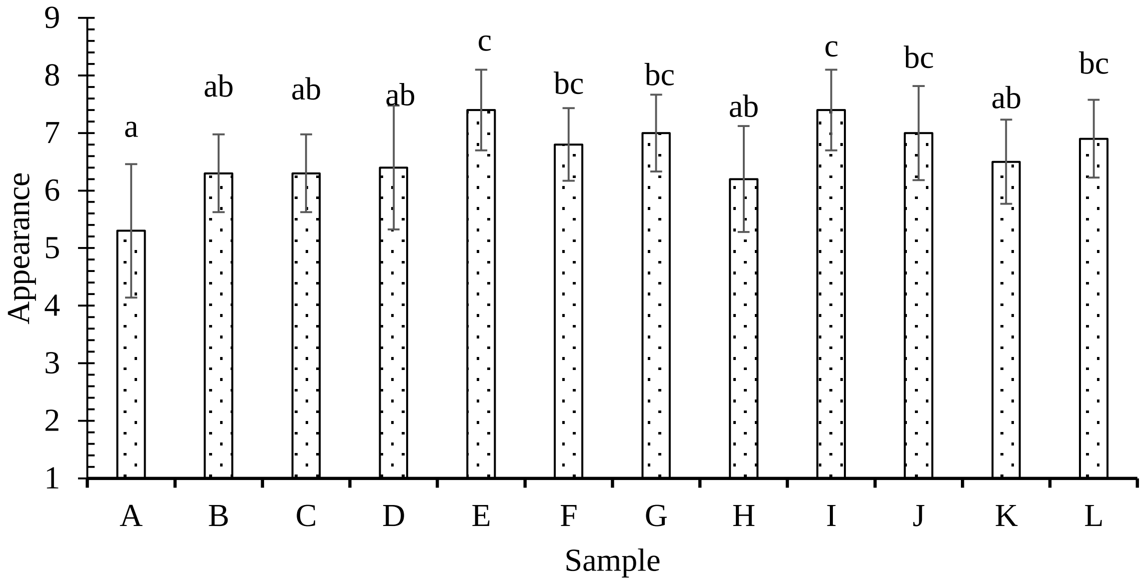

Fig. 4.1 Mean sensory scores for appearance of meatball.

The obtained mean values of samples are represented in Fig. 4.1. Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by 10 panelists.

The mean score of appearance for sample E and I (7.4± 0.70) was highest which was significantly different from samples A, B, C, D, H and K but similar with rest of the samples. Sample H (6.2±0.92) had the lowest score which was significantly different from samples A, E, G, I, J and L but not different from rest of the samples. LSD showed no significant differences between the samples E, F, G, I, J and K. Most of the samples showed no significant difference in terms of appearance and also the mean scores for the samples did not show much variation. However, samples with 3.33% yangben were more preferred.

The highest score for the sample E was found to be slightly intense (7.4±0.70) which showed that preference was highest for the sample with lowest amount of yangben.

Samples with relatively high amount of yangben was less rated which may be due to the masking effect of yellow color by black color of yangben. Thus the color factor was negatively related with yangben. Similar effect was seen with increasing fat content. This supports the color factor in product was negatively related with fat in food as described by Hardy and Moncel (2011). Hence, the color perception of panelists were effected by proportion all of the three ingredients in meatball.

4.2.1.2 Effect of formulation on aroma

The mean sensory scores for aroma of twelve samples with their standard deviation are given in Appendix C. The statistical analysis showed that there was significant effect ($P<0.05$) of fat, water and yangben variation on aroma at 5% level of significance.

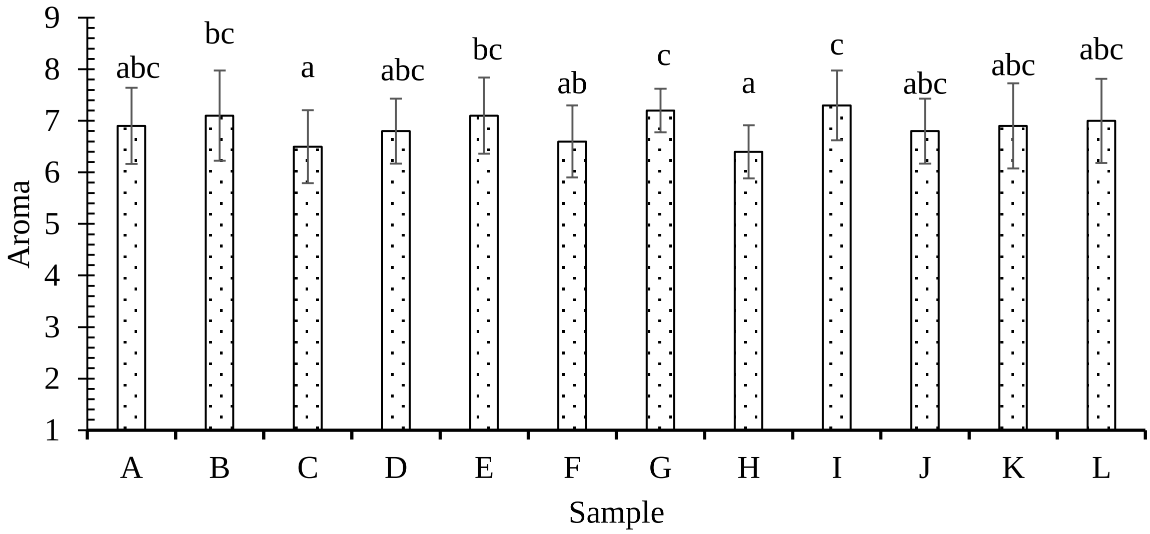

Fig. 4.2 Mean sensory scores for aroma of meatball.

The obtained mean values of samples are represented in Fig. 4.2. Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by 10 panelists.

The mean sensory score for sample I (7.3 ± 0.67) was highest which was significantly different from samples C, F and H but not significantly different from rest of the samples. Sample H (6.4 ± 0.52) had the lowest score which was significantly different from samples B, E, G and I but not different from rest of the samples. LSD showed no significant differences between the samples A, B, D, E, G, I, J, K and L. However, samples with 3% yangben were more preferred. According to Pearson (1966) and Rabe-Hesketh and Everitt (2003), aroma compounds are more lipophilic than hydrophilic. Thus, release of volatiles responsible for typical aroma in meat products is affected by fat content.

4.2.1.3 Effect of formulation on texture

The mean sensory scores for texture of fifteen samples with their standard deviation are given in Appendix G. Statistical analysis showed that there was significant difference in texture between the samples due to variation in fat, water and yangben at 5% level of significance.

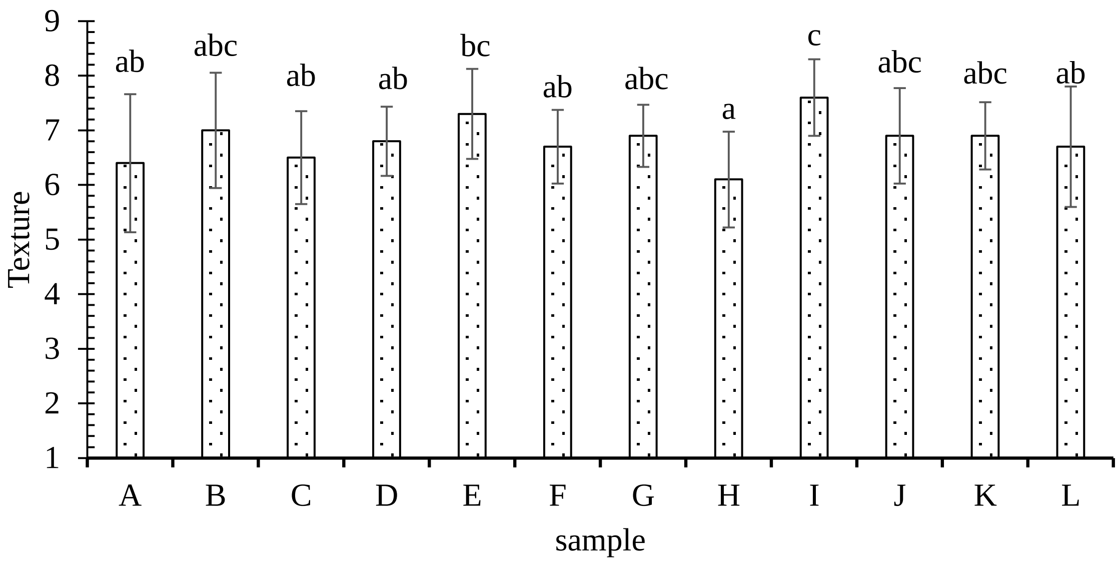

Fig. 4.3 Mean sensory scores for texture of meatball.

The obtained mean values of samples are represented in Fig. 4.3. Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by 10 panelists.

Sample I (7.6 ± 0.70) had the highest scores and this sample was not significantly different from samples B, E, G, J and K but significantly different from rest of the samples. Sample H (6.1± 0.88) had the lowest mean score which was not significantly different from samples A,C, D, F and L while significantly different from rest of the samples. LSD showed no significant differences between the samples B, E, G, I, J, and K. The lowest rating for the samples with highest concentration of yangben indicated the poor texture of meatball on increasing the yangben concentration. Similarily, the average rating was for the samples with lowest yangben concentration among which those with high fat content were more preferred than meatball with low fat content. According to Purslow (1985) the presence of higher amount of fat within or between the muscles improves the texture of meat because of easier disruption of muscle fibers during chewing. Water amount seems affect the preference of meatball as most of the samples with same amount of fat and yangben but varying water amount showed significant differences.

4.2.1.4 Effect of formulation on juiciness

The mean sensory scores for juiciness of twelve samples with their standard deviation are given in Appendix H. Statistical analysis showed that there was significant difference in juiciness between the samples at 5% level of significance.

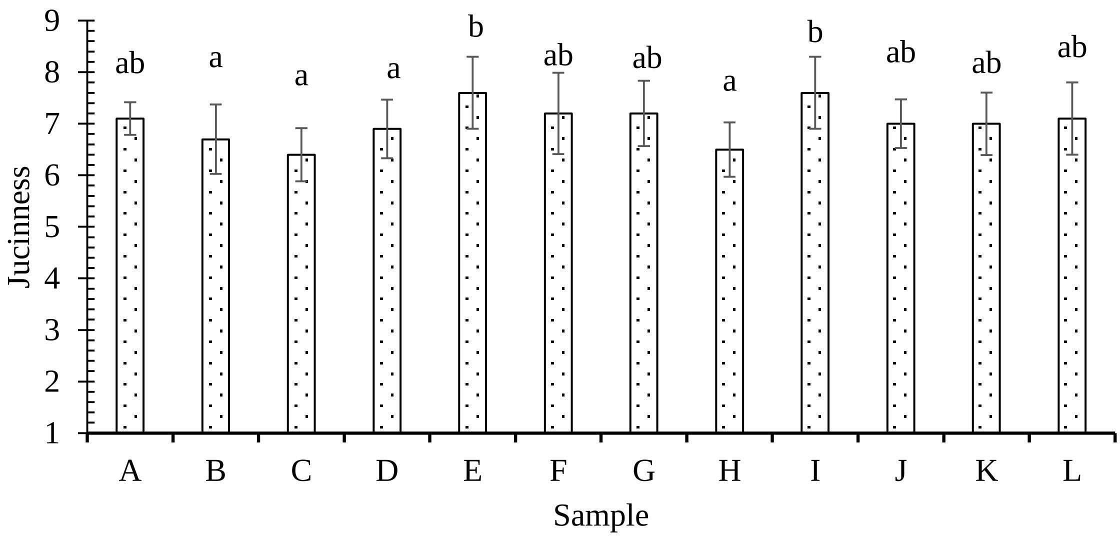

Fig. 4.4 Mean sensory scores for juiciness of meatball.

The obtained mean values of samples are represented in Fig. 4.4. Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by 10 panelists.

Sample E and I (7.6 ± 0.70) had the highest score and was not significantly different from samples A, F, G, J, K and L while significantly different from rest of the samples.

Among them samples with high fat and water amount appeared to be juicier and had higher scores. Sample C (6.4 ± 0.52) had the minimum score and significantly similar with the samples B, D and H while significantly different from rest of the samples. These all minimally rated samples contained lower amount of yangben while most of them had low fat and water content. This showed that yangben had the most profound effect on juiciness. LSD showed no significant differences between the samples A, E, F, G, J, K, I and L. According to Ofori and Hsieh (2012), yangben has good fat and water binding capacity in grounded meat product which enhances the juiciness of final product. Ramos *et al.* (2013) also states that fat has direct influence on the perceived juiciness of the product. This may be the reason for liking the product with high fat and water content.

4.2.1.5 Effect of formulation on overall acceptability

The mean sensory scores for overall acceptability of twelve samples with their standard deviation are given in Appendix I. Statistical analysis showed that there was significant difference in overall acceptability between the samples at 5% level of significance.

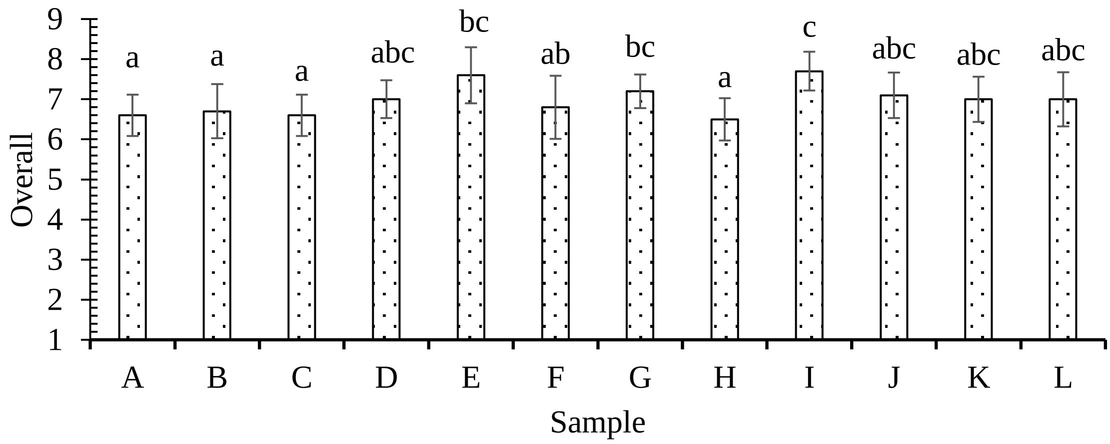

Fig. 4.5 Mean sensory scores for overall acceptability of meatball.

The obtained mean values of samples are represented in Fig. 4.5. Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by 10 panelists.

The mean sensory scores for sample I was highest (7.7 ± 0.48) and significantly similar with samples E and G while significantly difference from rest of the samples. Sample H

(6.4 ± 0.52) had the minimum score and significantly similar with the samples A, B, C and F while significantly different from rest of the samples. According to, yangben are the cheaper alternative for fat replacers and provide protein and moisture to the product without significantly affecting other sensory parameters. Most of the samples showed no significant difference in terms of overall acceptability and also the mean scores for the samples did not show much variation. This showed that yangben and fat mostly affected the overall acceptability of meatball. The lowest rating for the samples with highest concentration of yangben indicated the poor texture of meatball on increasing the yangben concentration. Similarily, the average rating was for the samples with lowest yangben concentration among which those with high fat content were more preferred than meatball with low fat content.The increasing mean scores for them with increasing fat content also pointed out some influence of fat content on the overall acceptability of meatball.

By sensory data samples I, E and G were found to be best in most of the parameters as well as overall palatability. However, the responses given by panelists were not consistent and it was difficult to point out the distinct differences between the samples. This may be due to large number of samples with slight variations in formulations and the panelists were also semi trained and only slightly familiar with meatball. The conclusion thus derived in the present study is based on sensory analysis of limited number of panelists. The result may be different when subjected to other populations. So, the experimental finding needs to be taken with some reservations. Here physiochemical analysis of all samples should be done and find significant result over all responses and compere with sensorial result. Finally best optimized sample was obtained and further analysis of sample was done.

4.3 Effect of recipe on functional properties of meatball

According to recipe obtained from design expert region. Meatball were prepared and subjected for evaluation of functional properties such as fat and jelly separation, water holding capacity and processing. Responses of the experimental plan were represented in Table.4.4.

Table 4.4 Different formulation with responses

	Component 1	Component 2	Component 3	Response 1	Response 2	Response 3
Run	A:water	B:fat	C:yangben	Fat and jelly separation	processing yield	WHC
5	0	20	0	4.44	86.76	75
4	15	3.80	1.19	3.8	87.05	75.97
11	12.17	5.82	2	3.62	88.07	75.8
9	10.74	6.25	3	2.98	88.95	76
7	6.42	8.57	5	1.15	92.16	81.37
10	6.16	9.83	4	2.21	90.02	78.11
2	2.81	12.99	4.18	2.17	91.63	81.11
6	4	11.5	4.5	1.91	92.07	82.33
1	5	10.36	4.64	1.67	91.77	80.98
3	2.72	12.27	5	1.41	92.84	82.69
8	3	12	5	1.15	92.98	82.61

4.3.2 Solution with expected response

The selection of optimized yangben, pig fat (lard) and water for the preparation of meatball was done by central composite response surface method setting the constraints above table. Here yangben acts as binding agent, if the amount of yangben increases fat and jelly separation decreases. Here limit of yangben set below 5 because above 5 it shows unattractive color and more tough balls. Fat and water gives more texture to the meatballs. Two solutions were found from the given constraints are represented as given in Fig. 4.6.

Solution 1:

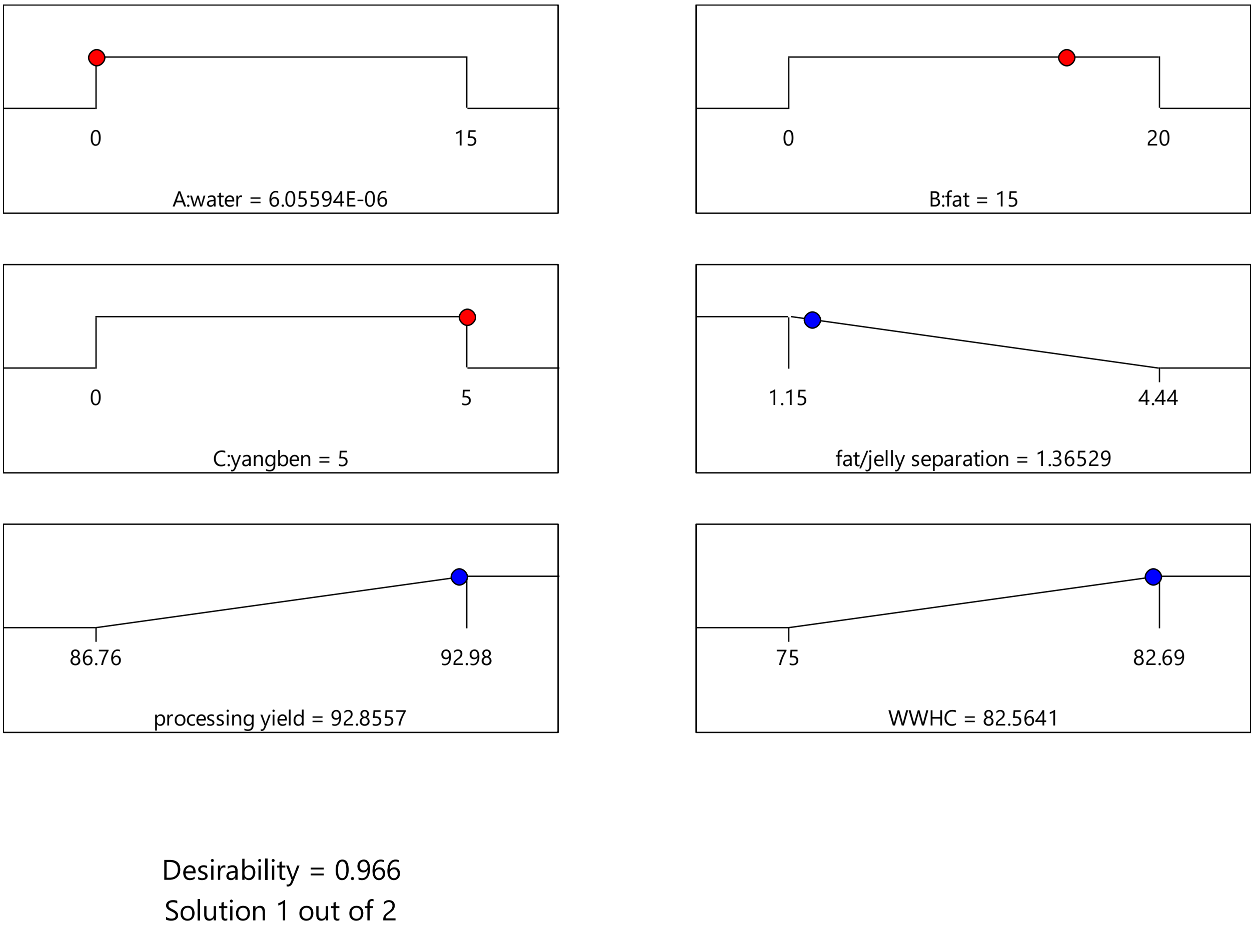

Fig. 4.6 Solution 1 with expected response

Solution 2:

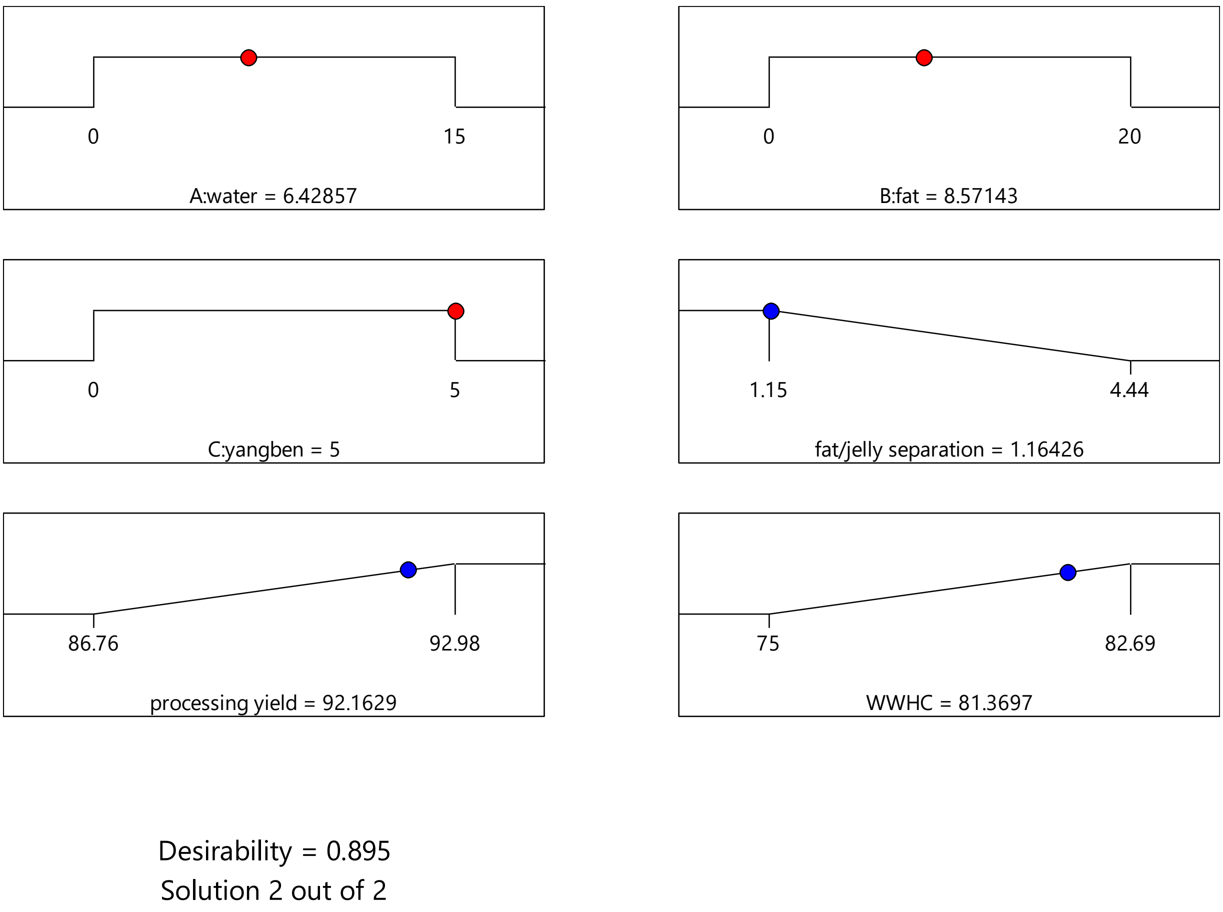

Fig. 4.7 Solution 2 with expected response

Solution 1 has maximum desirability of 0.97 which shows better optimization of yangben, lard and water in comparisons to solution 2. But from physiochemical evaluation product of solution 2 is more prefer than product prepared from solution 1 having better texture, flavour and color. Thus solution 2 was selected. Yangben, pig fat (lard) and water content of solution 2 is 5, 6.43 and 8.57 respectively. Fat and jelly separation, processing yield and water holding capacity of selected sample have 1.16, 92.16 and 81.36 respectively. For selected solution graphical optimization is shown in Fig. 4.7.

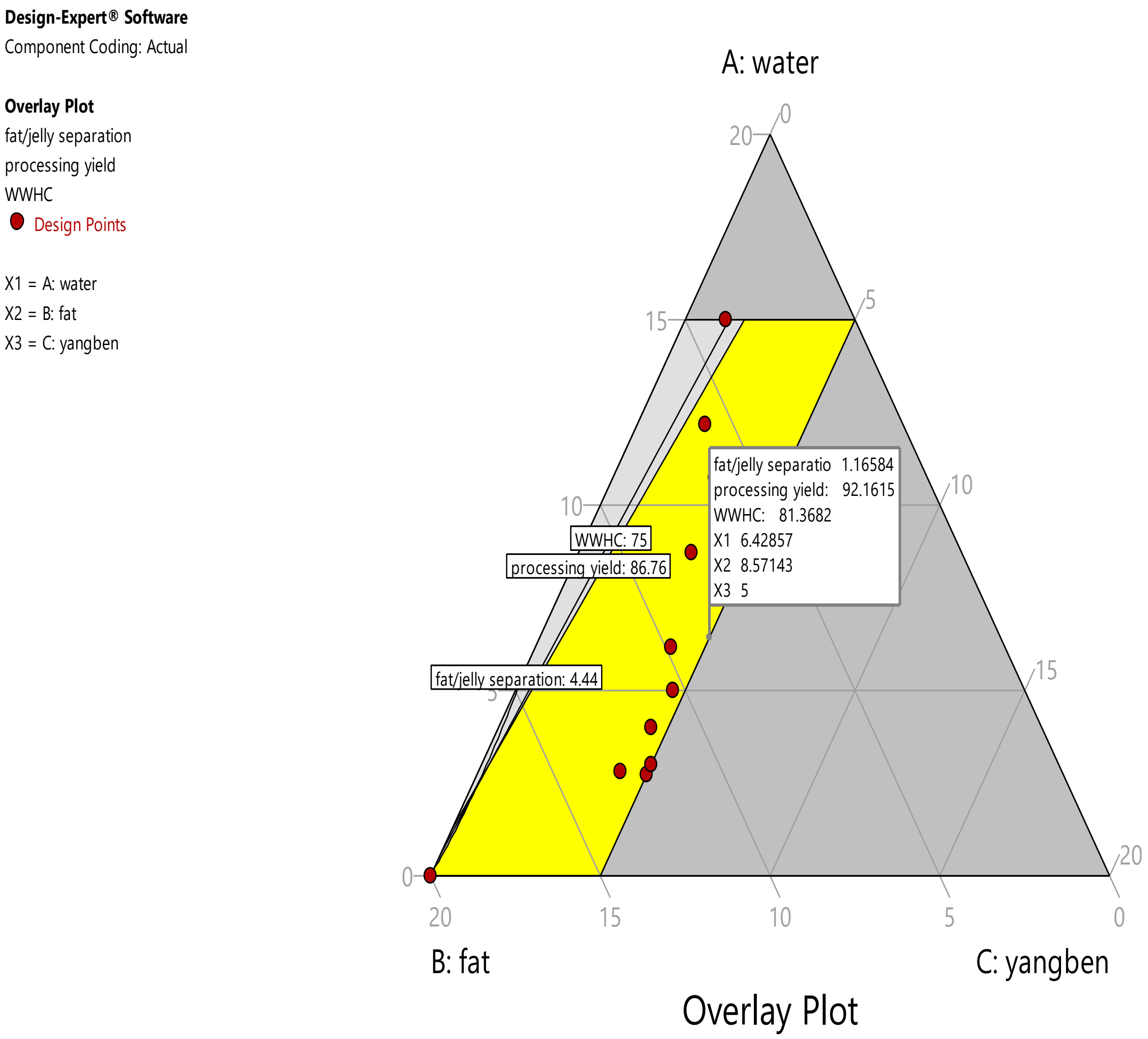

Fig. 4.8 Overlay plot for all responses as a function of water, pig fat (lard) and yangben in meatball.

Graphical optimization displays the area of feasible response values in the factor space. The overlay plots graphically define the location and desirability of the solutions. Regions that don't fit the optimization criteria are shaded grey and a region that satisfies the constraints is shaded yellow. In the Fig. 4.8, the red marks were the design points and the flagged spot represent most desired solution in the area of feasible response values. By plotting flags, can the response at that location in space can be predicted. Fat and jelly separation, WHC and processing yield in the most desired solution were found as 1.16, 92.16 and 81.36 respectively.

4.4 Evaluation of responses

4.4.1 Fat and jelly separations

The fat and jelly separation of chicken meatballs varied from 1.15 to 4.44. Table A.13 and A.14 of Appendix show the coefficients of the model and other statistical attributes of fat and jelly separation. The Model F-value of 234.61 implies the model is significant. There is only a 0.01% chance that an F-value this large could occur due to noise. Values of "prob. > F" less than 0.0500 indicate model terms are significant. In this case A, B, C, BC is significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model.

The Predicted R^2 of 0.8944 is close to the Adjusted R^2 of 0.9915 as one might normally expect; i.e. the difference is less than 0.2. Things to consider are model reduction, response transformation, outliers, etc. All empirical models should be tested by doing confirmation runs. The linear model fitted for processing yield obtained from regression analysis in terms of coded values of the variables is represented by

Fat and jelly separation = +3.86A + 4.44B - 41.35C +0.7981AB+43.09AC+44.66BC

Accuracy of this equation is 89.44% which is close to adjusted R^2. Adeq Precision measures the signal to noise ratio. A ratio greater than 4 is desirable. Your ratio of 43.689 indicates an adequate signal. This model can be used to navigate the design space. The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the mixture components are coded as +1 and the low levels are coded as 0. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients.

Where A, B and C are the coded values of water (%), fat (%) and yangben (%) respectively. The positive coefficient of A and B indicated that the increase in water and fat content of the meatball results increased fat and jelly separation of the product. Effect of variation of water, fat and yangben content was significant. Here according to the above equation the negative coefficient of yangben showed most negative correlation between yangben and fat and jelly separation. Having less fat and jelly separation for product is desirable. On increasing yangben content fat and jelly separation is decreases. Young *et al.* (1991) reported negative correlation between yangben percentage in meatball and fat and jelly separation. Response surface plots for fat and jelly separation is shown in Fig.4.9.

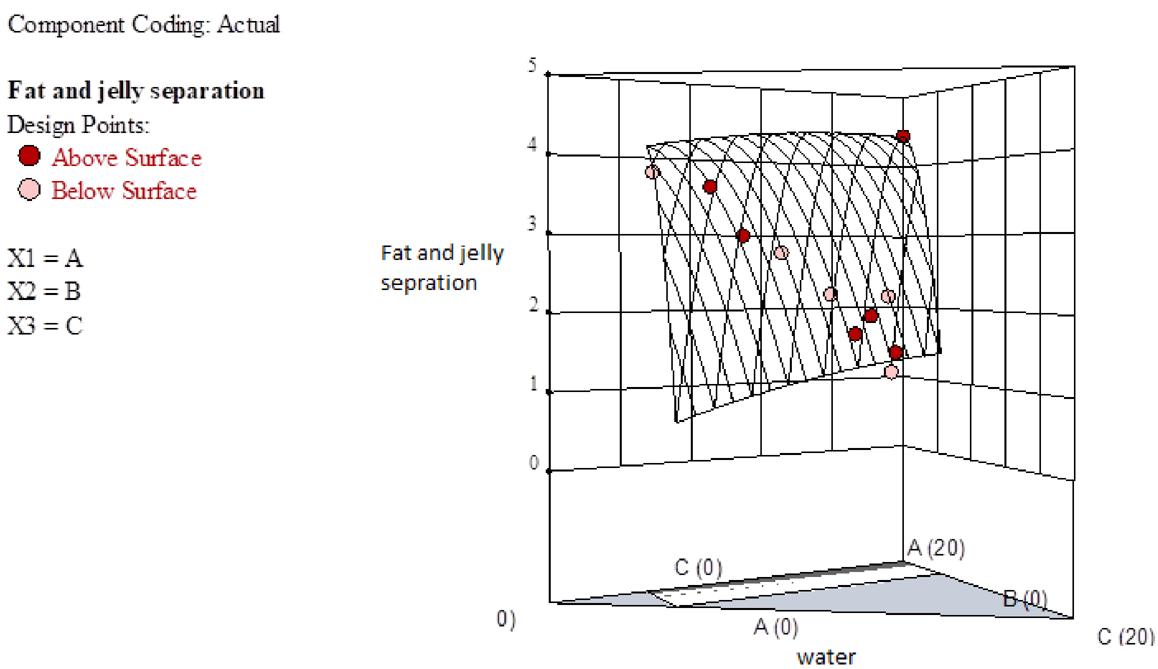

Fig. 4.9 Response surface plots for fat and jelly separation as a function of of water, pig fat (lard) and yangben in meatball.

Graphical optimization displays the area of feasible response values in the factor space. The response surface plots graphically define the location and desirability of the solutions. Regions that don't fit the optimization criteria are shaded grey and a region that satisfies the constraints is shaded dark grey. For quality meatball the fat and jelly separation should be less. From graph got information that increasing amount of yangben and decreasing amount of fat and water then fat and jelly separation of product is decreases, which is the desirability for product. Yangben in meatball as a binder thus it has more effective role on fat and jelly separation. From plot design point highest value for fat and jelly separation is 4.44 and lowest value is 1.15. Counter plot for fat and jelly separation is shown in Fig. 4.10.

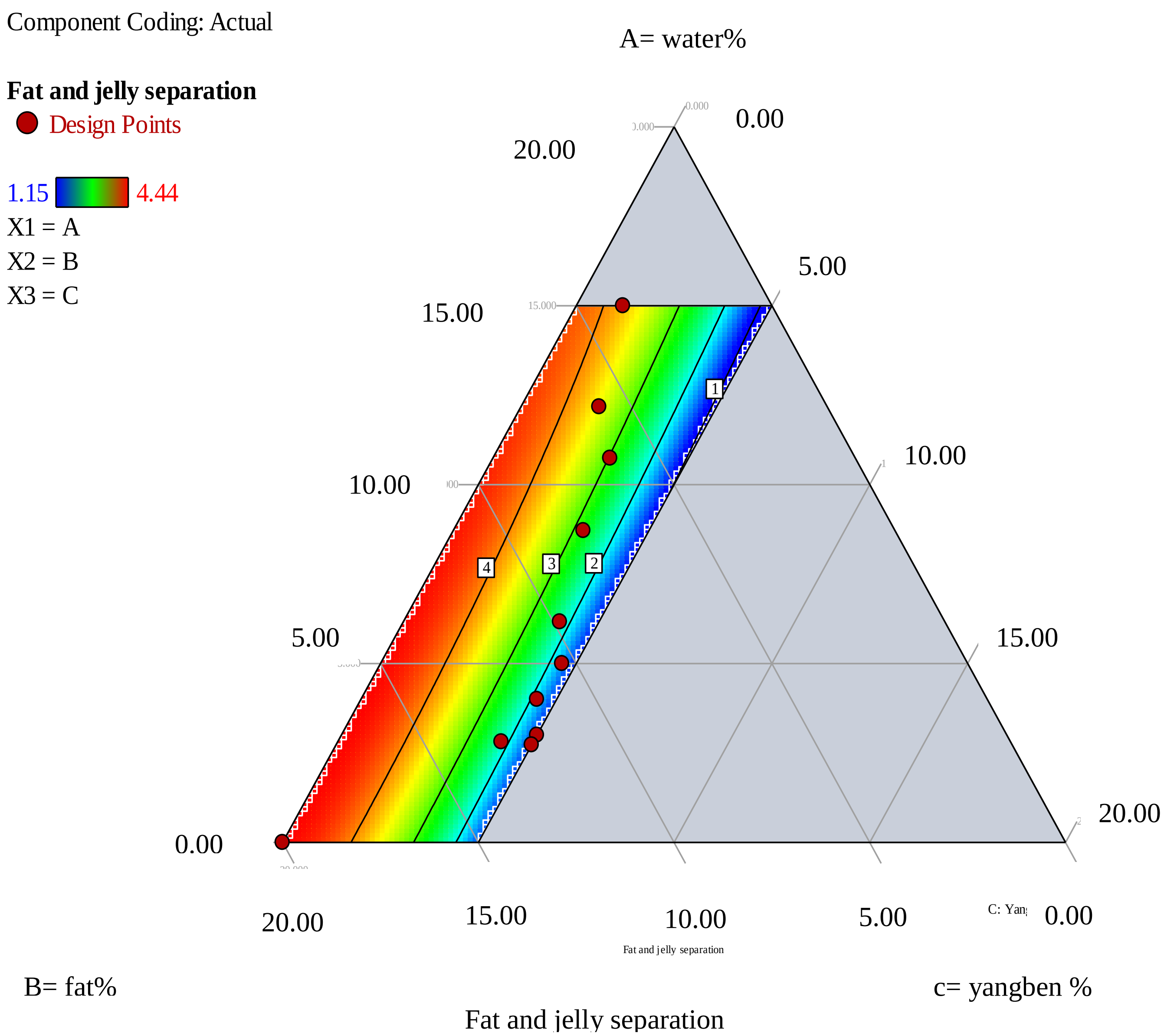

Fig. 4.10 Counter plot for fat and jelly separation as a function of water, pig fat (lard) and yangben in meatball.

4.4.2 Processing yields

The processing yields of chicken meatballs varied from 86.76 to 92.98%. Table A.13 and A.14 of appendix show the coefficients of the model and other statistical attributes of processing yield. The Model F-value of 122.93 implies the model is significant. There is only a 0.01% chance that an F-value this large could occur due to noise. P-values less than 0.0500 indicate model terms are significant. In this case A, B, C are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model. A ratio greater than 4 is desirable and hence this model may be used to investigate the design space (Myers *et al.*, 2009).

The Predicted R^2 of 0.8649 is in reasonable agreement with the Adjusted R^2 of 0.9606; i.e. the difference is less than 0.2. Adeq Precision measures the signal to noise ratio. A ratio greater than 4 is desirable. Your ratio of 25.334 indicates an adequate signal. This model can be used to navigate the design space. The linear model fitted for processing yield obtained from regression analysis in terms of coded values of the variables is represented by

Processing yield = +84.66A + 86.82B + 110.97C

Accuracy of this equation is 86.49% which is close to adjusted R^2. The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the mixture components are coded as +1 and the low levels are coded as 0. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients.

Where A, B and C are the coded values of water (%), fat (%) and yangben (%) respectively. The positive coefficient of A, B and C indicated that the increase in water, fat and yangben content of the meatball results increased processing yield of the product. Effect of variation of water, fat and yangben content was significant. Here according to the above equation the positive coefficient of yangben showed most positive correlation between yangben and processing yield.. According to Ranathunga *et al.* (2015), yield of comminuted meat product can be increased by use of fillers and binders. Counter plot for processing yield is shown in Fig. 4.11.

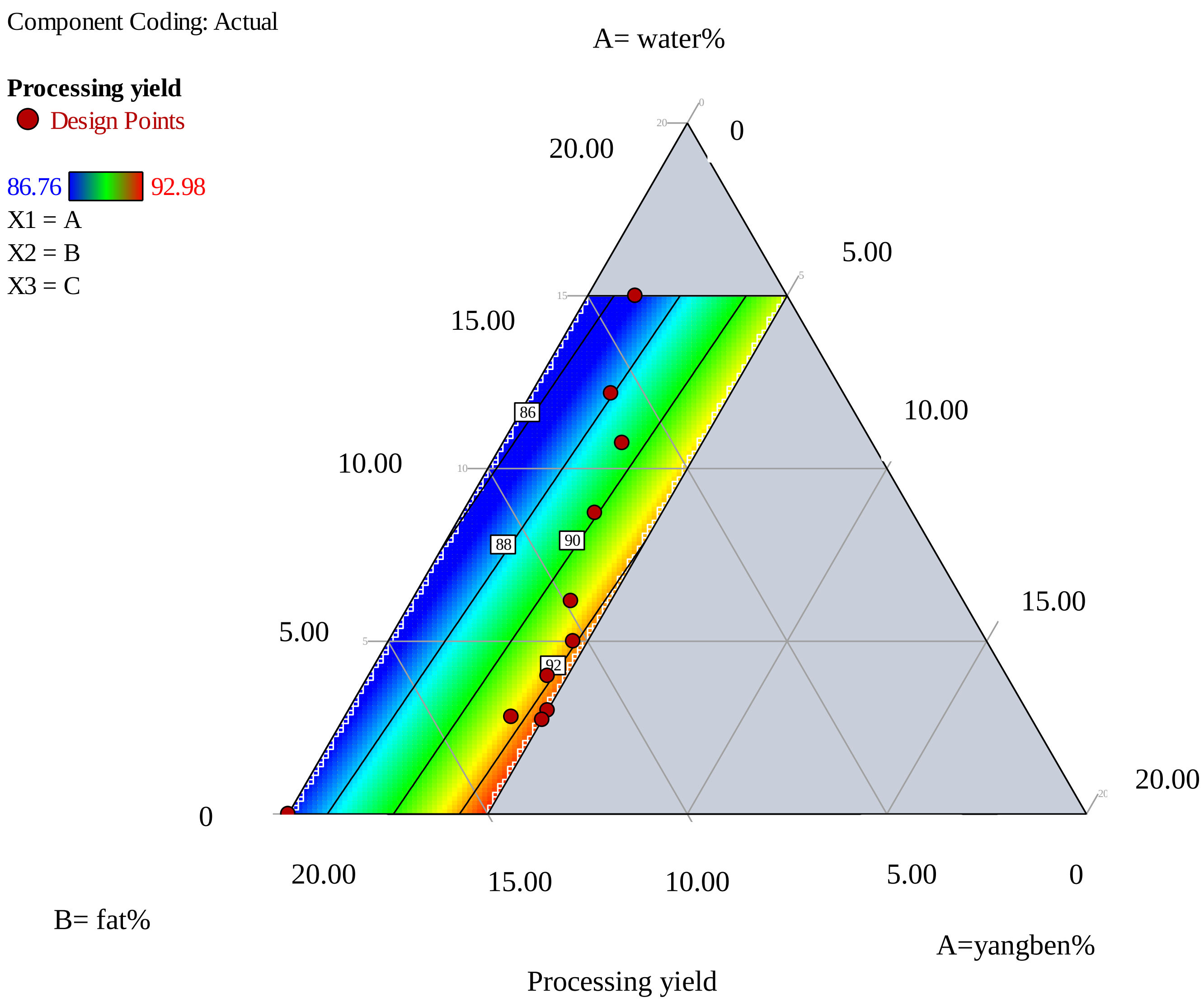

Fig. 4.11 Counter plots for processing yield as a Function of water, Pig fat (lard) and yangben in meatball.

Graphical optimization displays the area of feasible response values in the factor space. The response surface plots graphically define the location and desirability of the solutions. Regions that don't fit the optimization criteria are shaded grey and a region that satisfies the constraints is shaded dark grey. For quality meatball the processing yield should be more. From graph got information that increasing amount of yangben, fat and water the processing yield of product is also increases, which is the desirability for product. Yangben in meatball as a binder thus it has more effective role on processing yield. From plot design point highest value for processing yield is 92.98% and lowest value is 86.76%.

4.4.3 Water holding capacity

The water holding capacity of chicken meatballs varied from 75 to 82.69%. Table A.15 and A.16 of appendix show the coefficients of the model and other statistical attributes of water holding capacity. The Model F-value of 26.84 implies the model is significant. There is only a 0.03% chance that an F-value this large could occur due to noise. P-values less than 0.0500 indicate model terms are significant. In this case A, B, C are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model. A ratio greater than 4 is desirable and hence this model may be used to investigate the design space (Myers *et al*., 2009).

The Predicted R^2 of 0.8649 is in reasonable agreement with the Adjusted R^2 of 0.9396; i.e. the difference is less than 0.2. Adeq Precision measures the signal to noise ratio. A ratio greater than 4 is desirable. Your ratio of 25.334 indicates an adequate signal. This model can be used to navigate the design space. The linear model fitted for processing yield obtained from regression analysis in terms of coded values of the variables is represented by

$$WHC = +71.51A + 75.23B + 104.57C$$

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the mixture components are coded as +1 and the low levels are coded as 0. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients.

Where A, B and C are the coded values of water (%), fat (%) and yangben (%) respectively. The positive coefficient of A, B and C indicated that the increase in water, fat and yangben content of the meatball results increased water holding capacity of the product. Effect of variation of water, fat and yangben content was significant. Here according to the above equation the positive coefficient of yangben showed positive correlation between yangben and water holding capacity. Cheng and Sun (2008), also state that carbohydrate rich plant substances have extensive water binding capacity and gelling capacity as result of which produce final product with high water holding capacity. Counter plot for processing yield is shown in Fig. 4.12.

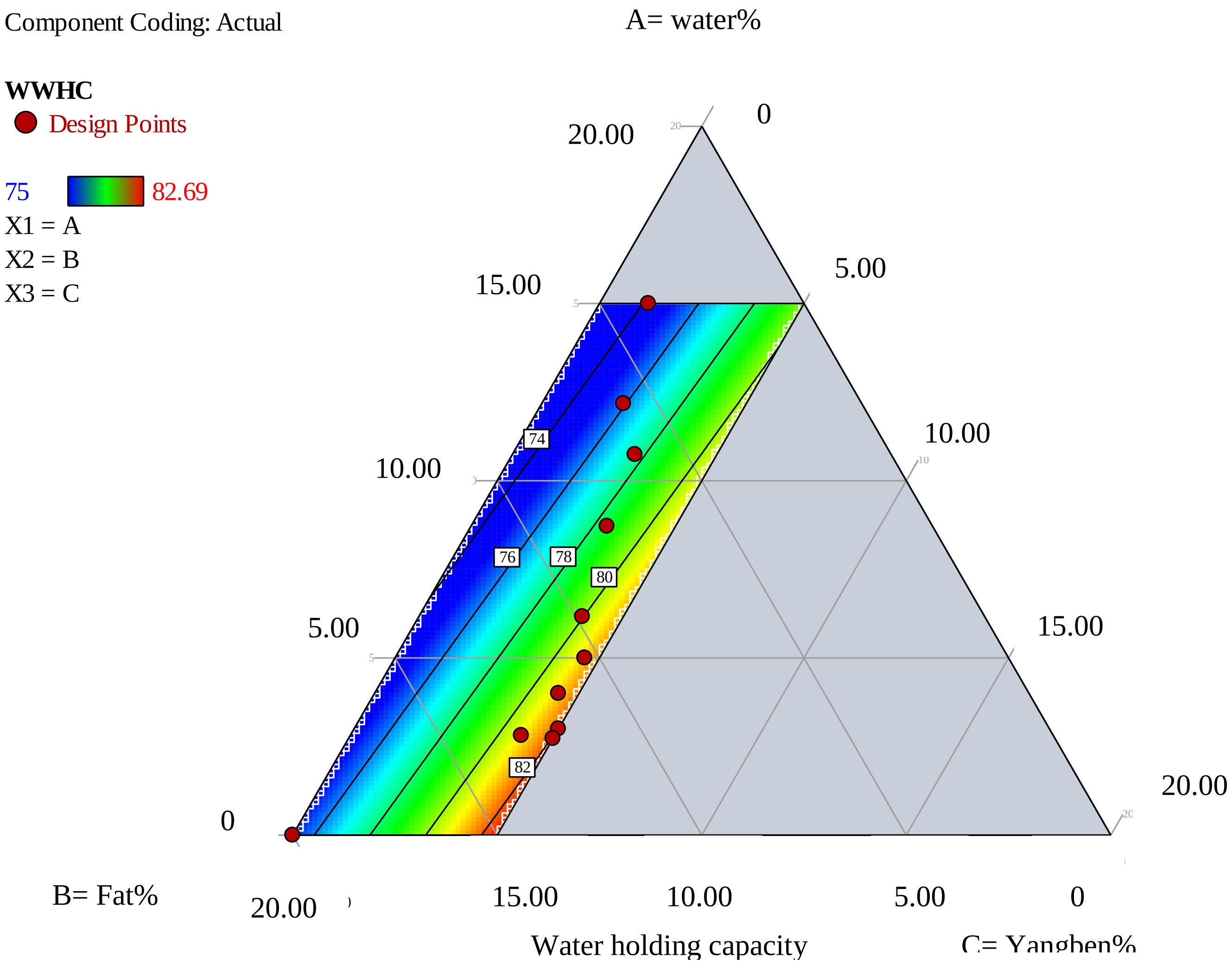

Fig. 4.12 Counter plots for WHC as a Function of water, Pig fat (lard) and yangben in meatball.

Graphical optimization displays the area of feasible response values in the factor space. The response surface plots graphically define the location and desirability of the solutions. Regions that don’t fit the optimization criteria are shaded grey and a region that satisfies the constraints is shaded dark grey. For quality meatball the WHC should be more. From graph got that increasing amount of yangben, fat and water the WHC of product is also increases, which is the desirability for product. Yangben in meatball as a binder thus it has more significant role on WHC. From plot design point highest value for WHC is 82.69% and lowest value is 75%.

4.5 Optimization study

Central composite design of response surface methodology was used for optimization of yangben, pig fat (lard) and water for the preparation of chicken meatball. The assumptions were to develop a product which would have maximum water holding capacity and processing yield and less fat and jelly separation in range. There have three variables (constrains). Constrains helped to set the goals for the optimization of yangben, pig fat (lard) and water for the preparation of chicken meatball and get predicted data with maximum desirability and their overlay plots given by design expert. Out of three constraints in which water (A) was set between 0-15, fat between 0-20 and yangben between 0-5. Design expert gives twelve samples. Fat and jelly separation, water holding capacity and processing yield of all 12 samples determined. All data are the means of triplicate. By sensory data and obtained data interpretation samples I, E and G were found to be best in most of the parameters as well as overall palatability. From the sensory evaluation the product prepared with sample E, G, I was found to be significantly ($P < 0.05$) superior at 5 % level of significance in terms of flavor, tenderness, juiciness and overall palatability. From the physiochemical analysis the product prepared with sample G having 8.57143% lard, 5% yangben, 6.42857% water was found to be significantly ($P < 0.05$) superior at 5 % level of significance in terms fat and jelly separation, processing yield, water holding capacity. On comparison between numerical optimization and sensory analysis, sensory analysis was preferred because consumer preference should be taken into account for the documentation of new product. Sample G was selected as best optimized sample for further analysis because it shows maximum desirability on sensory and physiochemical analysis. The processing yield, fat and jelly separation and water holding capacity of optimized sample i.e. sample G was found to be 92.16%, 1.16% and 81.37% respectively.

4.6 Proximate analysis of sensory optimized product

The proximate composition of optimized product is given in Table 4.5.

Table 4.5 Proximate composition of sensory optimized product

Parameters	Optimized product	Control product
Moisture (%)	78.7±0.6 ^{f}	73±0.43 ^{e}
Protein (% db)	22.58±0.3 ^{e}	18.58±0.7^{d}
Fat (% db)	9.71±0.8^{d}	5.26±0.46 ^{c}
Crude fiber (% db)	1.7±0.79^{a}	0.69± 0.30 ^{a}
Ash (% db)	5.88± 0.42^{b}	4.14±0.66 ^{b}
Carbohydrate (% db)	7.17±0.55 ^{d}	5.55±0.54 ^{c}

[The values in Table 4.5 are the mean of the triplicates ± standard deviation. The values obtained above are in dry basis. Values in the row having the same superscript are not significantly different at 5% level of significance.]

Statistical analysis at 5% level of significance shows that, in optimized and control sample parameters moisture, fat, protein and carbohydrate are significantly different with each other, whereas crude fiber and ash are significantly related. According to Ulu (2004) Aukkanita *et al.* (2015) fat content was found different because of incorporation of pig fat up to 0-20 % in optimized sample. The moisture, protein, fat and ash was the contribution of almost all the ingredients used in the preparation whereas crude fiber and carbohydrate are due to yangben and spices used in formulation. We can see all the parameters of optimized and control sample are significantly different. High moisture in optimized sample due to addition of water up to 0-15 % in optimized sample. High protein in optimized sample due to main contribution of yangben All the parameters were found significantly different then the result obtained by Purnomo and Rahardiyan (2008), Serdaroglu and Abrodimov (2005) but there is no significant difference in parameters crude fiber and ash.

4.7. Cost evaluation

The total cost of the recipe optimized meatball was calculated. The price of 100 g recipe optimized meatball was found to be NRs. 28.08. This is cheaper than commercial meatballs. The price of 100 g commercial meatball was found to be NRs. 28.38. This is shown in the Appendix B.

PART V

Conclusion and recommendations

5.1 Conclusion

Based on the physio-chemical, sensory and statistical analysis of the lab prepared chicken meatball of different formulations, following conclusions were drawn.

- From sensory evaluation samples I, G and E ranges with 6.26-20% lard, 0-5% yangben, 0-10.74% water were found to be significantly best.
- The meatball sample G containing with 8.57% lard, 5% yangben, and 6.43% water was deemed to be significantly better from functional property evaluation.
- With an increase in yangben quantity and a drop in water amount, the water holding capacity was shown to increase considerably. The separation of fat and jelly was shown to be greatly increased with an increase in fat and water content and a decrease in yangben content.
- According to the research, the optimized product has higher moisture, protein, fat, and carbohydrate content than the control. The optimized product is less expensive than the control, as indicated in Appendix B.

5.2 Recommendations

Based on the present study following recommendations for further study and suggestion for entrepreneur can be made:

- The meatball containing 8.57% lard, 5% yangben, and 6.4% water was deemed to be significantly better after sensory and functional property evaluation.
- Because the color of Yangben on the product is unappealing, natural color can be used to improve the product's attractiveness.
- Comparative study of binding capacity of yangben and different commercial binders can be performed.

PART VI

Summary

Meatball is getting popularity nowadays all over the world. In context of Nepal meatball is getting popularity day by day. Various kinds of meatball are already present in food market, but their formulation and processing are not standardized and technical. The present study was conducted to obtain the optimum formulation for fat, water and yangben based on sensory and chemical analysis. The recipe for the chicken meatball was extracted from the previous study and variation in the formulation to be done was fixed based on that recipe. There have three constraints in which water (A) was set between 0-15%, fat between 0-20% and yangben between 0-5%. Design Expert gives 12 samples. Fat and jelly separation, water holding capacity and processing yield of all 11 samples was determined. The effect of these variables on the responses processing yield, fat and jelly separation and water holding capacity was investigated.

The data were analyzed using Design Expert All data are the means of triplicate. By sensory data and obtained data interpretation samples I, E and G were found to be best in most of the parameters as well as overall palatability. From the sensory evaluation the product prepared with sample E, G, I was found to be significantly ($P < 0.05$) superior at 5 % level of significance in terms of flavor, tenderness, juiciness and overall palatability. From the physiochemical analysis the product prepared with sample G having 8.57% lard, 5% yangben, 6.43% water was found to be significantly ($P < 0.05$) superior at 5% level of significance in terms fat and jelly separation, processing yield, water holding capacity. On comparison between numerical optimization and sensory analysis, sensory analysis was preferred because consumer preference should be taken into account for the documentation of new product. Sample G was selected as best optimized sample for further analysis because it shows maximum desirability on sensory and physiochemical analysis. The processing yield, fat and jelly separation and water holding capacity of optimized sample i.e. sample G was found to be 92.16%, 1.16% and 81.37% respectively.

For the lab preparation of meatball meat, pig fat (lard), spices and corn flour were brought from local market of Dharan. Raw yangben was collected from Terhathum. All of the ingredients were weighed out as per the formulations. Meat, fat, yangben and spices

were chopped and all the ingredients were mixed together with corn flour and salt. Then the batter will be mixed properly and fisted manually for about 10-15 min so that the protein released from minced meat adhere all the ingredients together. The prepared meatball mass was fried in the range l75±10°C. The frying time taken was 4±1 min. The color of meatball after frying was purple brownish in color. The weight of meatball before cooking was noted and then cooked at l75±10°C for 4±1 min. The cooked meatball was again weighed for final weight and left overnight for sensory and chemical analysis. The sensory analysis was conducted for aroma, color, taste, texture, juiciness and overall acceptability of meatball.

From the sensory evaluation the product prepared with sample E, G, I was found to be significantly ($P < 0.05$) superior at 5 % level of significance in terms of flavor, tenderness, juiciness and overall palatability. From the physiochemical analysis the product prepared with sample G having 8.57% lard, 5% yangben, 6.43% water was found to be significantly ($P < 0.05$) superior at 5 % level of significance in terms fat and jelly separation, processing yield, water holding capacity. The moisture content, crude protein, crude fat, crude fiber, total ash and total carbohydrate of meatball was found to be 78.7%, 22.58%, 9.71%, 1.7%, 5.88% and 7.17% on dry basis respectively.

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Appendices

Appendix A

Table A.1 Experiment design for samples and their responses

	Component 1	Component 2	Component 3	Response 1	Response 2	Response 3
Run	A:water	B:fat	C:yangben	Fat and jelly separation	processing yield	WHC
5	0	20	0	4.44	86.76	75
4	15	3.80	1.19	3.8	87.05	75.97
11	12.17	5.82	2	3.62	88.07	75.8
9	10.74	6.25	3	2.98	88.95	76
7	6.42	8.57	5	1.15	92.16	81.37
10	6.16	9.83	4	2.21	90.02	78.11
2	2.81	12.99	4.18	2.17	91.63	81.11
6	4	11.5	4.5	1.91	92.07	82.33
1	5	10.36	4.64	1.67	91.77	80.98
3	2.72	12.27	5	1.41	92.84	82.69
8	3	12	5	1.15	92.98	82.61

Appendix B

Table A.2 cost evaluation of 100gm optimized chicken meatball.

Parameters	Quantity (g)	Rate (NRs)	Amount (NRs)
Meat	60	310/kg	18.6
Corn starch	6	150/750 g	1.2
Onion	12	75/kg	0.9
Ginger	3	60/kg	0.18
Garlic	3	150/kg	0.45
Salt	1.2	25/kg	0.03
Fat	3.75	15/100 g	0.57
Yangben	1.8	300/500 g	1.08
Chilli powder	0.36	10/25 g	0.144
Black pepper	0.36	25/50 g	0.18
MSG	0.18	10/25 g	0.072
Overhead cost (20%)			4.68
Total			28.08

Appendix C

Specimen card for sensory evaluation

Hedonic rating test

Panelist no.: ________ Name: ________________________________

Please evaluate the meatball samples and indicate how much you like or dislike it for tenderness, juiciness, Aroma, appearance and overall on 1-9 ranking scale.

1	2	3	4	5	6	7	8	9
Dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely

Sample	Texture	Juiciness	Aroma	Appearance	Overall
A					
B					
C					
D					
E					
F					
G					
H					
I					
J					
K					
L					
M					

Appendix D

Table A.3 Mean sensory score for appearance of meatball

Sample	mean scores ± standard deviation
A	5.3 ±0.86
B	6.3 ±0.67
C	6.3 ±0.67
D	6.4±0.76
E	7.4±0.70
F	6.8±0.63
G	7±0.67
H	6.2±0.92
I	7.4±0.70
J	7±0.82
K	6.5±0.73
L	6.9±0.67

Table A.4 One way ANOVA for appearance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
sample	11	38.0250	3.4568	6.18	<.001
Residual	99	55.3917	0.5595		
Total	119	108.1250			

Since, Fpr < 0.05, significant difference was observed between the samples at 5% level of significance. The Least Significant Difference (LSD) value was calculated to be 0.6059.

Table A.5 Mean sensory score for aroma of meatball

Sample	mean scores ± standard deviation
A	6.9 ±0.74
B	7.1 ±0.88
C	6.5 ±0.71
D	6.8±0.63
E	7.1±0.74
F	6.6±0.70
G	7.2 ±0.42
H	6.4±0.52
I	7.3±0.67
J	6.8±0.63
K	6.9±0.83
L	7±0.82

Table A.6 One way ANOVA for aroma

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
sample	11	8.5667	0.7788	1.61	<0.01
Residual	99	47.7667	0.4825		
Total	119	62.3667			

Since, Fpr < 0.05, significant difference was observed between the samples at 5% level of significance. The Least Significant Difference (LSD) value was calculated to be 0.5545.

Table A.7 Mean sensory score for texture of meatball.

Sample	mean scores ± standard deviation
A	6.4 ±1.26
B	7 ±1.05
C	6.5 ±0.85
D	6.8±0.63
E	7 .3±0.82
F	6.7±0.67
G	6.9±0.57
H	6.1±0.88
I	7.6±0.70
J	6.9±0.88
K	6.9±0.62
L	6.7±1.10

Table A.8 One way ANOVA for texture

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
sample	11	17.1667	1.5606	2.89	<.001
Residual	99	53.5000	0.5404		
Total	119	89.9667			

Since, Fpr < 0.05, significant difference was observed between the samples at 5% level of significance. The Least Significant Difference (LSD) value was calculated to be 0.7278.

Table A.9 Mean sensory score for juiciness of meatball

Sample	mean scores ± standard deviation
A	7.1 ±0.32
B	6.7±0.67
C	6.4 ±0.52
D	6.9±0.57
E	7.6±0.70
F	7.2±0.79
G	7.2±0.63
H	6.5±0.53
I	7.6±0.70
J	7±0.47
K	7±0.60
L	7.1±0.70

Table A.10 One way ANOVA for juiciness

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
sample	11	15.2250	1.3841	3.86	<.001
Residual	99	35.5250	0.3588		
Total	119	54.9250			

Since, Fpr < 0.05, significant difference was observed between the samples at 5% level of significance. The Least Significant Difference (LSD) value was calculated to be 0.4852.

Table A.11 Mean sensory score for overall acceptability of meatball

Sample	mean scores ± standard deviation
A	6.6 ±0.52
B	6.7±0.67
C	6.6 ±0.52
D	7±0.47
E	7.6±0.70
F	6.8±0.79
G	7.2±0.63
H	6.5±0.53
I	7.7±0.48
J	7.1±0.57
K	7±0.56
L	7±0.67

Table A.12 One way ANOVA for overall acceptability

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
sample	11	17.8667	1.6242	4.62	<.001
Residual	108	38.0000	0.3519		
Total	128	55.8667			

Since, Fpr < 0.05, significant difference was observed between the samples at 5% level of significance. The Least Significant Difference (LSD) value was calculated to be 0.5258.

Appendix E

Table no A. 13 ANOVA for effect of process variables on fat and jelly separation

Source	Sum of	d.f.	Mean	F-value	p-value	
Model	11.16407	5	2.232814	234.6098	6.35E-06	significant
â • ½Â¹â • ¾Linear Mixture	10.9293	2	5.464648	574.1903	1.24E-06	
AB	0.000386	1	0.000386	0.040517	0.848406	
AC	0.060694	1	0.060694	6.377375	0.052829	
BC	0.078916	1	0.078916	8.292035	0.034605	
Residual	0.047586	5	0.009517			
Corr. Total	11.21165	10				

Table no A. 14 Fit adjustments for fat/jelly separation

Std. Dev.	0.097556	RÂ²	0.995756
Mean	2.556364	Adjusted RÂ²	0.991511
C.V. %	3.816195	Predicted RÂ²	0.89447
		Adeq Precision	29.68912

Table no A.15 ANOVA for effect of process variables on processing yields.

Source	Sum of	d.f.	Mean	F-value	p-value
Model	49.16993	2	24.58496	122.9303	9.86E-07
â • ½Â¹â • ¾Linear Mixture	49.16993	2	24.58496	122.9303	9.86E-07
Residual	1.599928	8	0.199991		
Cor Total	50.76985	10			

Table no A.16 fit adjustments for processing yield

Std. Dev.	0.447204	RÂ²	0.968487
Mean	90.17364	Adjusted RÂ²	0.960608
C.V. %	0.495936	Predicted RÂ²	0.864879
		Adeq Precision	25.33356

Table no A.17 ANOVA for effect of process variables on WHC

Source	Sum of	d.f.	Mean	F-value	p-value	
Model	80.49169	2	40.24584	26.83686	0.000283	significant
â • ½Â¹â • ¾Linear Mixture	80.49169	2	40.24584	26.83686	0.000283	
Residual	11.99719	8	1.499648			
Cor Total	92.48887	10				

Table no A.18 Fit adjustment for water holding capacity

Std. Dev.	1.224601	RÂ²	0.939285
Mean	78.95545	Adjusted RÂ²	0.937856
C.V. %	1.551003	Predicted RÂ²	0.856664
		Adeq Precision	32.29007

Table no A.19 Tukey HSD table for control

parameter			Subset				
		N	1	2	3	4	5
Tukey HSD[a,b]	crude fiber	3	0.69				
	ash	3		4.14			
	fat	3			5.26		
	carbohydrate	3			5.55		
	protein	3				18.58	
	moisture	3					73.06
	Sig.		1.000	1.000	0.821	1.000	1.000

Table no. A.20 Tukey HSD table for optimized sample

VAR00001		N	Subset 1	2	3	4	5	6
Tukey HSD[a,b]	crude fiber	3	1.7467					
	ash	3		5.7967				
	carbohydrates	3			7.1667			
	fat	3				9.1833		
	protein	3					22.2200	
	moisture	3						78.5000
	Sig.		1.000	1.000	1.000	1.000	1.000	1.000

Table A.21 Equipment's used during preparation of meatball.

Equipment	Purpose
Meat mincer	For mincing fat and meat.
Plexi plate	For the estimation of WHC.
Cutting Knives	For cutting meat and ingredients
Chopping board	For chopping meat and ingredients
Frying pan and kitchen ware	For frying
Stainless steel bowl	

Color plates

Plate 1: Raw yangben collected from Terhathum. **Plate 2**: Cutting head part of raw yangben

Plate 3: Cooking yangben with 2-3 % ash.

Plate 4: Yangben after cooking

Plate 5: Minced meat through meat mincer.

Plate 6: Samples of chicken meatball.

Plate7: Samples for analysis of fat and. Jelly separation

Plate 8: Sensory evaluation of meatball

Plate 9: Samples for analysis of WHC.

Plate 10: Samples for analysis of processing yield.