DEVELOPMENT AND QUALITY EVALUATION OF VALUE ADDED PRODUCTS INCORPORATING QUINOA SEED

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Ms. GITIKA SHARMA

THESIS

DOCTOR OF PHILOSOPHY IN HOME SCIENCE

(Food Scienceand Nutrition)

2018

DEPARTMENT OF FOOD SCIENCE AND NUTRITION
COLLEGE OF COMMUNITY AND APPLIED SCIENCES
MAHARANA PRATAP UNIVERSITY OF AGRICULTURE & TECHNOLOGY, UDAIPUR
(RAJASTHAN)

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THESIS

SUBMITTED TO THE

MAHARANA PRATAP UNIVERSITY

OF AGRICULTURE AND TECHNOLOGY, UDAIPUR

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR

THE DEGREE OF

DOCTOR OF PHILOSOPHY IN HOME SCIENCE

(Food Science and Nutrition)

By

Ms. GITIKA SHARMA

2018

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, UDAIPUR

COLLEGE OF HOME SCIENCE, UDAIPUR

CERTIFICATE – I

Dated _ _ / _ _ / ____

This is to certify that **Ms. Gitika Sharma** had successfully completed the oral preliminary examination held on ..... as required under the regulation for **Doctor of Philosophy Degree.**

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CERTIFICATE – II

Dated _ _ / _ _ / __

This is to certify that the thesis entitled **"Development and Quality evaluation of value added products incorporating Quinoa seed"** submitted for the degree of **Doctor of Philosophy** in the subject of **Food Science and Nutrition** embodies bonafide research work carried out by **Ms. Gitika Sharma** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistant and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee in the pre thesis submission seminar held on _____.

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CERTIFICATE – III

Dated _ _ / _ _ / __

This is to certify that the thesis entitled **"Development and Quality evaluation of value added products incorporating Quinoa seed"** submitted by **Ms. Gitika Sharma** to Maharana Pratap University of Agriculture and Technology, Udaipur in partial fulfilment of the requirement for the degree of **Doctor of Philosophy** in the subject of **Food Science and Nutrition** after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination held on ……. was satisfactory; we therefore, recommended that the thesis be approved.

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CERTIFICATE – IV

Dated _ _ / _ _ / __

This is to certify that **Ms. Gitika Sharma** student of the **Department of Food Science and Nutrition,** College of Home Science has made all corrections/ modifications in the thesis entitled **"Development and Quality evaluation of value added products incorporating Quinoa seed"** which were suggested by the external examiner and the advisory committee in the oral examination held on _____. The final copies of the thesis duly bound and corrected were submitted on _____.

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CERTIFICATE –V

Dated _ _ / _ _ / __

This is to certify that **Ms. Gitika Sharma** (Ph.D. Scholar) has worked out under me on **"Development and Quality evaluation of value added products incorporating Quinoa seed".**

1. I have monitored her research work.
2. My self and the scholar were in contact with the committee members and the research work was reviewed regularly.
3. The advisory committee members have gone through Ph.D. of thesis critically and made the corrections as per requirement.

Dr. (Mrs.) Sarla Lakhawat
Major Advisor

ACKNOWLEDGEMENT

*I bow my head before **Almighty God**, the omnipotent, the merciful, the most gracious, the compassionate, the beneficent, who is the entire and only source of every knowledge and wisdom endowed to mankind and who blessed me with ability to do this work.*

*I express my heartfelt gratitude to my major advisor **Dr. (Mrs.) Sarla Lakhawat**, Head and Assoc. Professor, Department of Foods Science and Nutrition, College of community and applied Science, Udaipur for her valuable and gifted guidance, keen interest, constant encouragement, and unfailing source of inspiration, critical supervision and painstaking efforts during the entire course of my study.*

*I am gratified to record my sincere and humble thanks to the member of my advisory committee, **Dr. (Mrs.) Renu Mogra**, Professor, Department of Foods Science and Nutrition, **Dr. (Ms.) Dhiriti Solanki,** Professor of Department of Home Science Extension and Communication Management, **Dr. (Mrs.) Neeta Lodha**, Head and professor, Department of Resource management and consumer **Dr. (Mrs.) Sudha Babel**, Head and Professor, Department of textile and apparel designing, for their generous and valuable suggestions in planning and execution of this study.*

*I acknowledge my sincere thanks and indebtness to **Dr. (Mrs.) Shashi Jain**, Professor, Department of Foods Science and Nutrition, College of community and applied Science, MPUAT, Udaipur for providing all the necessary facilities and necessary guidance to carry out the study.*

*I am at loss of words to express my deep sense of gratitude to my respected father **Mr. Shiv Prasad Sharma** and my loving mother **Mrs. Rekha Sharma**, my brother and Sister **Ayush Sharma** and **Khushbu Sharma** whose constant love and blessing were always with me to complete this task. Indeed the words at my command are inadequate to acknowledge my best friend Puja Joshi her selfless help, encouragement and motivation at every stage of my research work.*

Still there are many well wishes, family members and friends who directly and indirectly rendered valuable help to complete this academic endeavor. I have deep sense of reverence for all of them.

Date- ***(Ms. Gitika Sharma)***

Place- Udaipur

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ABBREVATIONS

mg	Milligram
g	Gram
Kcal	Kilocalorie
hr	Hours
cm	Centimetre
mm	Millimetre
ml	Millilitre
kg	Kilogram
WAC	Water absorption capacity
HDPE	High Density Polyethylene
m.o.	Microorganism
QW	QuinoaWhole
QD	QuinoaDehulled
QDF	QuinoaDehulled Flour
tsp	teaspoon
Sec	Second

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, UDAIPUR, RAJASTHAN

COLLEGE OF COMMUNITY AND APPLIED SCIENCES

Department of Food Science and Nutrition

Ph.D. Thesis (2018)

TITLE: Development and Quality Evaluation of Value Added Products Incorporating Quinoa Seed

ABSTRACT

Quinoa (*Chenopodium quinoa*) has been cultivated in the Andean region for several thousand years, being one of the main grain crops supplying highly nutritious food. Quinoa is an important food source for human consumption in the Andean region and has immense industrial value. Quinoa has been selected by FAO (2014) as one of the crops destined to offer food security in the 21st century, because the quinoa plants are tolerant to salinity and drought stress, and can grow on marginal regions Its consumption may be less as it is hard to digest containing anti-nutritional factors as Saponin and phytic acid. There are numbers of technologies identified by which anti-nutritional factors can be reduced to a large extent.

The study was planned with the objectives to assess physico-chemical characteristics, development of products and quality evaluation of developed foods, preparation of information material. For the purpose Quinoa whole and quinoa dehulled were purchased from local market of Udaipur. Quinoa seeds were cleaned and stored in air tight container at room temperature. The study was conducted in five phases. First phase was physicochemical analysis of Quinoa seed in which physical properties, functional properties and chemical properties were analyzed. It was observed that Quinoa seed is similar to a flattened sphere is a small sized seed with poor hydration and swelling capacity. Quinoa flour has fair emulsion capacity although the foaming capacity of quinoa flour is weak but stability of foam is better than the refined wheat flour. Functional properties as oil absorption capacity, emulsifying activity of quinoa flour was found good and acceptable for bakery products. Depending on the chemical analysis of Quinoa whole, Quinoa dehulled, the Quinoa dehulled considered nutritionally dense due to its better nutritional composition and low anti-nutrients than Quinoa whole. In second phase processing treatments as soaking (6, 12, 18, 24 hr) and germination (12, 24, 36, 48hr) were applied on Quinoa whole and Quinoa dehulled and proximate composition, mineral profile and anti-nutrients, total anti-oxidant activity were assessed. Chemical

analysis of processing treatment depicts that in 24hr germination protein content was highest and anti-nutrients were lower and higest anti oxidant properties as compare to other processing treatments. Food Products (*Chapati, Biscuit, Namkeen, Khakhra, Handwa, ladoo, patty, chilla, sattu, utapam, khaman, cake*) were developed in phase three through incorporation of quinoa dehulled flour in 40, 60, 80 and 100 percent. On the basis of sensory evaluation by 30 panel members, 40 to 60% percent was found highly acceptable. In phase four, quality evaluation of Quinoa dehulled flour was performed in terms of functional properties and peroxide value. Results of functional properties WAC % decreased significantly, The oil absorption capacity (OAC) of seeds flour was low but gradually increased significantly in the first 3 month of storage and decreased significantly in the last month (6th month), There was a marginal difference in LGC values over the months. The peroxide value was not recorded during the initial storage period. It could only be detected at 90 days and 180 days of storage interval, with the values 0.89±0.03 meq/kg and 1.09±0.08 meq/kg respectively, on dry weight basis. In phase fifth booklet was developed. The topic was "Nutritious product of Quinoa". The findings of the study elucidate that the developed booklet was evaluated as very good by the experts.

Dr. (Mrs.) Sarla Lakhawat — Major Advisor

Gitika Sharma — Research Scholar

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INTRODUCTION

The Indian subcontinent is a large land mass covering India, Pakistan, Nepal, Sri Lanka and Bangladesh and it sustains 20% of the world' population. The area is prone to degradation of its natural resources due to intensive cultivation leading to declining soil fertility, changes in water table depth, deterioration in the quality of irrigation water, and rising salinity in the region. Much of the population has little access to a protein-rich diet, since wheat and rice are the principal food grains grown and consumed in the area. The growing population necessitates increased food production combined with a shift towards environmentally sound sustainable agriculture. It is therefore important to select crops requiring fewer inputs while able to respond to the nutritional deficiency prevalent in the region. Quinoa is still an "underutilized" crop, given its nutritional superiority over traditional crops and its wide adaptability to diverse agronomic conditions, and its commercial potential in South Asia has remained untapped. Quinoa, seed plant of *Chenopodium quinoa* is an annual broad-leaved plant, 1-2 m tall with deep penetrating roots which can be cultivated from sea level upto an altitude of 3800 m. It is a grain with intrinsic outstanding characteristics. Aspects like exceptional nutritional quality, genetic variability, adaptability to adverse climate and soil conditions, and low production cost constitutes quinoa as a strategic crop with potential contributor to food security and sovereignty. Quinoa adapts to desert, hot and dry climates. This crop can grow with relative humidity from 40% to 88%, and survive with temperatures from -4°C to 38°C. It is resistant to low soil moisture, and can produce acceptable yields even with precipitations from 100 to 200 mm. Due to its ability to adapt to adverse climate and soil conditions where other crops are unable to grow, harvest can be obtained at altitudes from sea level to 4000 m. The cultivation of quinoa provides an alternative for countries with limited food production. The history of its human consumption reaches back 5000 years (Ando *et al.* 2002; Oelke *et al.*2012). Quinoa (*Chenopodium quinoa*) has been cultivated in the Andean region for several thousand years, being one of the main grain crops supplying highly nutritious food.

Quinoa is an important food source for human consumption in the Andean region and has immense industrial value (Bhargava *et al.* 2006; Fuentes and

Bhargava, 2011). The crop grows in different ecological zones, from sea level to 2 000– 4 000 m asl (Bazile *et al.* 2013; Fuentes and Bhargava 2011). Quinoa has been selected by FAO (2014) as one of the crops destined to offer food security in the 21st century, because the quinoa plants are tolerant to salinity and drought stress, and can grow on marginal regions (Jacobsen *et al.* 2003).The edible seeds of quinoa are small, round and flat. Seed colors can range from white to grey and black, or can be yellow and red. *Chenopodium quinoa* was considered as the mother of cereals. Today everyone knows that it is one of the oldestcrop plants, included in the group of the so-called 'pseudocereals'. Seeds of this species are distinguished by high nutritive value because of its very good chemical composition, high proportion of vitamins, microelements, fat, including essential unsaturated fatty acids (EFA), mainly linoleic and linolenic acids (Coulter and Lorenz 1990). However, the greatest advantage of this plant is the content and quality of protein. Quinoa seed have a high protein content (about 15%), and its essential amino acid balance is excellent, because of a wider amino acid spectrum than cereals and legumes (Ruales and Nair, 1993), with higher lysine (5.1–6.4%) and methionine (0.4–1.0%) contents. Quinoa contains lysine, methionine and cysteine higher than common cereals and legumes making it complementary to these crops. Quinoa's protein quantity ranged from 10.4% to 17.0% depending on its variety.

The seeds are an excellent example of functional food, defined as lowering the risk of various diseases and exerting health-promoting effects (RepoCarrasco *et al.* 2011; Vega-Galvez *et al.* 2010). Besides nutrients, quinoa contains bitter and toxic compounds (saponins) especially in the hull. Therefore, quinoa in most cases is dehulled/polished and washed (Lopez Garcia, 2007). Research was focusing on developing effective dehulling methods to remove saponins and on cultivating new 'sweet' cultivars that contain less saponins (Galwey *et al.* 1990; Koziol, 1992; Reichert *et al.* 1986).

Quinoa farming and consumption in India is still at a nascent stage however recent impetus in this direction has already been taken. One of recent project "project Anantha" by Andhra Pradesh was sought to push quinoa, with its lower water intake, as an alternative crop in the dry terrain of Anantapur district. The United Nations has declared 2013 the International Year of Quinoa, which aims at focusing global

attention on the role it can play in contributing to food security, nutrition and poverty radication and policies (Burlingame *et al.* 2012; FAO, 2013).The worldwide popularity of quinoa and initial promising reports from Asia make it an important candidate as an alternative crop in this region. And this could be achieved only by an integrated effort at all levels: information, awareness, popularization, research and marketing.

OBJECTIVES:

1. To evaluate physico-chemical properties of quinoa seeds *(Chenopodium quinoa).*
2. To develop value added products by incorporating the quinoa seed flour.
3. To evaluate the nutritional quality (Proximate analysis) of developed product from quinoa seed flour.
4. To determine shelf life of the quinoa seed flour.
5. To prepare information material on value added product of quinoa seed.

REVIEW OF LITERATURE

The main function of citing review of literature is to provide base for developing a frame work, provide insight into the methodology and suggest operational definition of the concepts and finally to work out a basis for interpretation of findings. Keeping in view the objectives of the study, the literature has been presented under the following sub-heads:

2.1: Production, consumption and utilization of Quinoa

2.2: Physical and functional properties of Quinoa

2.3: Nutritional Quality and anti-nutrient of Quinoa seed

2.4: Effect of Processing on nutritional quality

2.5: Characteristics of Quinoa flour & its products

2.6: Therapeutic application of Quinoa

2.1: Production, consumption and utilization of Quinoa seed

Oelke *et al.,* (1992) this crop is somewhat drought tolerant with a water requirement of 10 to 15 in. per year (precipitation and irrigation combined on sandy-loam or loamy-sand soils). Studies on crop water use conducted during 1987 in Colorado found that the application of lower amounts of water reduced plant height by 50% with only an 18% reduction in yield. Crops planted during late April to mid-May in Colorado did not usually need irrigation until mid-June when the soil was near field capacity at planting time. Plants should not be irrigated until the two- or three-leaf stage. Rainfall in July has usually been sufficient during Colorado research trials to supply the crop until August. Excessive irrigation after stand establishment usually produces tall, lanky plants with no yield improvement. Damping off and severe stunting of plants will occur with excessive irrigation in the seedling stages

Oelke *et al* ., (1992) Plants grow from 1 1/2 to 6 1/2 ft in height, and come in a range of colors that vary from white, yellow, and pink, to darker red, purple, and black. Quinoa has a thick, erect, woody stalk that may be branched or unbranched, and alternate, wide leaves that resemble the foot of a goose. Leaves on younger plants are usually green; but as the plant matures, they turn yellow, red, or purple. The root

system develops from a tap root to form a highly branched system that makes plants more resistant to drought. Varieties of quinoa mature in 90 to 125 days after planting in southern Colorado. Early-maturing varieties are recommended because of the short growing season at these high elevations.Quinoa prefers cool soil conditions (45° to 50°F). Germination occurs within 24 hours after planting when adequate moisture is present, and seedlings emerge in three to five days. Quinoa seeds, like those of spinach, may not germinate if conditions are warm and may need to be refrigerated for a week (vernalized) to obtain adequate germination.

Quinoa is one of the oldest crops in the Andean Region, with approximately 7000 years of cultivation, and great cultures such as the Incas and Tiahuanacu have participated in its domestication and conservation (Jacobsen, 2003).

The main quinoa producers in the world are Bolivia, Peru, Ecuador, and the United States of America. In 2013, over 75,000 hectares of land were under quinoa cultivation in Bolivia and more than 45,000 hectares in Peru. These two countries are still the major producers in the Andes and in the world. Today the cultivation of quinoa has reached countries as far as Tibet, Morocco, France, India, China, the United Kingdom, Sweden, Denmark, Netherlands, and Italy, among others (Bhargava *et al*., 2006; Pulvento *et al*., 2010; Bazile)

Laura *et al.,* (2014) Reported that Chenopodium quinoa Willd., is the oldest pseudocereal native from the Andean Region from 20° N in Columbia to 40°S in Chile, it grows from sea level to an altitude of 3800 m, adapted to several agroclimates and abiotic stress, it can display a variety of colours from the leaves and inflorescences.

Quinoa has been selected by FAO (2014) as one of the crops destined to offer food security in the 21st century, because the quinoa plants are tolerant to salinity and drought stress, and can grow on marginal regions.

Quinoa is a viable alternative for food insecure countries in a world facing increasingly climate challenges and set to feed a growing population in terms of both food and nutrition security (Galwey, 1992, Ruiz *et al*., 2014).

About 97% of the nearly 26,000 tonnes imported to the European Union (EU) in 2016 came from Peru and Bolivia. Although Peru and Bolivia are still the main global suppliers, many other countries now aspire to cultivate and export. Bolivia

used to be the main exporter of quinoa to Europe until the year 2013. It has, however, become less competitive compared to Peru. CBI, Ministry of foreign affairs (2017).

2.2: Physical and functional properties of Quinoa seed

Luciana *et al.,* (2000) conducted a study on performance of quinoa (*Chenopodium quinoa Willd*) flour in the manufacture of gluten-free spaghetti. The objective of this work was to assess the performance of mixtures of corn and quinoa (*Chenopodium quinoa* Willd) flours in the development of a spaghetti-type product. Cooking quality (loss of solids, volume increase and weight increase), texture (adhesiveness, elasticity), peak and final viscosities and moisture content of the pre-gelatinised flour mixtures were the physical parameters studied. The combination of independent variables that resulted in higher elasticity values, desirable for spaghetti, were short thermal treatment and low-to-medium quinoa additions.

Vilche *et al.,* (2003) conducted a study on physical properties of quinoa (Chenopodium quinoa Wild.) seeds were determined as a function of moisture content. In the moisture range from to 4.6 to 25.8% dry basis, the 1000-seed mass increased from to 2.5 to 3.1 g, the sphericity from 0.77 to 0.80, the density from 928 to 1188 kgm, the porosity from 0.19 to 0.44, the angle of repose from 18 to 258, the static coefficient of friction from 0.14 to 0.27 and the terminal velocity from 0.6 to 1.02ms. Only the bulk density decreased with moisture content from 747 to 667 kgm. In the range of moisture evaluated, all properties showed moisture dependence according to linear relationships with correlation coefficients higher than 0.90.

Nienke *et al.,* (2005) Starches ranging in amylose content from 3 to 20% from eight quinoa (*Chenopodium quinoa* Willd.) lines were characterized with respect to thermal, retrogradation, and pasting properties; swelling and solubility behavior; freeze-thaw stability; water-binding capacity; shear stability; and granule size and morphology. The starches differed in gelatinization onset temperatures, peak temperatures, and retrogradation tendencies; these characteristics were positively correlated with amylose content. No variation in gelatinization enthalpy was observed. With the exception of pasting temperature, large variations in pasting characteristics were found among starches and were correlated with amylose content. Swelling, solubility, freeze-thaw stability, and water-binding capacity also differed

among starches and were correlated with amylose content. Granule morphology and size were similar for all starches.

An increase of water absorption index could be ascribed to an increase in protein content (Gamel *et al.*, 2006).These results were confirmed by Abugoch *et al.,* (2009) who reported that WAI of quinoa seeds flour ranged from 2.3 to 4.5g/g.

Physical properties of quinoa seeds(*Chenopodium quinoaWilld*.) noticed that the 1000-seed weight of quinoa seed was 2.708g which indicating that quinoa which cultivated in Egypt is similar to the result with obtained by Bhargava *et al.,* (2007) who found that the 1000-seed weight of quinoa seed was 2.69g. Also,these results are in agreement with that published by Bhargava *et al.,* (2006) who found that for 17 cultivars of quinoa, 1000-seed weight ranged from 1.99 to 5.08g.

Abugoch *et al.,* (2009) conducted a study on composition, chemistry, nutritional, and functional properties quinoa**.** It has remarkable nutritional properties; not only from its protein content (15%) but also from its great amino acid balance. It is an important source of minerals and vitamins, and has also been found to contain compounds like polyphenols, phytosterols, and flavonoids with possible nutraceutical benefits. It has some functional (technological) properties like solubility, water-holding capacity (WHC), gelation, emulsifying, and foaming that allow diversified uses. Besides, it has been considered an oil crop, with an interesting proportion of omega-6 and a notable vitamin E content. Quinoa starch has physicochemical properties (such as viscosity, freeze stability) which give it functional properties with novel uses.

According to Alvarez *et al.,* (2009) in the present study, the pseudocereals amaranth, quinoa and buckwheat were studied as potential healthy ingredients for improving the nutritional quality of gluten-free breads. The pseudocereal seeds and pseudocereal-containing gluten-free breads were evaluated in terms of their protein, fat, total starch, dietary fibre, ash and mineral content as well as their fatty acid composition. The pseudocereal containing gluten-free breads showed significantly higher levels of protein, fat, fibre and minerals than the control bread. These results suggest that the pseudocereals amaranth, quinoa and buckwheat can represent a healthy alternative to frequently used ingredients in gluten-free products.

Ogungbenle (2009) quinoa has a high water absorption capacity (147.0%) and low foaming capacity and stability (9.0%, 2.0%). The flour has a least gelation concentration of 16%w/v. Protein solubility of the flour was also evaluated and found to be pH dependent, with minimum solubility at about pH 6.0.

Elsohaimy *et al.,* (2015) The quinoa protein showed water absorption (3.94± 0.06 ml/g) and (1.88 ± 0.02 ml/g) oil absorption. The foaming capacity of quinoa protein isolate was (69.28± 9.39% in average) and the foaming capacity was increased with the increase in the protein concentration. The average of emulsion stability index was (38.43± 7.22 min). Quinoa protein isolate is a promising and impressive nutritive source.

The oil absorption capacity (OAC) of quinoa seeds flour was 1.44%. This result indicated that quinoa seeds flour showed lower OAC in comparison with wheat flour (1.69 g/g) and buckwheat flour (1.80 g/g) but higher than amaranth flour (1.04 g/g) (Chauhan *et al.,* 2015 and Kaur *et al.,*2015). The value of bulk density of quinoa seeds flour was 0.72 g/100ml. These results are in accordance with that reported by Vilche *et al.,* (2003).

Li and Zhu (2016) stated that composition and physicochemical properties of whole grain flour from 7 quinoa samples have been analyzed. Correlation analysis showed that thermal properties and enzyme susceptibility of quinoa flour are highly influenced by the starch. Interactions of starch with non-starch components, including lipids, protein, dietary fibre, phenolics, and minerals, greatly impacted the flour properties. For example, peak gelatinization temperature of the flour is positively correlated to that of the starch ($r=0.948$, $p<0.01$) and negatively correlated to the lipid content ($r=-0.951$, $p<0.01$). Understanding the roles of starch and other components in physicochemical properties of quinoa flour provides a basis for better utilization of this specialty crop.

Ghada *et al.,* (2017) Present study was carried out to evaluate the physical, chemical, nutritional and functional properties of quinoa seeds flour. Results showed that, the 1000-seed weight and the bulk density values of quinoa seeds were 2.71g and 0.80g/m3, respectively.

The seed geometrical properties of the different quinoa genotypes *Chenopodium Quinoa* (black), (white), (red), (Ames). The lower length and width in

the quinoa seeds were obtained as 1.65 mm and 2.13 mm from *Chenopodium quinoa* (black) genotype, whereas the higher length and width in the quinoa seeds were found as 1.72 and 2.19 mm from *Chenopodium quinoa* (red) genotype among the seven quinoa genotypes respectively. The geometric mean diameter (Dg), sphericity and surface area of seeds for seven quinoa genotypes ranged from 1.45 to 1.76 mm, 80.78% to 88.29% and 6.66 to 9.76 mm2 respectively. The higher geometric mean diameter and surface area were found in *Chenopodium quinoa* (red) genotype of quinoa. The length, width and thickness for all the seven genotypes varied statisticaly significantly ($p<0.01$). Altuntas *et al.,*(2018).

2.3: Nutritional Quality and anti-nutrient of Quinoa seed

Chauhan *et al.,* (1992) assessed the nutrients and antinutrients in quinoa Seed. Quinoa seeds, manually and water dehulled, were ground into meal and milled into bran and flour. The protein content of the whole seed was 13.7%, with bran, flour, and hulls accounting for 65, 28-30, and 7% of the total protein, respectively. Seeds prepared by manual dehulling were all higher in lysine and sulfur amino acids, which are typical of legumes and cereals. Mineral analysis showed that quinoa seed fractions were all rich in Ca P, and Fe. Examination of antinutrients indicated very little trypsin inhibitor activity. The saponin content was quite low in the quinoa variety examined, with 34% located in the hulls. Although manual dehulling reduced the saponin content, a further reduction in saponin was obtained by water extraction.

Jenny *et al.,* (1994) The *in vitro* digestibility of protein in raw quinoa assessed by an enzymic method was 78%, significantly ($P > 0.01$) lower than that of casein, 91%, and also somewhat lower ($P > 0.01$) than that of the raw washed quinoa sample, 83%. The process used to remove the outer layers of the seeds containing saponins increased the protein digestibility significantly ($P > 0.01$), by 7%. Heat treatments increased protein digestibility over that of raw quinoa samples. Only the cooked sample treated for 60 min presented a slightly lower protein digestibility, 77%, than those obtained for other heat-treated samples. The temperature, time and moisture used in cooking and autoclaving of whole seeds of quinoa did not improve starch digestibility significantly. the digestibility of the starch in the raw and precooked samples was 72 and 77%, respectively, after drum drying and about 64% after extrusion in both cases. Precooking at 60°C for 20 min does not improve the digestibility of the quinoa starch.

Chauhan et al., (1999) carried out a study on effect of saponin on the surface properties of quinoa proteins. Quinoa seeds were cleaned, ground, and defatted using hexane. Removal of saponins increased water hydration capacity and lowered the fat binding capacity. The emulsion capacity was also reduced in the desaponized protein although emulsion the stability increased markedly. A slight decrease in buffer capacity was observed which was attributed to the removal of saponins. The foaming capacity and foam stability were affected in the similar manner to that of the emulsifying properties. The removal of saponins also lowered the total nitrogen solubility of quinoa proteins

Chauhan *et al*., (2001) conducted a study on Comparison of raw, Nutrients and antinutrients in quinoa seed and study reported that 40-45% of the saponins were present in the hulls.

Nanqun *et al*., (2002) triterpene saponins from debittered quinoa (*Chenopodium quinoa*) seeds twelve triterpene saponins have been isolated from the debittered seeds of quinoa (*Chenopodium quinoa*), and their structures were characterized on the basis of hydrolysis and spectral data. Among them, three compounds, including 3-O-β-D-glucuropyranosyl oleanolic acid, 3-O-β-D-glucopyranosyl-(1→3)-α-L-arabinopyranosyl hederagenin, and the new compound 3-O-β-D-glucopyranosyl-(1→3)-α-L-arabinopyranosyl-30-O-methyl spergulagenate 28-O-β-D-glucopyranosyl ester (3), are identified for the first time from quinoa seeds.

SuChuen et al., (2007) The oxidative stability of lipids in processed quinoa was investigated in this study. Free fatty acids, conjugated diene hydroperoxides, and hexanal were used as indicators of lipid oxidation. The results from these tests suggest that quinoa lipids are stable for the period of time studied. With vitamin E as a naturally antioxidant occurring abundantly in quinoa, the potential for quinoa to be a new oilseed could be enhanced. This study provided some preliminary information on the oxidative stability of quinoa.

Ogungbenle (2009) conducted a study on Nutritional evaluation and functional properties of quinoa (Chenopodium quinoa) flour, proximate analysis, evaluation of nutritionally valuable minerals, sugars, chemical properties of the oil and functional properties of the seed flour of quinoa (*Chenopodium quinoa*) were studied. The results showed that the quinoa flour contained 11.2% moisture, 13.5% crude protein,

6.3% ether extract, 9.5% crude fibre, 1.2% total ash and 58.3% carbohydrate. The quinoa has a high proportion of D-xylose (120.0 mg in 100 g sample) and maltose (101.0 mg in 100 g sample), and a low content of glucose (19.0 mg in 100 g sample) and fructose (19.6 mg in 100 g sample), suggesting that it would be useful in malted drink formulations. The values for the chemical properties of the oil extracted were: acid value, 0.50%; iodine value, 54.0%; peroxide value, 2.44%; and saponification value, 192.0%.

Alvarez *et al.,* (2010) mentioned that quinoa had a high content of protein (13.1%) all essential amino acids were found to be present in quinoa and the amino acid pattern was close to the requirements. Specifically, quinoa proteins were high in lysine (4.8 g/100 g protein) and threonine (3.7 g/100 g protein), which were in general the limiting amino acids in conventional cereals but lower contents in leucine (6.0 g/100 g protein) and valine (3.7 g/100 g protein).

These results reported by Valencia and Serna (2011) who found that quinoa seeds flour had moisture, protein and fat contents equaled10.08, 13.96 and 4.69%, respectively. Also, the data obtained are in agreement with that reported by Vidueiros *et al.,* (2015).

Yamani and Suzana (2012) conducted a study on the use of quinoa (Chenopodium quinoa Willd.) and amaranth (Amaranthus spp.) and the result revealed that the grain in addition to being one of the important energy sources due to their starch content, these pseudocereals provide good quality protein, dietary fibre and lipids rich in unsaturated fatty acids. Also contain adequate levels of minerals, vitamins, and significant amounts of other bioactive components such as saponins, phytosterols, squalene, fagopyritols and polyphenols. Amaranth and quinoa are also gluten-free grains. This composition and nutritional facts describes their potential for functional properties and for human health, particularly for certain consumers such as the elderly, children, high-performance athletes, diabetics, celiac, and people who are gluten or lactose intolerant among others.

Taverna *et al.,* (2012) this study aimed to evaluate the effect of extrusion temperature, screw speed, moisture, and amount of quinoa flour on the physical properties of puffed snacks. Effects of moisture and amount of quinoa flour on the expansion index and specific volume of snacks were observed. There was a

pronounced increase in water solubility index of blends with the extrusion process with significant effects of all process parameters on the WSI. Higher absorption index (WAI) was observed under high temperature, low moisture, and lower quinoa flour amount. Temperature and amount of quinoa flour influenced the color of the snacks. A positive quadratic effect of quinoa flour on hardness of products was observed. Blends of sour cassava starch and quinoa flour have good potential for use as raw material in production of extruded snacks with good physical properties.

Gonzalez et al., (2012) This study analyses how much growing region and/or seasonal climate might affect grain yield and nutritional quality of quinoa seeds. Seeds of ten quinoa cultivars were analysed for seed yield, protein content and amino acid composition. Protein contents ranged from 91.5 to 155.3 and from 96.2 to 154.6 g kg(-1) dry mass for Encalillaand Bolivia/Argentina seeds respectively, while essential amino acid concentrations ranged from 179.9 to 357.2 and from 233.7 to 374.5 g kg(-1) protein respectively. Significant positive correlations were found between the content of essential amino acids and protein percentage. Essential amino acid composition was more affected than grain yield and protein level. The study revealed that both environmental and climatic factors influence the nutritional composition of quinoa cultivars growing in different agroecological regions.

A study done by Gesinski and Nowak (2011) with an objective to analysis of amino acid content in protein and the yield of aminoacids from seeds of *Chenopodium quinoa* and *Chenopodium album*. Seeds of both *Chenopodium*species were characterized by beneficial amino acid composition, especially by the lysine content. Biological value of the protein of *Chenopodium quinoa* measured with the essential amino acid index (EAAI) was higher than the protein value of *Chenopodium album*. However, *Chenopodium quinoa* significantly exceeded *Chenopodium album* with yield of both exogenous and endogenous amino acids as well as with the yield of all amino acids.

Quinoa has exceptional nutritional properties, with high protein content in comparison to cereals, which is combined with a good balance of essential amino acids (Vega-Galvez et al., 2010; Maureira and Martínez, 2012; Miranda et al., 2012; Lutz et al., 2013).

Quinoa seeds present a rich source of a variety of minerals, vitamins and higher contents of most essential amino acids, especially lysine which reveals its potential for a valuable ingredient in the preparation of highly nutritious food and also its nutraceutical properties. The high genetic variability and premises properties of quinoa make it potential to be grown worldwide, even it has been declared "The International Year of the Quinoa" (IYQ) by the United Nations in the year 2013.

Nascimento *et al.,* (2014) showed that quinoa flour consisted of 2.01% ash, 12.10% protein, 6.31% fat, 10.4% fiber and 57.2% starch.

Elsohaimy *et al.,* (2015) with an objective to investigate Physicochemical and functional properties of quinoa protein isolate. Result revealed that the Quinoa protein had reasonable concentrations of essential amino acids (except tryptophan) with a highlevel of lysine (17.13%). Quinoa protein showed ahigh In Vitro digestibility (78.37 ± 1.08%).

According to Sharma *et al.* (2015) The quinoa grain protein is rich in amino acids like lysine and methionine that are deficient in cereal proteins. The grain is used to make flour, soup, breakfast, cereal and alcohol, while the flour is utilized in making biscuits, bread and processed food. It is also been found to contain minor compounds like phytosterols and flavonoids with possible nutraceutical benefits. Quinoa starch has some functional (technological) properties like solubility, good water-holding capacity, gelation, emulsifying, and foaming that allow diversified uses. Besides, it has been considered an oil crop, with an interesting proportion of omega-6 and notable vitamin-E content. Quinoa starch has physico-chemical properties (such as viscosity, freeze stability).

Bastidas *et al.,* (2016) conducted a study on Quinoa potential and health benefits and exceptional nutritional value: a high concentration of protein (all essential amino acids highly bioavailable), unsaturated fatty acids, a low glycemic index; vitamins, minerals and other beneficial compounds, it is also gluten-free; furthermore, quinoa is a sustainable food, as plants exhibit a carbon and water food print that is between 30 and 60 times lower than that of beef. Quinoa is easy to cook, has versatility in preparation, and could be cultivated in different environments.

Verena and Juanduu (2016) conducted a study on nutritional composition of quinoa. In general, high variations in nutrient contents of quinoa were observed per

100 g edible portion on fresh weight basis, for example: protein (9.1–15.7 g), total fat (4.0–7.6 g) and dietary fiber (8.8–14.1 g). The results show the nutritional potential of quinoa but they also demonstrate that more high-quality analytical data of quinoa are needed, especially for minerals and vitamins.

Nowak *et al.,* (2016) conducted a study on quinoa and variations in nutrient contents of quinoa were observed per 100 g edible portion on fresh weight basis, protein (9.1–15.7 g), total fat (4.0–7.6 g) and dietary fiber (8.8–14.1 g).

Ghada *et al.,* (2017) carried out to evaluate the physical, chemical, nutritional and functional properties of quinoa seeds flour and results revealed that the chemical composition obtained data indicated that quinoa seeds flour contained 13.55, 7.30, 2.69, 3.45 and 63.56% for crude protein, crude fibers, ash, fat and total carbohydrates, respectively. Amino acids compositions of quinoa flour had a well-balanced amino acids composition especially lysine (4.67g/100gprotein).Also, quinoa seed flour oil was rich in unsaturated fatty acids, with unsaturated to saturated ratio observed from quinoa was86.9:13.1.

Ghada *et al.,* (2017) results shows the minerals content of quinoa seeds flour. It has been observed that the main minerals were potassium, phosphorus, and magnesium, their values were 8819.73, 4112.83and 1987.23 mg/kg, respectively. Also, quinoa had a high content of calcium (928.73 mg/kg), iron (149.407mg/kg), and zinc (62.55mg/kg). On the other hand, sodium, manganese and cupper were found to be154.38, 18.483 and 55.97mg/kg, respectively. From these results, potassium was found to be the most abundant mineral, while copper was the least abundant. These results are in close agreement with the observation reported by Palombini *et al.* (2013) and Gordillo-Bastidas *et al.* (2016).

Diego *et al.,* (2018) conducted a study on Developing processes to decrease or modify the bitterness of quinoa can enhance palatability, and thus consumption, of quinoa. In addition to the production of sweet varieties of quinoa, other processes have been proposed. Washing, pearling and the combination of the two have a direct effect on saponins, either by solubilization and/or the mechanical removal of seed layers. Others, such as fermentation or germination, are able to mask the bitterness with aroma compounds and/or sugar formation.

2.4: Effect of Processing on nutritional quality

Sharma and Sehgal (1992) studied the Effect of processing and cooking on the antinutritional factors of faba bean (Vicia faba) were subjected to various processing and cooking treatments such as soaking, dehulling, ordinary cooking, autoclaving and sprouting. Soaked and dehulled seeds showed significant reductions in phytic acid (4%) and saponin (26 to 29%) contents of both the varieties, whereas lectins could not be eliminated, though they were observed in the soaking water. Loss of antinutrients was at a maximum when soaked and dehulled seeds were autoclaved for 25 min. Antinutrient concentrations declined during germination; the longer the period of germination the greater was the reduction.

Ruiz *et al.,* (1996) studied Effect of soaking and cooking on the saponin content and composition of chickpeas (Cicer arietinum) and lentils (Lens culinaris) and result shows that Changes in the saponin content and composition of both chickpeas (Cicer arietinum) and lentils (Lens culinaris) were investigated after the seeds were soaked in distilled water, citric acid, and sodium bicarbonate solutions. The effect of cooking for 30, 60, 90, and 120 min after the seeds were presoaked in distilled water was also studied. An overall loss of saponin content was found for lentil (15-31% loss), but none was observed for chickpea.

Traditional food processing usually involves the use of endogenous enzymes activated by germination or produced by microorganisms during fermentation. The use of exogenous enzymes from plants, animals or microbes to improve existing reactions or initiate new reactions is more recent. A number of enzymes such as amylases, celluloses, and hemicelluloses are used in the processing of cereals such as wheat, rye, barley, etc. in the manufacture of breads and beers to improve the texture, volume, viscosity, water holding capacity, shelf life etc. (Tucker, 1996).

Azizah and Zainon (1997) studied the effects of soaking, boiling and roasting on TDF (total dietary fiber), SDF (soluble dietary fiber) and IDF (insoluble dietary fiber) of legumes (mung bean, soya bean, ground nut) and cereals (rice, wheat, and barley). Results indicated that thermal processing gave different effects on TDF, IDE and SDF when analyzed using enzymatic-gravimetric methods. The changes in IDE content may explain the observed changes in TDF since SDF of most samples remained the same. In samples with high protein both SDF and IDE increases with

thermal treatments, and this could be attributed to the production of Maillard reaction products.

Ayet *et al.,* (1999) conducted a study on Effect of Germination, under Different Environmental Conditions, on Saponins, Phytic Acid and Tannins in Lentils (Lens culinaris) and result revealed that, Germinated seeds at day 6 contained higher levels soyasapogenol B than the controls, whereas in general the tannin content was reduced. Total phytic acid amounts did not decrease after 3 days of germination but was greatly reduced after 6 days. This work shows that the optimal conditions to reduce some antinutritional factors (tannins and phytic acid) in lentils were 6 days of seed germination in dark and with alternate watering. Therefore, germination conditions offer a good opportunity to improve the nutritional quality of lentils.

Kaur & Kawatra (2000) studied the impact of soaking, sprouting, roasting, open pan cooking and pressure cooking on the ricebean raffinose and stachyose content. All processing methods led to significant reductions in the flatus producing sugars, and combinations of the methods reduced them further. The best results were obtained by sprouting and pressure cooking combined, which reduced the raffinose content from 1.48 to 0.29 g/100g dry matter (DM), and the stachyose content from 3.29 to 0.68 g/100g DM.

Saharan *et al.,* (2001) studied the effects of cooking methods on Ca, Fe and P. Soaking and sprouting reduced the content of these minerals slightly, probably due to leaching into the soaking medium. However, inexpensive and simple treatments had significant positive impact on the *in vitro* availability of the minerals, most likely due to a reduction in anti-nutrients such as phytic acid. The authors concluded that this type of processing should be recommended in projects advocating ricebean and similar foods. The apparent decrease was observed in the content of phytic acid of legume seeds during cooking may be partly due to leaching into the cooking medium, degradation by heat or formation of insoluble complexes between phytate and other components, such as protein and minerals (Siddhuraju and Becker, 2001).

Decrease in phytic acid is very advantageous due to its influence on nutrition therefore interest has been grown to reduce its anti-nutritional effect. Phytic acid contents decreases significantly ($p<0.01$) with increase in fermentation time in pearl millet cultivars and pH decreases with increase in mineral content and HCL

extractability. Good correlation exists between anti-nutritional factors as phytic acid contents reduction and increase in extractable minerals of pearl millet cultivars with increase in fermentation time (Abdelrehman *et al*. 2005).

The highest decreases for millet were obtained after soaking of flour for 8 h (Phy/Fe: 10.8–7.7 and Phy/Zn: 20.3–15.1), and after soaking of whole seeds for 24 h for soybean (Phy/Fe: 10.4–9.4 and Phy/Zn: 23.8–19.1). Cooking of flours with water used for soaking did not increase phytate degradation. Isabelle Lestienne (2005).

Germinated wheat and barley increased significantly ($P < 0.05$) in percent Relative Nutritive Value (RNV); the increase in % RNV was highly significant ($P<0.01$) for germinated rice. The increase in available lysine was highly significant ($P<0.01$) in germinated wheat, barley, oats and rice. Natural lactic acid fermentation increased the % RNV significantly ($P<0.05$) for wheat, barley and rice and significantly for millet and maize. The available lysine content increased significantly ($P<0.05$) in fermented oats, rice, millet, and maize but for the available lysine increase was highly ($P<0.01$) significant in fermented wheat. Both germination and fermentation had equivalent effects as procedures to improve the protein quality of cereals (Hamad and Fields, 2006).

Egli *et al.,* (2006) the possibility to increase phytase activity and/or reduce the phytic acid content by soaking and germination was investigated in a wide range of grains and seeds, but not found to be effective. High apparent phytase activity was found in untreated whole grain rye, wheat, triticale, buckwheat, and barley. Their usefulness as sources of phytase in complementary food production should be further investigated.

Sangronis and Machado (2007) evaluated the effect of germination on some nutrients as well as on some antinutritional factors of white beans (*Phaseolus vulgaris L.*), black beans (*Phaseolus vulgaris L.*) and pigeon beans (*Cajanus cajan L. Mill sp*.) and found that the reduction of phytic acid was more than 40% for the three grains germinated and these variations in the content of nutrients and antinutrients of the germinated grains are attributed to the joint effect of the germination and previous soaking.

Germination is a natural biological process of all superior plants by which the seed comes out of its latency stage. The process of germination has been developed in some countries as an alternative to defeat some of disadvantages associated with untreated grains, such as undesirable tables and smells, as well as the presence of trypsin inhibitors and phytates (Sangronis and Machado, 2007).

Mohamed *et al*. (2007) studied the effect of processing followed by fermentation on Antinutritional factors content of pearl millet (*Pennisetum glaucum* L.) cultivars. Results obtained showed that phytic acid content was 987.19 and 952.51 mg/100g for Gazira and Gadarif cultivars, respectively. Processing treatments were observed to decrease phytate content significantly (P = 0.05) for both cultivars with a maximum reduction observed when the grains of the cultivars were germinated. Polyphenols and tannin were also decreased significantly after processing of both cultivars. Further reduction in anti-nutritional factors was obtained when the processed grains were fermented for 12 and 24 hrs. The rate of reduction differs between the cultivars and the processing treatments.

Yasmin (2008) studied the effect of different processing methods (soaking in water or solutions of sodium bicarbonate, citric acid, soaking plus cooking, and germination) on anti-nutritional factors (phytic acid, total polyphenols, tannins, and hydrocyanic acid) of red kidney bean. The antinutritional factors were reduced significantly (P<0.001) with processing techniques.

Several methods have been generally adopted to improve the nutritional and organoleptic qualities of cereal-based foods. These include: genetic modification, amino-acid fortification, supplementation or complementation with protein- rich sources and processing techniques which include malting, milling and fermentation (Ugwu and Oranye, 2006; Mohammed *et al*., 2011).

Manrique *et al.,* (2014) studied on Changes in phenolic composition and antioxidant activity during germination of quinoa seeds (Chenopodium quinoa Willd.) In this work, quinoa seeds were subjected to germination and subsequent oven-drying at 40ºC in order to evaluate changes on phenolic compounds composition as well as on the antioxidant activity along different germination stages. Germination resulted in a 2 fold increase in antioxidant activity measured as DPPH radical scavenging activity, after 3 days of germination. At the same time, the amounts of HPLC

identified phenolic acids and flavonoids increased 8.57 fold, and 4.4 fold respectively. Germination and subsequent oven-drying was shown to be a good process to improve the phenolic content and antioxidant activity of quinoa seeds, and thereby obtain an ingredient to be used in functional food formulations.

Germination of legume seeds is one of the processing methods to increase nutritive value and health promoting qualities. By this simple and inexpensive method different seeds have been germinated for human consumption. These include legumes like (soybean, lentils, and beans), cereals (rye, wheat, barley and oats) and seeds of some vegetables. Germination has been suggested as an effective treatment to remove anti-nutritional factors from legumes and mobilizing secondary metabolites (Kaur *et al.,* 2015). Therefore germination is cheap and more effective in improving nutritional value, it is hoped that this can contribute to nutrition of infants.

Germination and subsequent oven-drying increases antioxidant activity of quinoa seeds, by 2 folds Germination followed by subsequent oven drying increases flavonoid content of quinoa to 4.4 folds (Carciochi *et al*., 2014).

The presence of anti-nutritional factors limits the digestibility of proteins and carbohydrates by inhibiting their respective proteolytic and amylolytic enzymes (Yagoub, 2003; Mohammed *et al.,* 2011).

Narsih and Harijono (2012) revealed that the time of soaking and germination improves the nutritional value of sorghum. Soaking for 24 and germination for 36 h produced sorghum with higher nutritional values having characteristics such as protein digestibility (85.18%), non-protein nitrogen (0.28%), protein content (8.03%), fat content (1.64%), fiber (1.45%) and ash (2.24%).

Available calcium was significantly increased in amaranth and quinoa seeds starting from the second day of germination; a percentage increase in calcium content was generated by germination in the order of 169.1% in amaranth and 24.75% in quinoa, whereas in pigeon pea and soybean the available calcium content diminished with germination. Diana *et al*., (2011)

Issis *et al.,* (2012) conducted a study on Kinetic Approach To Saponin Extraction During Washing Of Quinoa (*Chenopodium Quinoa*). The aim of this work was to show that the leaching process of saponins from quinoa (*Chenopodium quinoa* 10 × 0.15) ± min at 20, 30, 40, 50 and 60C. It was found that residual

saponin concentration in the quinoa seeds decreased as washing temperature increased.

Outi *et al.,* (2013) conducted a study on Germination of Oat and Quinoa and Evaluation of the Malts as Gluten Free Baking Ingredients. In this study, oat and quinoa malts were produced and incorporated in a rice and potato based gluten free formulation. Germination of oat led to a drastic increase of α-amylase activity from 0.3 to 48 U/g, and minor increases in proteolytic and lipolytic activities. Little change was observed in quinoa except a decrease in proteolytic activity from 9.6 to 6.9 U/g. Oat malt addition decreased batter viscosities at both proofing temperature and during heating. These changes led to a decrease in bread density from 0.59 to 0.5 g/ml and the formation of a more open crumb, but overdosing of oat malt deteriorated the product as a result of excessive amylolysis during baking. Quinoa malt had no significant effect on the baking properties due to low α-amylase activity.

Germinated grains are better in nutritional quality on account of a higher protein and starch digestibility, higher bioavailable minerals, B-complex vitamins, and ascorbic acid and inactivation of many anti-nutritional factors (Luo and Xie 2014).

Yuwei Luo and Weihua Xie (2014) the changes in phytate, phytase activity and in vitro availability of iron and zinc during soaking and sprouting of green and white faba bean (Vicia faba L.) were investigated. Faba bean were soaked for 24 h and germinated for 72 h after soaking for 24 h to reduce phytate content and increase iron and zinc in vitro availability. The results revealed that iron and zinc content was significantly reduced from 28.2 to 39.8 % and 12.5 to 27.6 % for soaking treatment and 38.2 to 38.9 % and 24.5 to 29.2 % for sprouting treatment, respectively. Phytate content was significantly reduced from 26.9 to 32.5 % for soaking treatment and 28.0 to 34.9 % for sprouting treatment, respectively. The results proved that the main distinct point is the change of phytase activity as well as specific activity during different treatment which showed no significant differences between the green and white faba bean. The in vitro availability of iron and zinc were significantly improved as a result of soaking and sprouting treatments.

You *et al.,* (2015) saw the effect of different germination conditions on antioxidative properties and bioactive compounds of germinated brown rice This study investigates antioxidative activity and bioactive compounds of ungerminated

brown rice (UBR) and germinated brown rice (GBR). The conditions for inducing germination are soaking time in water 24, 48, or 72 h; temperature 26 or 36°C; incubation in light or darkness; and open or closed vessels, in which the antioxidative activities and bioactive compounds of GBR were determined. We found that, in order to maximize antioxidative activity and bioactive compounds, germination should be under higher temperature (36°C), long soaking time (72 h), darkness, and closed vessel. GBR contains much higher levels of antioxidative activity and bioactive compounds than ungerminated brown rice (UBR).

Intelli *et al.,* (2016) Total antioxidant activity, Vitamin C and total polyphenols were determined for the first time in Indian *Chenopodium quinoa* seeds. The raw seeds were subjected to domestic processing method by soaking and germination to see the effect on antioxidant activity, Vitamin C and total polyphenols as compared to the industrially processed seeds. Antioxidant activities were determined by DPPH and FRAP method. Total phenolic content and flavonoid was determined colorimetrically and vitamin C by N- bromosuccinimide (NBS) method. The results show that domestically processed seeds have higher vitamin C, total phenolic content (TPC), total flavonoid content (TFC) and antioxidant activity as compared to the raw and industrially processed seeds. Antioxidant activity was found significantly correlated to the total phenolic content in raw, domestically processed and industrially processed seeds. The results suggest use of domestic processing of quinoa seeds to retain nutrient value and also infer dietary importance of Indian *Chenopodium quinoa*.

Carciochi *et al.,* (2016) carried out a study on Effect of Germination and Fermentation Process on the Antioxidant Compounds of Quinoa Seeds In this work, the effect of germination time and fermentation on the levels of antioxidant compounds (ascorbic acid, tocopherol isomers and phenolic compounds) and antioxidant activity of quinoa seeds was evaluated. Ascorbic acid and total tocopherols were significantly increased ($p \leq 0.05$) after 72 h of germination process in comparison with raw quinoa seeds, whilst fermentation caused a decrease in both types of compounds. Phenolic compounds and antioxidant capacity were improved using both bioprocesses, being this effect more noticeable for germination process (101 % of increase after three days of germination). Germination and fermentation

proved to be desirable procedures for producing enriched ingredients with health-promoting antioxidant compounds in a natural way.

Handa *et al.,* (2017) the physicochemical and functional characteristics were significantly affected by both soaking and germination, whereas, germination done in light and dark conditions, exerted significant effect on the ascorbic acid content, total protein, total phenols, antioxidant activity and tannin content only. Based on the quality attributes, it was found that treatment having 18 h soaking and 48 h germination in the presence of light was the best where maximum decrease in the anti-nutritional factors was observed. Moreover, there was an increase in ascorbic acid, total protein content and a decrease in the anti-nutritional factors such as oxalate and tannin content. Thus, it is concluded that 18 h soaking and 48 h germination in the presence of light can be considered as the optimum conditions to increase the nutritional content of horsegram flour.

Morteza and Jamuna (2017) The study aimed at investigating the effect of germinating green gram (Vigna radiata, Green Gram) in mineral fortified soak water on total and bioaccessible nutrients and bioactive components in whole and dehulled GG. Whole GG was soaked in water fortified with iron (100 or 200 mg/100 ml) or zinc (50 or 100 mg/100 ml), germinated and a portion was dehulled. GG germinated in water served as controls. Protein and calcium content did not differ significantly. In vitro digestible starch and protein was higher in dehulled grains. A remarkable increase in bioaccessible iron and zinc was seen in grains germinated in mineral fortified water, the increase was more at lower level of fortification of levels for both minerals. Both total and bioaccessible bioactive components, total phenols, tannins and flavonoids were significantly lesser in grains germinated in fortified water. Germinating pulses in fortified water can be used as a pre-processing technology for fortification of minerals.

2.5: Characteristics of quinoa flour & its products

Coulter and Lorenz (1990) the performance of quinoa-wheat flour blends (5/95, 10/90, 20/80, 30/70) were evaluated in breads, cakes and cookies. Breads baked with 5% and 10% quinoa flour were of good quality. Loaf volume decreased, crumb grain became more open and the texture slightly harsh at higher usage levels of quinoa flour. A bitter after taste was noted at the 30% level. Cake quality was

acceptable with 5% and 10% of quinoa flour. Cake grain became more open and the texture less silky as the level of quinoa substitution increased. Cake taste improved with either 5% or 10% quinoa flour in the blend. Flavor improved up to 20% quinoa flour in the blend. Cookie spread and cookie appearance was improved with a quinoa/low-spread flour blend by using 2% lecithin.

Dogan and Karwe (2003) analyse the effect of temperature, screw speed, and feed moisture content on physicochemical properties of quinoa extrudates. The best product, characterised by maximum expansion, minimum density, high degree of gelatinization and low water solubility index, was obtained at 16% feed moisture content, 130C die temperature, and 375 rpm screw speed, which corresponds to high SME input. It was demonstrated that the pseudo-cereal quinoa can be used to make novel, healthy, extruded, snack-type food products.

Dough physical properties and baking quality of wheat flour substituted by 10% with non germinated quinoa flour (control), 24-h, 48-h and 72-h germinated quinoa flours were studied. The 10% substitution of germinated quinoa flour for wheat flour made distinctly harder dough than that of the control. The low amount of total and inner gas generations was observed for the 48-h and 72-h samples, as compared with those of the control and 24-h germinated quinoa samples. The volume of bread made from 24-h germinated quinoa flour substitution for wheat flour was the largest among the germinated samples; however, no significant differences were observed between the control and 24-h samples. Park and Morita (2005)

It could be produced acceptable biscuits with 75 or 100% replacement with quinoa seeds flour. The accomplished results are in agreement with those obtained by Lee *et al.,* (2009).

Laura *et al.,* (2010) carried out a study on baking properties of the pseudocereals amaranth, quinoa and buckwheat as potential healthy and high-quality ingredients in gluten-free breads were investigated. No significant differences were obtained in the acceptability of the pseudocereal-containing gluten-free breads in comparison with the control.

Andrea *et al.,* (2013) studied about Quinoa fermentation by lactic acid bacteria (LAB) is an interesting alternative to produce new bakery products Growth and lactic acid production during slurry fermentations by Lactobacillus plantarum CRL 778

were greater in quinoa (9.8 log cfu/mL, 23.1 g/L) than in wheat (8.9 log cfu/mL, 13.9 g/L). Lactic fermentation indirectly stimulated flour protein hydrolysis by endogenous proteases of both slurries. However, quinoa protein hydrolysis was faster, reaching 40–100 % at 8 h of incubation, while wheat protein hydrolysis was only 0–20 %. In addition, higher amounts of peptides and free amino acids (5 g/L) were determined in quinoa compared to wheat. These promising results suggest that this LAB strain could be used in the formulation of quinoa sourdough to obtain baked goods with improved nutritional quality and shelf life, suitable for celiac patients.

According to Chase (2014) Specific gravity was calculated on the batter before baking with significant ($p<0.05$) differences existing among all batters. The 100% GF quinoa yeast bread was ($p<0.05$) smaller in volume than the other breads. Crust and crumb color did not ($p>0.05$) differ among any of the breads. The 100% GF quinoa yeast bread had the lowest water activity ($p<0.05$). Sensory analysis showed that for tenderness, flavor, and overall acceptability the 100% GF quinoa yeast bread was liked less ($p<0.05$) compared to the other breads. Based on the instrumental and sensory data collected, both the 36 and 72% QF yeast breads are acceptable GF yeast bread options containing QF.

Gearhart and Rosentrater (2014) studied Extrusion processing of amanramth and quiona. The specific objectives of this project included extruding each of the grains, then measuring extrudate properties, such as color, unit density, expansion ratio, and durability. Both the quinoa and amaranth were extruded as raw grain, as well as ground to 2mm and 1mm particle sizes. Other experimental conditions included moisture contents of 20% and 40% (d.b.), and extruder screw speeds of 50 rpm and 100 rpm. All treatments were successfully extruded, and all extrudates had high quality attributes, making this the first time either quinoa or amaranth was extruded without any binding ingredients.

A study done by Liviade *et al.,* (2015) the goal was to develop quinoa milk with increased amount of protein and low glycemic index. The product was analyzed for proximate analysis, sodium, starch, sugar, glycemic index, and consumer acceptance in comparison with commercial rice milk. Sodium content (20.3 mg/100 g) and lipids (0.2 g/100 g) were lower in comparison with other milks. Quinoa milk presented 5 g/100 g of starch and 9.7 g/100 g of glucose, but the glycemic index was low.

Sunan (2015) Quinoa has unique physicochemical and nutritional properties among diverse food grains. Quinoa flour (QF) was blended into wheat flour (WF) formulate composite flour for the production of cookie, bread and Chinese steamed bread (CSB). Physicochemical properties of quinoa–wheat composite flour (QWCF) and quality characteristics of the bakery products were characterized. Compared with products of WF, the resulting products from QWCF had reduced specific volume, and increased density, hardness and chewiness of the texture, darkness, redness, and yellowness of the color. The mold-free shelf life of bread and CSB increased as a function of QF level.

Fanny *et al.,* (2017) In order to expand the traditional uses of quinoa and to provide new, healthier and more nutritious food products, a fermented quinoa-based beverage was developed. Two quinoa varieties (Rosada de Huancayo and Pasankalla) were studied. The fermentation process, viscosity, acidity, and metabolic activity during the preparation and storage of the drink were monitored, as well as the preliminary organoleptic acceptability of the product. The drink had viable and stable microbiota during the storage time and the fermentation proved to be mostly homolactic. Both quinoa varieties were suitable as base for fermented products; Pasankalla, however, has the advantage due to higher protein content, lower saponin concentration, and lower loss of viscosity during the fermentation process.

Ghada *et al.,* (2017) carried out to evaluate the physical, chemical, nutritional and functional properties of quinoa seeds flour biscuits prepared with replacing either of 50% of quinoa seeds flour or 75% of rice had overall acceptability which was not significant ($P \leq 0.05$) different comparing with to that of control biscuits. Also, physical properties, such as volume, weight, diameter and thickness of biscuits from different blends of rice and quinoa seeds flours showed that as the level of quinoa flour increased, the volume of biscuits decreased gradually. On the other side, chemical analysis and caloric values of biscuits from different blends of rice flour and quinoa flour showed that protein, fat, ash contents of flour-replaced biscuits were higher than that of the control biscuits.

The study investigated the replacement of wheat flour with quinoa flour, its effect on physicochemical, functional, pasting, and antioxidant properties of blend flour and cookies and their comparison with control. The fiber and protein content increased from 1.20 to 3.11% and 9.12 to 11.95%. Water absorption, oil absorption,

bulk density, and foaming capacity properties of blends were significantly higher than control and showed an increase of about 10.47, 9.42, 16.63, and 28.43%, respectively. Increase in the concentration of quinoa flour improved the texture of cookies and decreased the spread ratio. The cookies remained acceptable up to the 40% incorporation of quinoa flour because of its improved texture and mouth feel. Further increase in the quinoa incorporation shifted the product to marginal acceptance category Khan *et al.,* (2018).

2.6: Therapeutic application of Quiona seed

Shela *et al.,* (2007) conducted a study with the objective of to investigate the effect of phenolic substances and proteins on the antioxidant potentials in some cereals and pseudocereals and to compare their bioability. The polyphenol dry matter extracts (PDME) from the investigated seeds of buckwheat, rice, soybean, amaranth and quinoa These results indicate that the major antioxidant components in these extracts mostly derived from the polyphenols, and proteins showed only minimal values of bioactivity. Based on high contents of polyphenols, anthocyanins, flavonoids and their antioxidant activities pseudocereals such as buckwheat, quinoa and amaranth can be a substitute for cereals for common and atherosclerotic diets and sometimes in the allergic cases.

Pawel *et al.,* (2009) Total antioxidant capacity, total phenolic contents (TP) and anthocyanins contents (ANT) were determined in Amaranthus cruentus and Chenopodium quinoa seeds and sprouts. Antioxidant activity of the investigated seeds Sprouts activity depended on the length of their growth, and the peak values were reached on the fourth day in the case of amaranth and on the sixth day in the case of quinoa. The data obtained by the three methods showed significant correlation between TP content in seeds and sprouts. In sprouts grown in the daylight and in the darkness we observed some significant changes of TP, ANT and antioxidant activity. Amaranth and quinoa seeds and sprouts can be used in food, because it is a good source of ANT and TP with high antioxidant activity.

Alvarez (2010) carried out a study on Polyphenol composition and in vitro antioxidant activity of amaranth, quinoa buckwheat and wheat as affected by sprouting and baking and study examined the polyphenol composition and antioxidant properties of methanolic extracts from amaranth, quinoa, buckwheat and

wheat, and evaluated how these properties were affected following two types of processing: sprouting and baking. The total phenol content amongst the seed extracts were significantly higher in buckwheat (323.4 mgGAE/100 g) and decreased in the following order: buckwheat > quinoa > wheat > amaranth. Total phenol content and antioxidant activity was generally found to increase with sprouting, and a decrease in levels was observed following bread making. Overall, quinoa and buckwheat seeds and sprouts represent potential rich sources of polyphenol compounds for enhancing the nutritive properties of foods such as gluten-free breads.

Antioxidant activity, antihypertensive activity and allergenicity of quinoa and amaranth were investigated and compared with those of seven cereals: buckwheat, barley, wheat, rice, foxtail millet, Japanese millet and millet. The radical scavenging activities of quinoa and amaranth were 42.3 and 22.6 mg gallic acid equivalent/g, respectively; thus, the pseudocereals have stronger radical scavenging ability than cereals. On the other hand, the antioxidant ability against linoleic acid was not very strong. Quinoa exhibited high angiotensin I converting enzyme (ACE) inhibition activity, which was equal to that of buckwheat. The ACE inhibition activity of amaranth was lower than that of quinoa, but higher than that of rice and wheat. Quinoa and amaranth did not show a positive reaction band against wheat protein antibodies. Masayo and Katsumi (2010)

Yuko *et al*., (2010) conducted a study to evaluate the nutritional advantages of quinoa seeds (*Chenopodium quinoa* Willd.) cultivated in Japan, antioxidative properties and flavonoid composition were determined and compared to corresponding data for conventionally-used cereals and pseudo-cereals, including quinoa seeds from South America. The aglycone quercetin content of the Japanese quinoa seeds is higher than in the seeds from South America and buckwheat. The amounts of quercetin and kaempferol formed via acidic hydrolysis in quinoa are much higher than those of conventionally-used edible plants. The quinoa seeds cultivated in Japan are the most effective functional foodstuff – in terms of being a source of antioxidative and bioactive flavonoids – among cereals and pseudo-cereals.

Panel *et al.,* (2010) The antioxidant activity and the relationship between total antioxidant activity and the main classes of antioxidants in the seeds of bitter and sweet *Chenopodium quinoa* seeds were measured before and after boiling, in order to establish which one showed the best antioxidant property and how a traditional

cooking method could affect it. Our results, obtained by using DPPH (1,1-diphenyl-2-picrilhydrazyl) and FRAP (Ferric Reducing/Antioxidant Power) methods, showed that antioxidant activity of bitter seeds was higher than that of sweet seeds. This activity principally depended on phenols and flavonoids in bitter seeds, while it was mainly due to phenol, flavonoid and carotenoid compounds in sweet seeds. Moreover, boiling caused a significant loss of antioxidant capacity in water.

Seeds of quinoa (*Chenopodium quinoa willd*.) are an excellent source of the free-soluble antioxidant fraction (Laus *et al*., 2012).

A study conducted by Masayo and Katsumi (2012) with an objective to analysis Antioxidant activity, antihypertensive activity and allergen city of quinoa and amaranth were investigated and compared with those of seven cereals: buckwheat, barley, wheat, rice, foxtail millet, Japanese millet and millet. The radical scavenging activities of quinoa and amaranth were 42.3 and 22.6 mg Gallic acid equivalent/g, respectively; thus, the pseudo cereals have stronger radical scavenging ability than cereals. On the other hand, the antioxidant ability against linoleic acid was not very strong. Quinoa exhibited high angiotensin I converting enzyme (ACE) inhibition activity, which was equal to that of buckwheat. The ACE inhibition activity of amaranth was lower than that of quinoa, but higher than that of rice and wheat.

Total Phenolic Content and Antioxidant Activity of Red and Yellow Quinoa (*Chenopodium quinoa Willd*.) The effects of baking and cooking processes were examined on total phenolic content (TPC), total flavonoid content (TFC) and ferric-reducing ability of plasma antioxidant activity (FRAP AA) of red and yellow quinoa seeds. Our results indicate that red quinoa seed contains significantly higher levels of TPC, TFC and FRAP AA than yellow quinoa seeds. In addition, cooked and baked quinoa seeds retain most of their TPC, TFC and FRAP AA in the final product. Thus, red quinoa seeds processed by these two methods might be considered a functional food, in addition to its traditional role of providing dietary proteins. Due to their high antioxidant activity, red quinoa seeds might also contribute significantly to the management and/or prevention of degenerative diseases associated with free radical damage according to Brend *et al.,* (2012).

Margarita *et al.,* (2014) shows result of Antimicrobial Potential and Phytochemical Content of Six Diverse Sources of Quinoa Seeds (Chenopodium

quinoa Willd.) A significant influence of quinoa source on chemical composition of seeds was observed. The TPC and TFC ranged from 3.71 to 16.55 mg GA/100 g d.m. and 7.77 to 14.37 mg QE/100 g d.m., respectively. TSC varied from 1.78 to 3.08 g/100 g d.m. A cor-relation between TFC and antimicrobial activity was found. In conclusion, the six types of quinoa seeds were identified as potential sources of antioxidant compounds and antimicrobial activity.

Abderrahim *et al.,* (2015) conducted a study on Physical features, bioactive compounds and total antioxidant capacity (TAC) of coloured quinoa varieties (Chenopodium quinoa Willd.). Results revesled that bioactive compounds, total phenolic (1.23-3.24mg gallic acid equivalents/g) and flavonol contents (0.47-2.55mg quercetin equivalents/g) were highly correlated (r=0.910). Betalains content (0.15-6.10mg/100g) was correlated with L colour parameter (r=-0.569), total phenolics (r=0.703) and flavonols content (r=0.718). Unexploited coloured quinoa seed are proposed as a valuable natural source of phenolics and betalains with high antioxidant capacity.

Tang *et al.,* (2015) conducted a cross sectional study on identified the composition of different forms of extractable phenolics and betacyanins of quinoa cultivars in white, red and black, and how they contribute to antioxidant activities. Results showed that at least 23 phenolic compounds were found in either free or conjugated forms (liberated by alkaline and/or acid hydrolysis); the majority of which were phenolic acids, mainly vanillic acid, ferulic acid and their derivatives as well as main flavonoids quercetin, kaempferol and their glycosides. Betacyanins, mainly betanin and isobetanin, were confirmed for the first time to be the pigments of the red and black quinoa seed, instead of anthocyanins. Darker quinoa seed had higher phenolic concentration and antioxidant activity.

Inglett *et al.,* (2015) Antioxidant Activities of Selective Gluten Free Ancient Grains - Ancient grains were known for special nutritional values along with gluten free qualities. Amaranth, quinoa, teff, and buckwheat flours were evaluated for pasting properties, water holding capacities, phenolic contents, and antioxidant activities (free and bound). They all had higher water holding capacities than wheat flour. Amaranth, quinoa, and teff showed higher pasting viscosities than wheat flour. The bound phenolic contents were higher than the free phenolic contents regardless of the solvents with the exception of water extraction of quinoa and buckwheat. Our

study suggested that the total phenolic contents and antioxidant activities of grains could be underestimated in the literature without considering the bound phenolic compounds. These ancient grains have nutrition, antioxidants, and textural qualities suitable for functional foods.

Tang *et al.,* (2015) The present study identified the composition of different forms of extractable phenolics and betacyanins of quinoa cultivars in white, red and black, and how they contribute to antioxidant activities. Results showed that at least 23 phenolic compounds were found in either free or conjugated forms (liberated by alkaline and/or acid hydrolysis); the majority of which were phenolic acids, mainly vanillic acid, ferulic acid and their derivatives as well as main flavonoids quercetin, kaempferol and their glycosides. Betacyanins, mainly betanin and isobetanin, were confirmed for the first time to be the pigments of the red and black quinoa seeds, instead of anthocyanins. Darker quinoa seeds had higher phenolic concentration and antioxidant activity. Findings of these phenolics, along with betacyanins in this study add new knowledge to the functional components of quinoa seeds of different cultivar background.

Bhaduri (2016) Water extract showed highest Phenol content (89.73 ± 1.74), antioxidant activity (1586 ± 41.42) and DPPH scavenging capacities (82.71 ± 0.03) compared to other solvents used for extraction. IC50 value for percentage DPPH scavenging capacities by water extract was 14.71 ± 0.02, compared to ascorbic acid (7.15 ± 0.13), which is a control. All extracts exhibit significantly high levels of flavonoid content. Ethyl acetate extract represented highest (88.41 ± 0.37) NO scavenging capacity. Lowest IC50 value (52.58 ± 0.14) for NO scavenging capacity was identified for ethanol extract compared to control (24.19 ± 3.53). Ascorbic acid used as control in both DPPH and Nitric oxide scavenging capacities measurement. Quinoa seed extracts from all six solvents found to have antimicrobial activities towards gram positive bacteria but not towards all gram negative bacteria. All extracts showed significant anti proliferative activities towards P 116 cells.

Zuzana *et al.,* (2018) The aim of this work was to evaluate the effect of cooking and germination on antioxidant activity, total polyphenols and flavonoids, fiber content, and digestibility of lentils. Lentils were assessed for basic chemical analyses (dry matter and ash content), total phenolic and flavonoid contents, antioxidant analysis (DPPH assay), crude and neutral-detergent fiber contents and in

vitro digestibility. Germination caused an increase in total phenolic and flavonoid contents, antioxidant activity, and digestibility and, contrariwise, a decrease in both crude and neutral-detergent fiber contents. Cooking resulted in the rising of digestibility and the reduction of total phenolic and flavonoid contents, antioxidant activity, and both crude and neutral-detergent fiber contents.

There is a dearth of literature exploring the effects of these crucial variables. Therefore present study is an effort to bridge the chasm existing in the field of this new crop quinoa.

METHODOLOGY

Research in common parlance refers to a search for knowledge. It is scientific and systematic search for pertinent information on a specific topic. It represents the logic behind the methods used by the researcher in the context of research study and explains the relevance of a particular method or technique adopted for the research purpose.

This chapter deals with the procedure adopted for conducting the present investigation was undertaken on Development and Quality Evaluation of Value Added Products Incorporating Quinoa Seed. An attempt has been made to provide detailed outline of the methodological plan followed under the following sub-heads:

The study was undertaken in the following phases:

3.1: PHASE 1- PROCUREMENT OF SAMPLE AND INGREDIENTS

3.2 PHASE 2- PHYSICO-CHEMICAL ANALYSIS OF QUINOA

3.2: PHASE 3- QUINOA PROCESSING

3.3: PHASE 4- DEVELOPMENT OF PRODUCTS

3.4: PHASE 5- SHELF LIFE ASSESSMENT OF DEHULLED QUINOA SEED FLOUR

3.5: PHASE 6- PREPARATION OF INFORMATION MATERIAL

3.1: PHASE 1- PROCUREMENT OF SAMPLE AND INGREDIENTS

- **Locale of the study:**

The present study was conducted at Department of Food & Nutrition, College of Community and Applied Sciences, Maharana Pratap University of Agriculture & Technology Udaipur, (Rajasthan)

- **Collection of Samples**:

Quinoa sample as whole (QW) and Dehulled (QD) were purchased from local market of Udaipur (Rajasthan) in a single lot to avoid varietal difference.

3.2 PHASE 2- PHYSICO-CHEMICAL ANALYSIS OF QUINOA

3.2.1: Physical Properties:

Dehusked Quinoa (QD) was selected for analysis of physical properties (Plate3.2).It was carried out using standard techniques.

- **Seed Size:** Length and width of 30 seeds were measured using electronic digital calipers Color and appearance was visually examined.
- **Thousand Kernel weight –** Ten gm. seeds were counted manually and replicate 30 times.
- **Weight of 100 seeds –** Hundred seeds were counted manually and weighed using weighing balance (make, least count, maximum count) and replicate 30 times.
- **Thousand Kernel volumes:** Volume of seeds was assessed through method suggested by Bishnoi and Khetrapal (1993) in triplicate. Raw sample (QD) weighing 10 g were transferred to a measuring cylinder, where 10 ml distilled water was added. Seed volume was recorded after subtracting 100 ml from the total volume (ml).
- **Seed Density:** It was determined through the method suggested by Bishnoi and Khetrapal (1993). Seeds weighing 10 g were transferred to a measuring cylinder, where 10 ml distilled water was added. Seed volume was recorded after subtracting 100 ml from the total volume (ml). Density was recorded as g per ml.
- **Bulk Density:** Bulk density was assessed using the method suggested by Okaka and Potter (1977) Fifty gram of the sample was placed in a 100 ml graduated cylinder and packed by gentle tapping of the cylinder on a bench top 20 -30 times from a height of 5-8 cm. The bulk density was calculated as weight per unit volume of sample.

$$\text{Bulk Density (g/ml)} = \frac{\text{Weight of seeds (g)}}{\text{Final volume of seeds (ml)}}$$

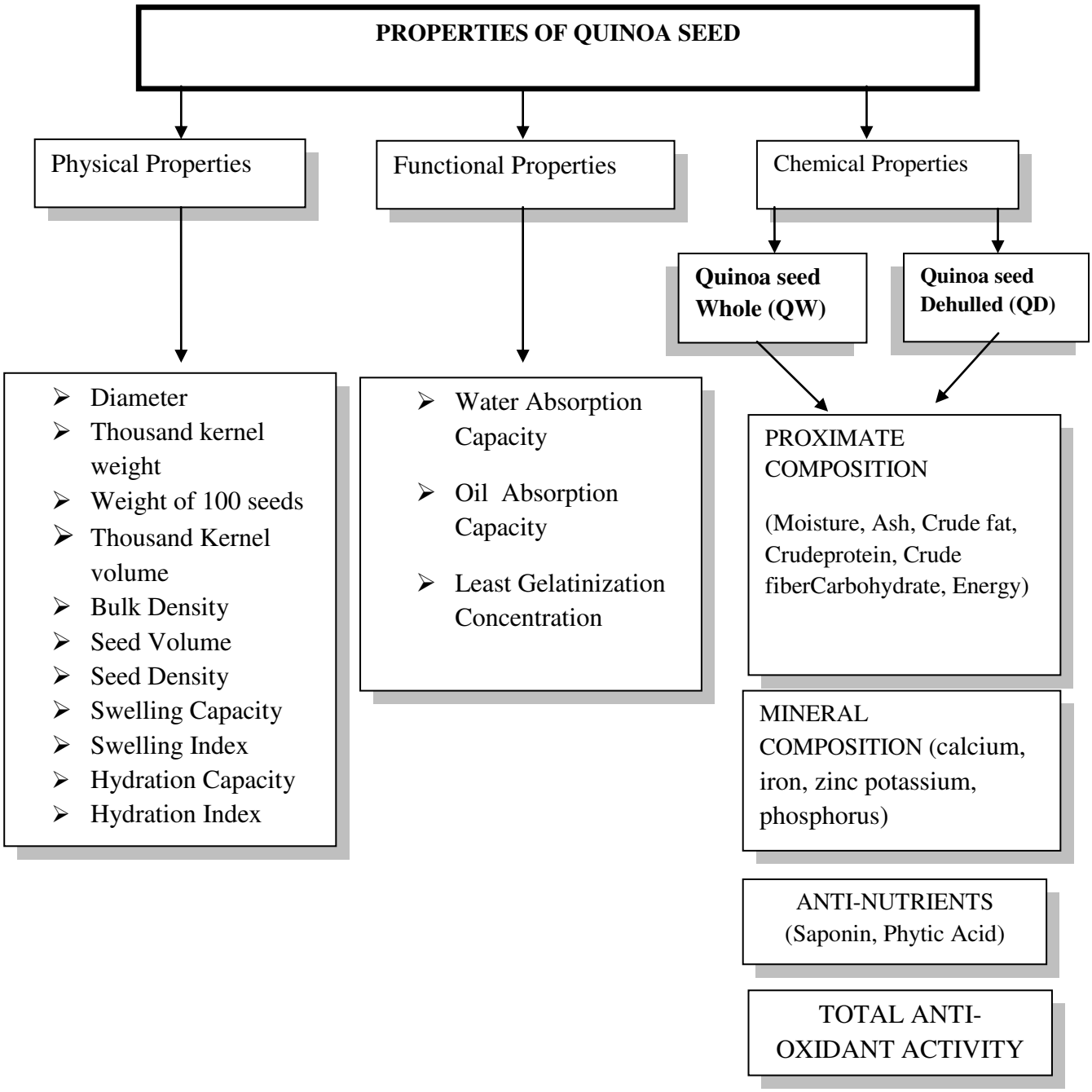


Figure 3.1: Assessment of physico-chemical and functional properties of Quinoa

Hydration capacity and Hydration Index: It was determined through the method given by Bishnoi and Khetrapal (1993). Seeds weighing 100 g were counted and transferred to a measuring cylinder and 100 ml water was added. The cylinder was covered with aluminum foil and left overnight at room temperature. Next day seeds were drained, superfluous water was removed with filter paper and swollen seeds reweighed. Hydration capacity per seed and hydration index were determined using following formulae:

$$\text{Hydration Capacity per seed} = \frac{\text{Weight of soaked seeds (g) - weight of seeds before soaking (g)}}{\text{Number of seeds}}$$

$$\text{Hydration Index} = \frac{\text{Hydration capacity per seed}}{\text{Weight of one seed (g)}}$$

- **Swelling capacity and Swelling Index:** It was assessed with the method suggested by Bishnoi and Khetrapal (1993). Seeds weighing 100 g were counted, their volume noted and soaked overnight. The volume of soaked seeds was noted in a graduated cylinder. Swelling capacity per seed and swelling index were determined using formula given below:

$$\text{Swelling Capacity per seed} = \frac{\text{Volume after soaking (ml) - volume before soaking (ml)}}{\text{Number of seeds}}$$

$$\text{Swelling Index} = \frac{\text{Swelling capacity per seed}}{\text{Volume of one seed (ml)}}$$

3.2.2: Functional Properties of Flour

- **Water and Oil Absorption Capacity :** The water and oil absorption capacity (WAC) (OAC) were determined with method suggested by Sosulski *et al* (1976).One g Quinoa seed flour (QDF) sample was mixed with 10 ml distilled water and refined soybean oil, kept at ambient temperature for 30 min and centrifuged for 10 min at 2000×g .Water and oil absorption capacity was expressed as percent water and oil bound per gram of the sample.

$$\text{WAC and OAC\%} = \frac{\text{Weight of sample after centrifugation (g) - weight of sample before centrifugation (g)}}{\text{Weight of original sample taken (g)}} \times 100$$

- **Least Gelatinization concentration (LGC) -** The least gelatinization concentration was determined using method of Coffman and Garcia (1977). The Quinoa seed flour (QDF) dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34% (w/v) prepared in 5 ml distilled water were heated at 90^0C for 1 hour in water bath. The contents were cooled under tap water and kept for 2h at 10^0C. The least gelatinization concentration was determined as that concentration when the sample from inverted tube did not slip.

3.2.3: Chemical Properties:

Nutritional components: Quinoa whole (QW), Quinoa Dehulled (QD) were analyzed for nutritional content. Nutritional evaluation of the Quinoa whole (QW), Quinoa Dehulled (QD) was done for their proximate composition and mineral estimation (calcium, iron, zinc, potassium, phosphorous). Anti-nutritional factors (Saponins and Phytates) were also analyzed (Plate 3.3). Standard procedures were used for the estimations. Percentage carbohydrate and energy contents were determined by calculation using difference method respectively. The procedures have been described as under:

Proximate composition

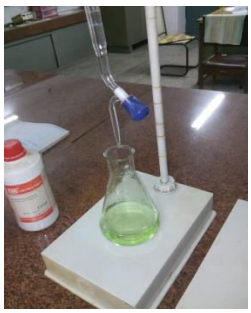
It is the determination of a group of closely related compounds together. It includes determination of amount of moisture, protein, fat (ether extract), ash and fiber with nitrogen free extract and carbohydrates being estimated by subtracting the sum of these five percentages from 100.

- **Moisture**: Moisture is the major component of food. The moisture content of any food is determined not only to analyze the chemical composition of food material on moisture free basis but also to assess the shelf life of the products.

Moisture content of samples was analyzed by the method described by NIN (1983). Ten gram sample was weighed in a dried and weighed petri dish. The weight of the sample along with the petri dish was taken at regular intervals until a constant weight was obtained. The moisture percentage was calculated using following formula:

$$\text{Moisture (g/100g)} = \frac{\text{Initial weight (g)} - \text{Final weight (g)}}{\text{Weight of the sample (g)}} \times 100$$

Crude Protein Estimation



Estimation of Crude Fat

Estimation of Ash

Crude Fiber Estimation

Preparation of Mineral Solution

Atomic absorption spectrophotometer

Saponin Estimation Estimation of Phytic Acid

Plate 3.1: Chemical analysis of Quinoa

- **Crude Protein:** The protein nitrogen is converted into ammonium sulphate by boiling with concentrated sulphuric acid. It is subsequently decomposed by the addition of excess alkali and the liberated ammonia is absorbed into boric acid solution containing an indicator by steam distillation. Ammonia forms a loose compound, ammonium borate with boric acid, which is titrated directly against standard HCl. The protein content of food stuff is obtained by estimating the nitrogen content of the material and multiplying the nitrogen content by the factor 6.25 (NIN, 1983). Kjel plus nitrogen estimation system was used to estimate the amount of nitrogen in the samples. 0.2 g moisture free sample was transferred to the digestion tube. Ten ml of concentrated sulphuric acid and 3 g catalyst mixture (5 parts of K_2SO_4 + 1 part of $CuSO_4$) was added and was left overnight. The tubes were then placed in a pre-heated digestion block. The digestion block was pre heated to 60°C for 10 minutes. Once the digestion tubes were placed, temperature was further increased to 100°C and samples were kept until the colour of the samples turned bluish green or colorless. Digested samples were taken for distillation where the ammonium radicals were converted to ammonia under excess alkali post neutralization of acid in the digested samples with 40 per cent sodium hydroxide. Mixed indicator (methyl red + methyl blue) was added to the solution and titrated with the standardized N/10 HCl. The titration value was determined and the following formula was used to estimate the amount of nitrogen liberated:

$$\text{Nitrogen (g/100g)} = \frac{14.01 \times \text{Normality of HCL(0.1)} \times (\text{TV-BV})}{\text{SW (gm)}} \times 100$$

Where, 14.01= Ammonia's molecular weight

0.1N= Titration solution (HCl) normality

TV= Titer value

BV= Blank value

SW= Sample weight

Protein%=%N×6.25 (For food samples)

The protein content of the sample was obtained by multiplying the nitrogen with a factor 6.25.

- **Crude Fat:** Fat was estimated as crude ether extract of moisture free sample by the method given by Jain and Mogra (2006). Fat content of the sample was estimated on Soxhlet Plus system, which works on the principle of improved soxhlet method. Weighed amount of moisture free sample (5 g) was placed in a thimble. The thimble was inserted in the thimble holder to be kept in an already weighed beaker and 80 ml petroleum ether (60-80˚C) was poured in the beaker. The beakers were loaded in the system and temperature was set at 100˚C. The process was left to operate for 120 minutes and the temperature was increased to the recovery temperature, which was twice the initial boiling temperature. Rinsing was thus done twice in order to collect the remaining fat in the sample. Beakers were taken out and put in a hot air oven. Thimble holders were removed from the beakers and the beakers were weighed. The amount of fat present in the sample was calculated using the following formula:

$$\text{Fat (g/100g)} \frac{\text{Weight of ether extract fat (B-A)}}{\text{Weight of sample (gm)}} \text{ x } 100$$

Where, A= Weight of empty flask (g)

B= Weight of flask+ fat (g)

B-A = Weight of fat (g)

- **Ash:** Ash was estimated by the method given by Jain and Mogra (2006). Five grams of moisture free sample was weighed in previously heated, cooled and weighed crucible. Sample was then completely charred on the hot plate, followed by heating in muffle furnace at 600^0C for 5 hours. The crucible was cooled in desiccators and weighed. The process was repeated till constant weights were obtained and the ash was almost white or greyish in color. Ash content of samples was calculated using following formula:

$$\text{Ash (g/100g)} = \frac{\text{Weight of ash (g)}}{\text{Weight of sample taken (g)}} \times 100$$

- **Crude Fibre:** Fibre is an insoluble vegetable matter indigestible by proteolytic and diastatic enzymes and cannot be utilized except by microbial fermentation. It is usually composed of cellulose, hemicelluloses and lignin. Crude fiber estimation was done as per the method given by (Jain and Mogra, 2006) 3 gram of moisture and fat free sample was placed in 500 ml beaker and boiled with 200 ml of 1.25 per cent sulphuric acid for thirty minutes. The volume was kept constant during boiling by adding hot distilled water. This was filtered through muslin cloth and the residue was washed with hot distilled water till free from acid. The residue was then transferred to same beaker and boiled for 30 minute with 200 ml of 1.25 per cent sodium hydroxide solution. After boiling, mixture was filtered through muslin cloth and the residue was washed again with hot distilled water till free from alkali followed by washing with 50 ml alcohol and ether. Then it was taken into a crucible (it was weighed before as W_1) and residue was dried in an oven at 130^0C for 2-3 hours, cooled and weighed (W_2). Heat in muffle furnace at 600^0C for 2-3 hours, then cooled and weigh again (W_3). Crude fiber was determined using following formula:

$$\text{Percent crude fibre} = \frac{W - W1) - (W3 - W1)}{\text{Weight of sample}} \times 100$$

Where, W_1= Weight of empty crucible

W_2 =Weight of crucible with dry residue

W_3 = Weight of crucible with heated residue

- **Carbohydrate:** The carbohydrate content of the sample on dry weight basis was calculated by difference method (Jain and Mogra, 2006) as given below:

Carbohydrate (g/100g) = 100 – (moisture + crude fibre + ash + protein + fat)

- **Energy:** The energy value of sample was calculated using physiological fuel value i.e. 4, 9, 4 kcal per gram of protein, fat and carbohydrate respectively.

Energy (kcal/100g) = [(% protein x 4) + (% carbohydrate x 4) + (% fat x 9)]

Mineral profile: Mineral solutions of selected samples were prepared by wet ashing method compiled by Jain and Mogra (2006). The plant material was digested with a

mixture of acids to form a clear white precipitate which was then dissolved in water and made up to a definite volume. An aliquot from this was used for determination of selected minerals.

- **Wet Ashing:** One gram moisture free sample was taken in a digestion tube and 5 ml of concentrated HNO_3 was added to it and was left overnight. It was then heated slowly for 30 minutes and cooled. Five ml of perchloric acid (70%) was added and heated over digestion block until the particles were completely digested and the solution became clear. After digestion, volume of digested matter was made up to 50 ml with double distilled water. Prepared mineral solution was stored in makeup bottles and mineral analysis was done by atomic absorption spectrophotometer (AAS4141)

Anti- nutritional factors: The nutritional quality and digestibility of plant nutrients is affected by the presence of anti nutritional factors. The presence of these anti-nutrients was analyzed in selected quinoa varieties.

- **Phytate:** Phytic acid content of the samples was estimated using the method compiled by Jain and Mogra (2006). One gram of moisture free finely ground sample was taken in a conical flask and added 50 ml HCl. The mixture was shaken in a shaker for 3 hours and filtered. The clear filtrate thus obtained was reduced to 25 ml over water bath. The filtrate was neutralized adding required amount of sodium hydroxide. Ten ml of 0.01 per cent ferric chloride was then added and the mixture heated over water bath for 15 minutes, cooled to room temperature and filtered again using a pre-weighed filter paper. The residue was washed with ethanol and then ether. The filter paper was dried and weighed.

$$\text{Phytin Phosphorus (g)} = \frac{\text{Weight of ferric phytin (B-A)}}{\text{Weight of sample (g)}} \times 100$$

Where, A= Weight of filter paper (g)

B= Weight of filter paper with ferric phytin (g)

- **Saponin:** A 5gm of sample was dispended in 100 ml of 20% ethanol. The suspension was heated over a hot water bath maintained at about 50^0C and

stirred with a magnetic stirrer for 4 hour. The mixture was centrifuged and the residue re-extracted with another 100ml of 20% ethanol. The combined extracts were reduced to 40ml over water bath at about 90^0C. The concentrate was transferred into a 250ml separator funnel and 20ml of diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer discarded. The purification process was repeated. A 60ml of n-butanol was added. The combined n-butanol extracts were washed twice with 10ml of 5% aqueous sodium chloride. The remaining solution was evaporated to almost dryness on a water bath. The last traces of moisture were removed by drying in an oven (85^0C) to almost constant weight. The difference in weight represents the saponin content. Obadoni, and Ochuko (2002)

Total Antioxidant activity

Principle: The main characteristic of an antioxidant is its ability to trap free radicals. Highly reactive free radicals and oxygen species are present in biological systems from a wide variety of sources. These free radicals may oxidize nucleic acids, proteins, lipids or DNA and can initiate degenerative disease. Antioxidant compounds like phenolic acids, polyphenols and flavonoids scavenge free radicals such as peroxide, hydroperoxide or lipid peroxyl and thus inhibit the oxidative mechanisms that lead to degenerative diseases. Various antioxidant activity methods have been used to monitor and compare the antioxidant activity of foods. These analytical methods measure the radical scavenging activity of antioxidants against free radicals like the 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical.

Reagents Required: The reagents used for the study were 2,2- diphenyl-1-picryl-hydrazyl(DPPH), methanol, obtained from Merck or sigma. All reagents used were of analytical grade.

Extraction Method: The dried powder of sample was extracted individually by cold percolation method (Parekh and Chanda, 2007) using methanol to determine the antioxidant activity. Ten g. of dried powder was taken with 100ml of methanol in a conical flask, plugged with cotton wool and then kept on a rotary shaker at 120rpm for 24 hrs. After 24 hrs the extract was filtered with eight layers of muslin cloth; centrifuged at 5000 rpm for 10 min. Supernatant was collected and the solvent was evaporated and the dry extract was stored at 4^0C in air tight bottles.

Procedure: The reaction mixture consisted of DPPH in methanol (0.3mM, 1 ml) 1 ml methanol and the solvent extracts (1ml) was incubated for 30 min. in dark, after triplicate and expressed in mean average. Control solution was also prepared and zero was set using solvent methanol. The free radical scavenging activity was calculated according to the following equation:

$$\text{Scavenging (percent)} = \frac{(A0-A1)*100}{A0}$$

Where, A0 – Absorbance of the control

A1 – Absorbance of sample

The DPPH scavenging activity was determined using the method followed by Ranilla *et al.* with slight modifications. Summarily, 250 µL of quinoa beverage was added to 4ml of 60 µM DPPH solution prepared in 95% ethanol. The reaction mixture was placed in a dark environment for about 20 minutes and absorbance was read at 517 nm. For comparison, 250 µL of 95% ethanol was used as control. Percentage inhibition was calculated according to the formula:

$$\%\ \text{inhibition} = \frac{DPPH_{control}\ DPPH_{test\ sampple}}{DPPH_{control}} * 100$$

3.3: PHASE 3- QUINOA PROCESSING:

It was done in three stages (Figure 3.2)

I. Selection of suitable processing techniques

II. Chemical analysis of processed Quinoa seed

3.3.1: Selection of Processing: Processing techniques as soaking, cooking, germination and fermentation have been found to reduce significantly the level of saponin and phytate by exogenous and endogenous enzyme formed during processing. Germination is accompanied by various metabolic reactions in the seed, which lead to alteration of its chemical composition as compared to raw seed. Among the micromolecules, amino acids play an important role in various growth and metabolic activities in seeds. Sibian *et al.,* (2017)

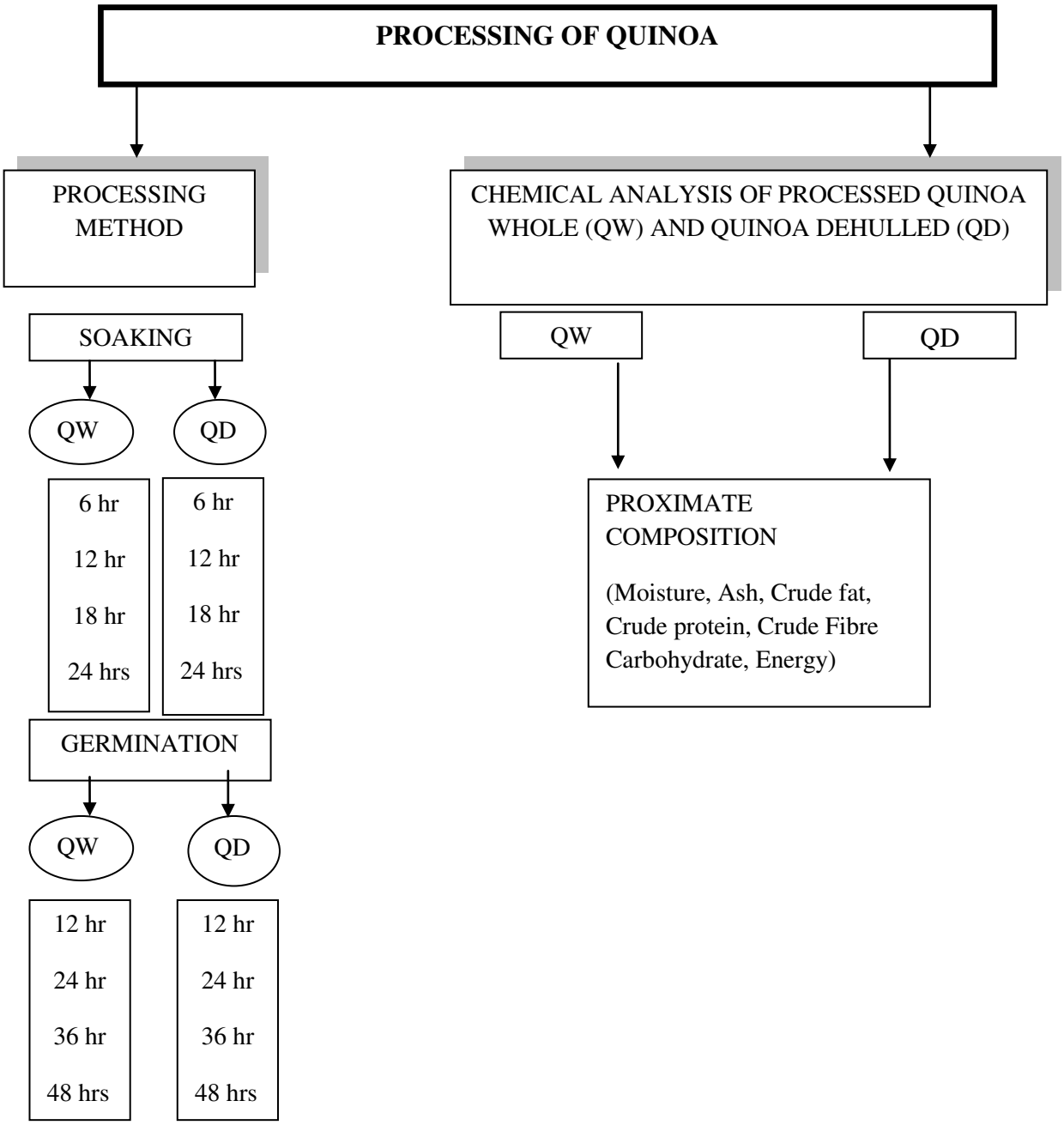


Figure 3.2 : Processing of Quinoa seed

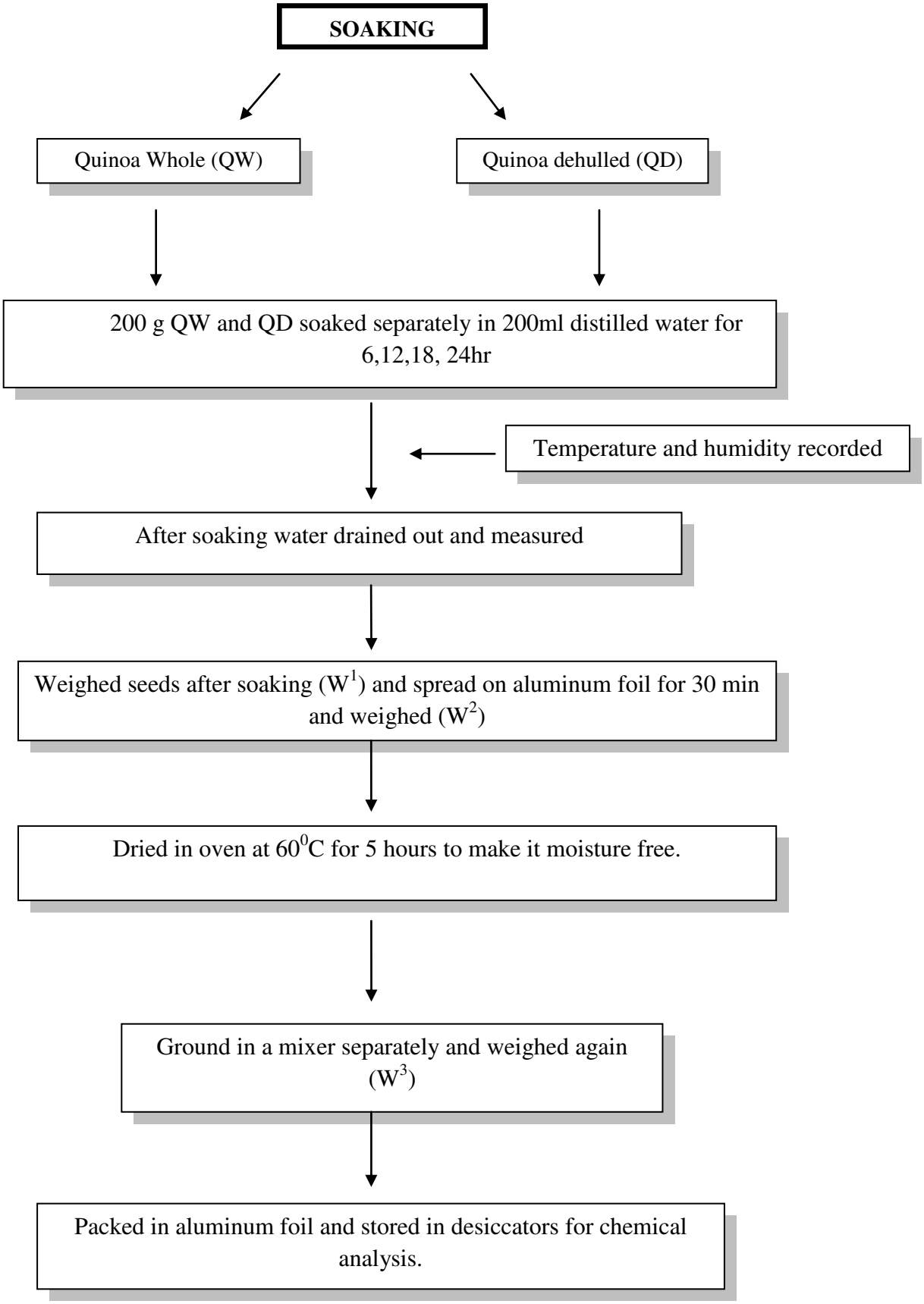


Figure 3.3: Unit operations of soaking process

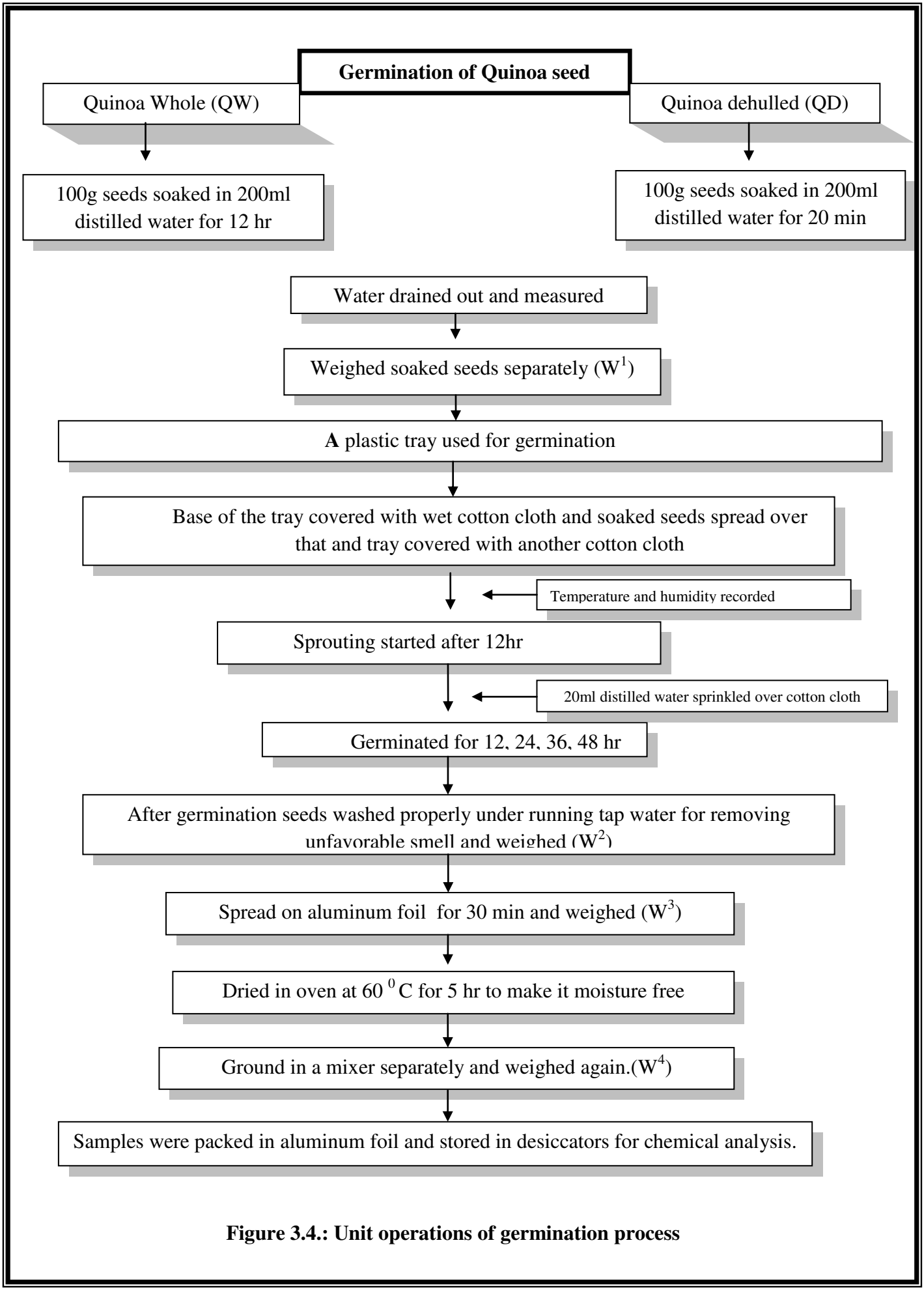


Figure 3.4.: Unit operations of germination process

During processing of quinoa for human consumption, a washing process is necessary to remove most of the bitter saponins found in the seeds, as this type of saponin is considered to be a serious antinutritional factor. The processing method soaking and germination were selected for standardization as both methods improve the nutritional quality and reduce saponin and phytic acid content of grain. Various trials were done for standardization of processing steps.

3:3:2 Standardization of processing method- Quinoa seed whole (QW) and Quinoa seed dehulled (QD) were trialed for different time period of soaking and germination. The brief summary of trials in Table 3.1-3.3 and described below:

Table 3.1: Summary of trials for soaking of Quinoa seed whole (QW) and Quinoa seed Dehulled (QD)

Treatment	Time(hr)	Observation
Quinoa seed whole Soaking	6	No change in appearance of seeds
	12	Seed swollen
	18	Seed swollen and unfavourable smell
	24	Unfavorable smell occurred
Quinoa seed Dehulled Soaking	6	No change in appearance of seeds
	12	Seed swollen
	18	leaching, slime occurred, Unfavorable smell occurred due to slime and a part of seeds broken
	24	Unfavorable smell slime occurred in large amount and a part of seeds broken

Table 3.2 : Summary of trials for germination of Quinoa seed whole (QW):

Treatment	Time(hr)	Observation	
Quinoa seed whole Germination	Soaking	Germination	**Observation**
		12	No sprouting in seeds
	6	24	sprouting in seeds
		36	Sprouted
		48	Sprouted
	12	12	Seeds sprouted well
		24	Seeds sprouted well
		36	Seeds sprouted but unfavorable smell occurred
		48	Seeds sprouted but unfavorable smell occurred
	18	12	No Sprouting
		24	No Sprouting
		36	No Sprouting
		48	No Sprouting

Table 3.3 : Summary of trials for germination of Quinoa seed Dehulled (QD):

Treatment	Time(hr)		Observation
Quinoa seed Dehulled Germination	6	12	Seeds not sprouted
		24	Seeds not sprouted
		36	Sprouted
		48	Sprouted
	12	12	Seeds broken down and not sprouted, slime occurred in large amount with unfavorable smell
		24	Seeds broken down and not sprouted, slime occurred in large amount with unfavorable smell
		36	Seeds broken down and not sprouted, slime occurred in large amount with unfavorable smell
		48	Seeds broken down and not sprouted, slime occurred in large amount with unfavorable smell
	18	12	Seeds broken down and not sprouted, slime occurred in large amount with unfavorable smell
		24	Seeds broken down and not sprouted, slime occurred in large amount with unfavorable smell
		36	Seeds broken down and not sprouted, slime occurred in large amount with unfavorable smell
		48	Seeds broken down and not sprouted, slime occurred in large amount with unfavorable smell

It was revealed from the experiment that:

i. 6 hr soaking time is suitable for germination of Quinoa seed whole.

ii. Quinoa seed should be soaked for a short time period (1hr) for germination to prevent breakage of seeds and slime formation.

iii. Prolonged soaking like 12hr, 18 hr inhibits sprouting in Quinoa seed whole.

iv. Quinoa seed whole need to be washed smoothly under running water.

3.3.3: Standardized Processing: On the basis of trials, the following procedure was selected for both Quinoa seed whole (QW) and Quinoa seed dehulled (QD).

Soaking:

Two hundred gm sample of QW and QD separately were cleaned, weighed and soaked in 200ml distilled water for 6, 12, 18 and 24hr. After six hr. water was drained out .The amount of drained water was measured. Sample was weighed separately just after removal of water after spreaded on aluminum foil and dried in oven at 60^0C for 5 hours. Both samples (QW& QD) were weighed during drying. Both samples were ground in a mixer separately and weighed again. Samples were packed in aluminum foil and stored in desiccators for chemical analysis.

Germination-

The cleaned Quinoa seed whole and Quinoa seed Dehulled samples (100g) were taken, washed with water and were germinated separately for 12, 24, 36 and 48 hrs. Quinoa seed whole (QW) and Quinoa seed dehulled (QD) in two parts separately (100 g each) were cleaned, measured and selected for treatments of germination for 12, 24, 36 & 48 hr (Figure 3.4). Quinoa seed whole were soaked in 200ml of distilled water for 12 hr while Quinoa seeds were soaked for 20 min. After soaking the remaining water was drained off and grains were then tied in muslin cloth and kept in dark for germination. The amount of drained water was measured. Firstly, the bottom of the tray was covered with wet cotton cloth and soaked seeds were spread over that and then, the tray was covered with another cotton cloth. Temperature and humidity was recorded at every 12 hr intervals. Sprouting in the seeds started after 20 hr. Following these steps seeds (QW and QD) were germinated for 24, 36 and 48 hr. During germination process, 20 ml distilled water was sprinkled between 3-4 hr intervals over the covered cotton cloth. After germination, seeds were again washed

properly under the running tap water for removing unfavorable smell and were weighed on weighing balance just after germination (W2). Then, seed were spread on aluminum foil for 30 min. and weighed (W3). Seeds were dried in oven at 60 ^{0}C for 5 hr to make it moisture free. All germinated samples were ground in a mixer separately and were weighed again (W^4). Samples were packed in aluminum foil and stored in desiccators for chemical analysis.

3.3.4: Chemical Analysis of processed Quinoa seed :

Processed Quinoa Seed whole (QW) and Quinoa Seed Dehulled (QD) were analyzed including proximate composition (Moisture, ash, protein, fat, fiber, energy carbohydrate), minerals (Calcium iron, zinc, potassium, phosphorous) & anti-nutritional factors (Saponin and Phytic acid) as mentioned under Phase 1 of study.

Selection of best processing technique : On the basis of nutritional profile and minimum anti- nutrients 24 hr germinated Quinoa seed whole (QW) was selected best among all treatments.

3.3 : PHASE 4-DEVELOPMENT OF PRODUCTS:

Products were developed from quinoa seed dehulled. The quinoa seed dehulled was used to standardize the recipe for best acceptable product quality. Then final product was developed using quinoa seed dehulled with the standardize recipe:

Products were developed under the following steps from unprocessed Quinoa seed .

a) Selection of recipes

b) Preparation of flour

c) Standardization of recipes

d) Preparation of recipes

e) Sensory evaluation

   i. Selection of panel members

   ii. Development of score card

   iii. Method of evaluation

f) Final Product development

a) **Selection of the recipe -** Various recipes as were tried to prepare from Quinoa seed flour in various trials. Among these trials Twelve were selected as given below:

(i) *Chapati*

(ii) *Biscuit*

(iii) *Namkeen*

(iv) *Khakhra*

(v) *Handvo*

(vi) *Ladoo*

(vii) *Handwa*

(viii) *Chilla*

(ix) *Sattu*

(x) *Utapam*

(xi) *Khaman*

(xii) *Cake*

b) **Preparation of flour-** Quinoa Seed Dehulled was ground in an electric grinder to make fine powder and sieved it. The flour of Quinoa seed dehulled was packed separately in a polythene bag for further evaluation.

c) **Standardization of Recipes-** Standardization was done in terms of ingredients, processing steps and organoleptic qualities of product. For the purpose basic ingredient was replaced in different proportion to find out best combination for preparing each product (*Chapati, Biscuit, Namkeen, Khakhra, Handwa, ladoo, Pattie, chilla, sattu, utapam, khaman, cake)* from dehulled Quinoa seed flour with the replacement of basic ingredient in 40,60,80 ,100

percent to obtain the acceptable percent of product. All developed products were judged by panel members.

d) Preparation of Recipes- as *Chapati Biscuit, Namkeen, Khakhra, Handwa, Ladoo, Patty, Chilla, Sattu, Utapam, Khaman, Cake* were prepared by incorporation of quinoa seed dehulled flour in 40,60,80 and 100 percent (Plate 3.5).

Quinoa *(Chenopodium quinoa),* which is considered a pseudo-cereal or pseudo-grain it is highly nutritious due to its outstanding protein quality and wide range of minerals and vitamins. Quinoa starch has physicochemical properties (such as viscosity, freeze stability) which give it functional properties with novel uses (Vandana *et al.,* 2015). Although these grains are highly nutritious very limited products are being manufactured due to their physical properties *viz* no gluten in them.

(i) Standardization of *Chapatti:*

Table 3.4: Ingredients and Preparation of chapatti from Quinoa seed dehulled flour in various proportions:

S. No.	Ingredients	Variations			
		40	**60**	**80**	**100**
1	Quinoa seed dehulled Flour (g)	20g	30g	40g	50 g
2	Wheat flour(g)	30g	20g	10g	-
3	Salt	1/4tsp	1/4tsp	1/4tsp	1/4tsp
4	Water	48ml	62ml	65ml	66ml

Method of Preparation-

- Weigh wheat flour and Quinoa seed dehulled flour and Sieved together.
- Salt was added and kneaded with water.
- Soft dough was prepared and divided in to equal size small balls
- Rolled the balls and make round chapati.
- Chapati roasted on hot and flat tawa and flame.

(ii) Standardization of *Biscuit:*

Table 3.5: Ingredients and preparation of Biscuit from Quinoa seed Dehulled flour in various proportions:

S. No.	Ingredients	Variations			
		40	**60**	**80**	**100**
1	Quinoa seed flour	20 g	30 g	40 g	50 g
2	Refined Wheat flour	30 g	20 g	10 g	-
3	Amul Butter	25g	25g	25g	25g
4	Baking powder	1/4tsp	1/4tsp	1/4tsp	1/4tsp
5	Baking Soda	1/8 tsp	1/8 tsp	1/8 tsp	1/8 tsp
6	Milk	4drops	4drops	4drops	4drops
7	Powdered Sugar	25g	25g	25g	25g
8	No. of biscuit	7	7	6	7
9	Weigh /biscuit	15 g	16 g	16 g	15 g
10	Total weight of biscuit	93 g	88 g	86 g	93 g

Method of preparation-

- Butter and sugar was mixed properly in one direction only left or right.
- Quinoa seed dehulled flour, wheat flour refined, soda and baking powder were mixed in the mixture.
- Some drops of milk were also added to mix up well.
- Prepared dough was cut into shapes and pieces were baked in microwave oven for 15 min.
- Cooked Biscuits were weighed and stored in aluminum foil.

(iii) Standardization of *Namkeen:*

Table 3.6: Ingredients and preparation of *Namkeen* from Quinoa seed Dehulled flour in various proportions:

S. No.	Ingredients	Variations			
		40	**60**	**80**	**100**
1	Quinoa seed flour	20g	30g	40g	50 g
2	Gram Flour	30g	20g	10g	-
3	Oil	5g	5g	5 g	5 g
4	Green Chilli paste	2gm	2gm	2gm	2gm
5	Oil	150 ml	150 ml	150 ml	150 ml
6	Salt	1/4tsp	1/4tsp	1/4tsp	1/4tsp
7	Cooked weight	32 g	37 g	37 g	36 g

Method of preparation-

- Quinoa seed dehulled flour, gram flour, salt with chilli water were mixed.
- Stiff dough was prepared.
- Dough was poured in machine and pressed by hand.
- Refined oil was heated in pan and started to move the machine by hand roundly.
- Fry just for one min in pan both.
- Weighed after cooling and were stored in aluminium foil.

(iv) Standardization of *khakhra:*

Table 3.7: Ingredients and preparation of *Khakhra* from Quinoa seed Dehulled flour in various proportions

S. No.	Ingredients	Variations			
		40	**60**	**80**	**100**
1	Quinoa seed flour	40 g	60 g	80 g	100 g
2	Wheat flour	60 g	40 g	20 g	-
3	Salt	1 tsp	1 tsp	1 tsp	1 tsp
4	Red Chilli	¼ tsp	¼ tsp	¼ tsp	¼ tsp
5	Cumin seeds	1/4tsp	1/4tsp	1/4tsp	1/4tsp
6	Kasoori methi	1¼ tsp	1¼ tsp	1¼ tsp	1¼ tsp
7	Water	300ml	280ml	280ml	300ml
8	Time of cooking	20 min	20 min	20 min	20 min
9	No.of Khakhra	14	20	20	22
10	Wt of one cooked	8 g	7 g	6 g	7 g
11	Wt of one Khakhra non cooked	7 g	5 g	4 g	5 g
12	Wt of total no of Khakhra non cooked	90 g	95 g	95 g	105g

Method of preparation-

- Weight wheat flour and Quinoa seed dehulled flour and Sieved together.
- Kasoori methi, 1 tsp oil and salt was added and kneaded with water like chapatti dough. Cover it with a plain muslin cloth and let it rest for 15-20 minutes.
- Grease its surface with oil and divided in to equal size small balls
- Rolled the balls and make round chapati.
- Chapati roasted on hot and flat tawa and flame.
- After 20-30 seconds, turn it and press it using wooden press or folden thick cloth.
- Flip it repeat same process of pressing and cooking wooden press or folded cloth until it becomes crispy.
- Cool then for 10-15 minutes at room temperature and store in airtight container.

(v) Standardization of *Handwa:*

Table 3.8: Ingredients and preparation of *Handwa* from Quinoa seed Dehulled flour in various proportions

S. No.	Ingredients	Variations			
		40	**60**	**80**	**100**
1	Quinoa seed flour	40 g	60 g	80 g	100 g
2	Semolina	60 g	40 g	20 g	-
3	Curd	10ml	10ml	10ml	10ml
4	Bottle gourd	5g	5g	5g	5g
5	Green peas	5g	5g	5g	5g
6	Carrot	5g	5g	5g	5g
7	Ginger-green chilli paste	2g	2g	2g	2g
8	Mustard seeds	1 tsp	1 tsp	1 tsp	1 tsp
9	Chilli	¼ tsp	¼ tsp	¼ tsp	¼ tsp
10	Cumin seeds	1/4tsp	1/4tsp	1/4tsp	1/4tsp
11	Sesame seeds	0.5g	0.5g	0.5g	0.5g
12	Asafoetida	1g	1g	1g	1g
13	Curry leaves	0.5g	0.5g	0.5g	0.5g
14	Time of cooking	20 min	20 min	20 min	20 min
15	Wt of one cooked	88 g	87 g	86 g	87 g

Method of preparation-

- Take quinoa flour and semolina and added curd in it and blended until smooth consistency.
- Transfer the batter to medium size container. cover it with a lid and keep in warm place to ferment for around 20-25 minute
- Added grated bottle gourd, grated carrot, green peas, ginger-green chilli paste, one tea spoon oil and turmeric powder.
- Mix well. Batter should have thick consistency.
- Heat one teaspoon oil in a small non-stick pan over medium flame add ¼ teaspoon mustard seeds and then when they begin to crackle, add ¼ teaspoon cumin seed, half teaspoon sesame seeds a pich of asafoetida and curry leaves
- Pour batter depending on the size of a pan and spread it evenly with spatula to make 1-inch thick *handwa*.

- Cover the pan with a lid or a plate. Reduce flame to low and cook until top surface looks cooked till bottom surface turns light brown.(4-5 minutes)
- Flip it gently with spatula and cover cook until another side turns golden brown, for around 3-4 minutes.
- Transfer it to a plate and serve with chutney.

(vi) Standardization of *ladoo:*

Table 3.9: Ingredients and preparation of *ladoo* from Quinoa seed in various proportions

S. No.	Ingredients	Variations			
		40	**60**	**80**	**100**
1	Quinoa seed	40 g	60 g	80 g	100 g
2	Ground nut	60 g	40 g	20 g	-
3	Sesame seed	5g	5g	5g	5g
4	Jaggery	50g	50g	50g	50g
5	Ghee	10g	10g	10g	10g
6	Cardamon	¼ tsp	¼ tsp	¼ tsp	¼ tsp
7	Wt of one cooked	8 g	7 g	6 g	7 g

Method of preparation-

- Wash Quinoa seed dehulled and soak in luke warm water for 5mins.
- Drain the water and dry them for 10mins.
- Now keep a thick pan/kadai and let it become hot.
- Once the pan is hot, pour Quinoa and keep stirring with a ladle.
- When the grains start roasting, cover the pan with a lid. Make sure there is a gap and the pan is not completely closed.
- Once the popcorn is ready, keep in a vessel.
- Now grind the popcorn coarsely and then add jaggery and grind it again.
- Add cardamom powder to this mix.
- Make ladoos by adding sufficient hot ghee.

(vii) Standardization of *Patty:*

Table 3.10: Ingredients and preparation of *Patty* from Quinoa seed in various proportions

S. No.	Ingredients	Variations			
		40	**60**	**80**	**100**
1	Quinoa seed Dehulled	40 g	60 g	80 g	100 g
2	Potato	60 g	40 g	20 g	-
3	Green peas	5g	5g	5g	5g
4	Ginger	1g	1g	1g	1g
5	Green Chilli	2g	2g	2g	2g
6	Cumin seeds	1/4tsp	1/4tsp	1/4tsp	1/4tsp
7	Garam masala	1/4tsp	1/4tsp	1/4tsp	1/4tsp
8	Coriander leaves	1g	1g	1g	1g
9	Red chilli powder	1/4tsp	1/4tsp	1/4tsp	1/4tsp
10	Onion	5g	5g	5g	5g
11	Wt of one cooked	115g	109g	111g	111g

Method of preparation-

- Boil quinoa seed dehulled and potatoes in pressure cooker. Boil peas in boiling water for 5 minutes.
- Take mashed potatoes and quinoa seed in another bowl. Add boiled peas, grated ginger, coriander leaves, finely chopped green chilli and onion, garam masala powder, red chilli powder, salt.
- Mix them to prepare smooth dough like mixture. Divide mixture and roll them into small size balls.
- Heat non-stick flat pan. When pan or griddle is hot enough, drizzle 3-4 teaspoons oil over it put patties over oil and cook until bottom surface turn golden brown.
- Flip each patty up side down and cook until second side also turns golden brown.

(viii) Standardization of *chilla:*

Table 3.11: Ingredients and preparation of *chilla* from Quinoa seed Dehulled flour in various proportions

S. No.	Ingredients	Variations			
		40	**60**	**80**	**100**
1	Quinoa seed flour	40 g	60 g	80 g	100 g
2	Gram flour	60 g	40 g	20 g	-
2	Curd	10ml	10ml	10ml	10ml
3	Onion	5g	5g	5g	5g
4	Salt	1 tsp	1 tsp	1 tsp	1 tsp
5	Green Chilli	¼ tsp	¼ tsp	¼ tsp	¼ tsp
6	Cumin seeds	1/4tsp	1/4tsp	1/4tsp	1/4tsp
7	Water	100ml	100ml	100ml	100ml
8	Wt of total chilla	90 g	95 g	95 g	105g

Method of preparation-

- Take quinoa seed dehulled flour, gram flour, chopped green chillies, onion and curd in a large bowl.
- Add water and salt. Mix well and keep batter foe 30 min minutes to settle. Better should have pouring consistency like buttermilk.
- Add chopped onion and coriander leaves and stir to mix well
- Heat 1 teaspoon oil in small pan for tempering. Remove pan from flame and pour tempering over batter.
- Take ladle full batter and pour it over tawaw from center to the side in circular motion.
- Pour 1 teaspoon oil around the edges of chilla and cook until of top surface to brown.
- Ease out chilla with spatula and flip it over another side and cook.
- Fold and serve with chutney.

(ix) Standardization of *sattu:*

Table 3.12: Ingredients and preparation of *sattu* from Quinoa seed Dehulled flour in various proportions

S. No.	Ingredients	Variations			
		40	**60**	**80**	**100**
1	Quinoa seed flour	40 g	60 g	80 g	100 g
2	Wheat flour	60 g	40 g	20 g	-
3	Ghee	30g	30g	30g	30g
4	Jaggery	50g	50g	50g	50g
5	Cardamom powder	¼ tsp	¼ tsp	¼ tsp	¼ tsp
12	Cooked weight	80 g	89 g	90 g	105g

Method of preparation-

- Heat 2 tbsp of ghee in a kadai, and roast Quinoa seed dehulled flour and wheat flour on medium heat until you get a nice aroma of roasted flour.
- Once the flour is well roasted, switch off the heat and add jaggery powder.
- Add coarsely ground cardamom powder
- Transfer to a wide vessel or plate.

(x) Standardization of *Uttapam:*

Table 3.13: Ingredients and preparation of *Uttapam* from Quinoa seed Dehulled flour in various proportions

S. No.	Ingredients	Variations			
		40	**60**	**80**	**100**
1	Quinoa seed flour	40 g	60 g	80 g	100 g
2	Semolina	60 g	40 g	20 g	-
4	Salt	1 tsp	1 tsp	1 tsp	1 tsp
5	Curd	10ml	10ml	10ml	10ml
6	Green Chilli	1gm	1gm	1gm	1gm
7	Cumin seeds	1/4tsp	1/4tsp	1/4tsp	1/4tsp
8	Tomato	5g	5g	5g	5g
9	Onion	5g	5g	5g	5g
10	Water	50ml	50ml	50ml	50ml
11	Wt of total no of Uttapam non cooked	90 g	95 g	95 g	105g

Method of preparation-

- Take Quinoa seed dehulled flour and semolina, salt, green chilli add curd and Mix well and keep batter for 30 min minutes to settle.
- Heat tava and few drops of oil on hot tawa.
- Pour one ladle batter and spread.
- Sprinkle 1-2 tablespoons finley chopped onion and tomato. Gently press the veggies with a spatula.
- Cook for approx. 2-3 minutes until bottom surface turns light golden brown.
- Flip it gently and cook another side for a minute or until the bottom surface looks cooked
- Transfer it to a plate.

(xi) Standardization of *khaman:*

Table 3.14: Ingredients and preparation of *khaman* from Quinoa seed Dehulled flour in various proportions

S. No.	Ingredients	Variations			
		40	**60**	**80**	**100**
1	Quinoa seed flour	40 g	60 g	80 g	100 g
2	Gram flour	60 g	40 g	20 g	-
3	Sugar	1/2tsp	1/2tsp	1/2tsp	1/2tsp
4	Salt	1 tsp	1 tsp	1 tsp	1 tsp
5	Curd	10ml	10ml	10ml	10ml
6	Oil	1tsp	1tsp	1tsp	1tsp
7	Water	50ml	50ml	50ml	50ml
8	Curry leaves	1g	1g	1g	1g
9	Mustard seeds	1/4tsp	1/4tsp	1/4tsp	1/4tsp
10	Cumin seed	1/4tsp	1/4tsp	1/4tsp	1/4tsp
11	Coriander leaves	1g	1g	1g	1g
12	Soda /Eno (fruit salt)	1/4tsp	1/4tsp	1/4tsp	1/4tsp
13	Green chilli	1g	1g	1g	1g
15	Final weight	90 g	95 g	95 g	105g

Method of preparation-

- Take gram flour, quinoa seed dehulled flour, water and salt in bowl. Mix them properly into smooth batter. Make sure that there are no lumps.
- Put fruit salt in batter and stir in one direction for 1 minute. You will notice it size would increased almost double.
- Now pour batter immediately into each greased plate and fill it upto ½-inch thickness.
- Place plate in steamer and steam for 10-12 minutes over medium flame.
- After 10-12 minutes, insert a knife or toothpick into *khaman* and check if it comes out clean. If it does, then it is ready otherwise cook 2-3 minutes more.

- Heat 2 tablespoons oil in a small pan or tempering pan. Add mustard seed and asafoetida. When seeds begin to crackle, add cumin seeds, sesame seeds, curry leaves and green chillies sauté them for for few seconds.
- Add 1/3 cup water and sugar and bring it to boil, let it cook for a minute over high flame. Tempering is ready, pour it over khaman and toss toss gently until each khaman is coated well with tempering.
- Garnish with chopped coriander.

(xii) Standardization of *cake:*

Table 3.15: Ingredients and preparation of *cake* from Quinoa seed Dehulled flour in various proportions

S. No.	Ingredients	Percents			
		40	**60**	**80**	**100**
1	Quinoa seed flour	40 g	60 g	80 g	100 g
2	Wheat flour	60 g	40 g	20 g	-
3	Baking soda	1/2tsp	1/2tsp	1/2tsp	1/2tsp
4	Salt	1 tsp	1 tsp	1 tsp	1 tsp
7	Milk	100ml	100ml	100ml	100ml
8	Vanilla essence	1-2 drop	1-2 drop	1-2 drop	1-2 drop
9	Ghee	30g	30g	30g	30g
10	Sugar	30g	30g	30g	30g
11	Total Wt of product	90 g	95 g	95 g	105g

Method of preparation-

- Preheat oven to 350^0F (180^0C).
- Take ghee and sugar in large bowl. Beat together ghee and powdered sugar until fluffy and light.
- Take wheat flour, quinoa seed dehulled flour, baking soda and salt in bowl. Then add in alternately flour and milk to ghee mixture and fold it very gently with a spatula

- Mixture should be thin and lumpy it should not be very thick
- Grease inside surface of baking pan (any shape) with oil and butter. Pour batter in it.
- Place baking pan in pre-heated oven and bake for 30 minutes. Remove pan from the oven. Check whether the cake is cooked or not by inserting a toothpick, knife in the center and pulling it back. If it comes out clean, cake is cooked. If it does not, then cook it for 5 more minutes.
- Run the knife on sides of the cake. Place plate over the pan. Flip the pan and plate together to easily remove the cake.
- For frosting you can use, chopped chocolate, cream.

e) **Sensory evaluation** –Sensory quality or evaluation is a combination of different senses of perception which come into play for choosing and eating a food or it can be defined as a scientific discipline used to evoke , measure, analyze and interpret results of those characteristics of food as they are perceived by senses of sight ,smell, taste and touch. Therefore, the sensory qualities were evaluated by the panel of judges selected for ensuring the acceptability of the products.

i. Selection of panel members: A panel of judges was selected on the basis of sensitivity threshold test as suggested by Griswold, (1962) and Srilakshmi (2002). For the purpose five dilutions of different concentrations of salt and sugar were served randomly to the post graduate students of College of Home Science, Udaipur and others willing to participate. All of them were ask to arrange the solutions in correct order to salinity and sweetness. A panel of 30 judges who arranged the solutions with maximum correctness in an increasing order of salinity and sweetness were selected for the product evaluation.

ii. Development of score card- For evaluating the products for its sensory qualities viz. color, taste, texture, flavor, appearance, and overall acceptability score card was developed (Appendix I). Nine point hedonic scale of Peryam and Pilgrim (1957) quoted by Swaminathan (1987) was used for rating of the sensory attributes for each of the product. All the

panel members were asked for rating of the sensory attributes for each of the product. All the panel members were asked to assign scores to indicate their preference for the product (Appendix I).

iii. **Method of Evaluation-** Sensory evaluation requires concentration on the part of the panel members. Therefore, disturbances such as noise, off-odors etc. were avoided during the entire time period. All convenience foods with different percentage were coded separately and were presented to panelists with score card for evaluating the degree of acceptable for each characteristics that is being tested. The way of presenting the samples was kept uniform. A glass of water was served to avoid intermingling of the taste of two samples and ensured proper evaluation. The temperature of the test samples was also kept at optimum level.

f) **Final product development:** Final products were developed in combination with suitable processing method and most acceptable percentage of incorporation of Quinoa seed Dehulled flour or Dehulled Quinoa seed.

a) *Chapati* (60% percent)

b) *Biscuit* (40% percent)

c) *Namkeen* (60% percent)

d) *Khakhra* (40% percent)

e) *Handwa* (40% percent)

f) *Ladoo* (40% percent)

g) *Patty* (60% percent)

h) *Chilla* (60% percent)

i) *Sattu* (60% percent)

j) *Utapam* (40% percent)

k) *Khaman* (40% percent)

l) *Cake* (40% percent)

4.4: PHASE4 – SHELF LIFE ASSESSMENT OF QUINOA SEED FLOUR - :

Quality of products was evaluated in terms of changes in functional properties and peroxide value between storage periods.

4.4.1: Storage of developed foods – Packaging is necessary to keep food free from contamination and to prevent deterioration during storage .In the present study the shelf life of the Quinoa seed dehulled flour kept in packaging condition was assessed.

Required quantity of each developed food was packed in high density polyethylene (HDPE) packets having density 0.65 g/cm^3 and 0.1 mm thickness. These packets were packed by using heat sealing. After packaging flour were stored at room temperature in a dry place for a period of 6 months (August 2017-Febrary 2018).

4.4.2: Functional properties Analysis (0 month and 6th month):

Functional properties analysis by previously mentioned standard methods under Phase 1.

4.4.3: Peroxide value:

Its principle involves, to a known amount of fat or oil, excess potassium iodide is added which reacts with the peroxides in the sample. The iodine liberated is titrated with standardized sodium thiosulphate using a starch indicator. The calculated amount of potassium iodide required to react with the peroxide present is used to determine the peroxide value. Peroxide value is defined as the milli equivalents of peroxides per kilogram of fat, as determined in a titration procedure to measure the amount of peroxide or hydroperoxide groups in meq/kg (Jain and Mogra, 2006).

Procedure:

One gram of sample was taken into 250ml conical flask. One gram powdered potassium iodide was added and 20ml solvent mixture was prepared. It was boiled vigorously for not more than 30sec. in water bath. Twenty ml of KI solution was added. The tube was washed twice with 25ml water and the same was collected in to flask. It was titrated against N/500 sodium thio-sulphate solution until yellow color disappeared. Point five ml (0.5ml) starch solution was added and stirred vigorously. It was titrated carefully till blue color disappeared.

Calculation:

$$\text{Peroxide Value (meq/kg)} = \frac{\text{S x N x 1000}}{\text{Weight of Sample Taken (g)}}$$

Where, S = ml solution of thio-sulphate

N = normality of sodium thio-sulphate

4.4.4: Cost of developed foods: Cost of developed foods was calculated through market price survey of ingredients used in the preparation of foods.

Cost of developed foods(100g)	=	Price of ingredients	+	20% additional cost as processing charges

3.5: PHASE 6- PREPARATION OF INFORMATION MATERIAL

To educate, Visual aids like booklet was developed. Booklet related to "Nutritious product of Quinoa" was designed by the investigator. At the initial stage, for designing booklet on "Nutritious product of Quinoa seed" in-depth literature was reviewed by the investigator from text books, magazines, journals and internet to gather relevant information. Discussion was also made with subject matter specialists regarding the content of booklet. After gathering relevant information the major topics for the booklet in consultation with subject matter specialists. The topics finalised for the booklet. The designed booklet was subjected to evaluation by a panel of 10 experts from Extension Education and Communication Management, Agriculture Extension, Food science and Nutrition, Soil Science. All the experts were contacted personally to evaluate the designed booklet. The evaluation sheet used by Gupta (2000) was slightly modified and used for evaluating the booklet. The experts were requested to critically judge the booklet on various criteria which were as follows:

1. Relevance to topic
2. Subject matter coverage
3. Layout
4. Subtitle
5. Continuity/ sequence

6. Accuracy
7. Language- A: Clarity, B:Selection of words, C: Sentence structure
8. Illustration
9. Size of booklet
10. Overall presentation

The booklet was evaluated on the basis of these criteria on a five point continuum i.e. excellent, very good, good, fair and poor with scores 5, 4, 3, 2 and 1 respectively (Appendix-II). On the basis of scores assigned by experts, mean weighted score for each criterion of evaluation and overall mean weighted score for booklet was worked out. Further, based on the suggestions of experts, layout of booklet on "Nutritious products of Quinoa" was modified.

Statistical Analysis: The data were statistically analyzed as per the objectives of the study. Mean ±SD., Analysis of Variance (ANOVA) two way classifications (CRD Factorial design) and correlation were applied.

Formulas used for analysis of data are given below (Gupta, 2004).

Mean:

$$(\overline{X}): \overline{X} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

where, x = observation

n = number of observation

i = 1, 2, 3……n

Standard deviation (SD):

$$SD(\sigma) = \sqrt{\frac{\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}{n-1}}$$

ANOVA two way classifications (Factorial design):

It was applied to assess the effect of processing treatments on chemical properties of Quinoa seed whole, Quinoa seed dehulled, selecting most acceptable

percent of incorporation of Quinoa seed flour in recipes and effect of storage on sensory characteristics, nutritional quality of developed foods.

In two way classification, the analysis of variance is studied in following three parts:

i. Sum of squares Between Columns (SSC)

ii. Sum of Squares Between Rows (SSR)

iii. Residual Variation (SSE)

Total sum of Squares = Sum of Squares between Columns + Sum of Squares between Rows + Residual Variation or TSS = SSC + SSR + SSE.

Following steps should be followed to calculate Variance Ratio (F) in the case of Two way Classification.

(i) Coding method can be used to simplify the Calculations.

(ii) Calculation of Correction Factor

Correction Factor (c.f.) = $\frac{T^2}{N}$

(iii)Total Sum of Squares (TSS): It is obtained by subtracting correction factor from the total of squared values of the sample, i.e.

TSS = $\sum X^2_1 + \sum X^2_2 + \sum X^2_3 + \sum X^2_4 + \ldots\ldots\ldots\ldots - \frac{T^2}{N}$

(iv)Sum of Squares between Columns (SSC): The total of each column us squared and divided by the number of items in respective columns. The correction factories subtracted from the total of thus arrived values and SSC is obtained :

SSC = $\sum \left\{ \frac{(\sum X_c)^2}{n_c} \right\} - \frac{T^2}{N}$

Where $\sum X_c^2$ = Total of Squarred values in Each Columns

n_c = Number of Items in Each Column.

(v) Sum of Squares Between Rows (SSR): The total of the sample values in each row is squared and divided by the number of items in the respective row. From the total of the values thus arrived correction factor is deducted and remaining is known as sum of squares between rows or SSR.

$$SSC = \sum \left\{ \frac{(\Sigma X_R)^2}{n_R} \right\} - \frac{T^2}{N}$$

Where EX_R = Sum of the squared value of each row

n_R = No. of Items in each row.

(vi) Sum of the Squares of the Residual (SSE) : The sum of the squares of the residual is obtained by deducting the sum of squares between columns and sum of squares between rows from the total sum of squares :

SSE = TSS – (SSC + SSR)

(vii) Number of Degrees of Freedom : It is calculated as follows :

No. of degrees of freedom between columns = (c-1)

No. of degrees of freedom between rows = (r- 1)

No. of degrees of freedom for residual = (c -1) (r- 1)

Total No. of degrees of freedom = N -1 or Cr- 1

where,

r refers to number of rows

c refers to number of columns

N refers to total number of items in the samples.

(viii) ANOVA Table : In a two way classification the analysis of variance table is prepared in the following form :

Table 3.16 : ANOVA Table (Two-Way Classification)

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Sum of Squares (MSS)	F Ratio
Between Columns	SSC	C-1	SSC ÷ (c -1) = MSC	$F = \frac{MSC}{MSE}$
Between Rows	SSR	r – 1	SSR ÷ (r -1) = MSR	$F = \frac{MSC}{MSE}$
Residual	SSE	(c -1) (r -1)	SSE ÷ (c - 1) x (r - 1) = MSE	
Total	TSS	N -1 Or Cr – 1		

RESULTS AND DISCUSSION

The section of study sets forth clearly and precisely the finding and interpretation in the context of major objectives of study, thus providing a bird's eye view of complete study, which makes this section the most significant and crucial part of the research work. The results of the study have been systematically illustrated with the help of Tables and figures tracing the objectives of the presented under the following sections:-

4.1: PHASE1: PHYSICO-CHEMICAL ANALYSIS OF QUINOA SEED

4.2: PHASE2: PROCESSING OF WHOLE AND DEHULLED QUINOA SEED

4.3: PHASE3: DEVELOPMENT OF PRODUCTS

4.3.1 Selection of products

4.3.1 Organoleptic Evaluation

4.3.2 Nutritional Quality Evaluation

4.4: PHASE5: SHELF LIFE ASSESSMENT OF DEHULLE QUINOA FLOUR

4.5.1 Functional properties

4.5.2 Peroxide value

4.5: PHASE: PREPARATION OF INFORMATION MATERIAL

4.1: PHASE1: PHYSICO-CHEMICAL ANALYSIS OF QUINOA SEED

4.1.1: Physical properties:

Physico-chemical property of a food is important because it indicates the utility of products in specific applications and therefore reflects the properties encountered by their use during the preparation of usable products; reduce processing losses and helps in improving the overall quality of the product. These denote characteristics that govern behavior of foods during processing, storage and preparation as they affect food quality and consumer acceptability (Sangwan, 2002).

Physical characteristics of Quinoa seed assessed by the parameters like seed length, seed width, Thousand Kernel weight, Thousand Kernel volume, seed volume, seed density, bulk density, hydration capacity and Index, swelling capacity and index. The results obtained are presented in Table 4.1 and 4.2.

Table 4.1: Physical properties of Quinoa seed:

S. No.	Physical Properties	Mean ± SD
1	Diameter (mm)	0.024± 0.002
2	Thousand Kernel weight (g)	269.09±7.85
3	Weight of 100 seeds (g)	1.14±0.0
4	Thousand Kernel volume (ml)	9.6
5	Seed Density(g/ml)	0.86±0.03
6	Bulk Density(g/ml)	0.72±0.01
7	Hydration capacity(g/seed)	0.01±0.00
8	Hydration Index	0.48±0.02
9	Swelling capacity(ml/seed)	0.002±0.00
10	Swelling Index	0.18±0.04

Physical examination of Quinoa seed revealed that it is the shape of Quinoa seed is similar to a flattened sphere their mean equivalent diameter varies from 1.4 to 1.6 mm (Chauhan *et al*., 1992, Vilche *et al*., 2003). The seed diameter was 0.024mm (Table 4.1). Kernel weight was 269.06 and weight of 100 seeds was found 1.14 g. Ghada *et al* (2017) carried out a study and Results shows that, the 1000-seed weight and the bulk density values of quinoa seeds were 2.71g and 0.80g/m3, respectively. The value of bulk density of Quinoa seed was 0.72 g/100ml. accordance with that reported by Vilche *et al.,* (2003). Kernel volume, seed density and bulk density of Quinoa seed was found 9.6 ml, 0.86 g/ml, and 0.72 g/ml respectively. Abalone *et al.,* (2004), the average length, width, thickness and sphericity of Amaranth seeds found as 1.42, 1.29 and 0.87 mm respectively, which were lower than the quinoa seed genotypes. Hydration capacity and Hydration index of Quinoa seed was 0.01 ml/seed and 0.48 respectively.

Swelling index is an important parameter since it determines the consistency

of the diet. Swelling index refers to the expansion accompanying spontaneous uptake of solvent. Flours with high swelling index value indicates high water absorption capacity and will therefore hold large volume of water during cooking into gruels, to yield voluminous low energy and nutrient food (Cameroon & Hafvander, 1983). Swelling capacity and swelling index of Dehulled Quinoa seed was 0.002 ml/seed and 0.18 respectively .

4.1.2: Functional Properties:

Result of functional properties analyzed in Quinoa seed flour was water absorption capacity, oil absorption capacity and least gelatinization concentration (Table 4.2).

Table 4.2: Functional properties of Quinoa flour:

S.No.	Functional Properties	Mean ± SD
1	Water Absorption Capacity (%)	143.3±0.80
2	Oil Absorption Capacity (%)	78.30±0.56
3	Least Gelatinization concentration (%)	14±0.02

Water absorption capacity is the ability of flour to absorb water and swell for improved consistency in food (Adepeju *et al.*, 2014). It gives an indication of the amount of water available for gelatinization (Ghavidel and Prakash, 2010). It measures the volume occupied by the starch after swelling in excess water. Lower water absorption capacity is desirable for making thinner gruels. Water absorption capacity of Quinoa seed flour was found 143.3%. Ogungbenle (2009) analyzed functional properties of quinoa seed flour and results revealed that Quinoa has a high water absorption capacity (147.0%) and low foaming capacity and stability (9.0%, 2.0%). The flour has a least gelation concentration of 16%w/v. Oil absorption capacity of Quinoa seed flour was 78.33%. The oil absorption capacity (OAC) of quinoa seeds flour was low. This result indicated that quinoa seeds flour showed lower OAC in comparison with wheat flour and quinoa dehulled flour but higher than amaranth flour (Chauhan *et al.,* 2015 and Kaur *et al.,* 2015).

The least gelation concentration (LGC) indicates the gelation capacity and the lower the LGC, the better the gelling ability of proteins. Gelling ability is a function of the ability of the flour to absorb water and swell. Gelation is not only based on protein quantity but appears to be related to the type of protein as well as to non-

protein components. Least Gelatinization concentration of Quinoa flour was found 14%. (Ogungbenle, 2009). The flour has a least gelation concentration of 16%w/v.

4.1.3: Chemical Properties:

Chemical properties of Quinoa seed whole flour (QW), Quinoa seed Dehulled flour (QD) were analyzed and the results obtained on dry matter basis have been presented in following sections (Table 4.3- 4.6).

Proximate Analysis:

Moisture, crude fat, ash, crude protein, crude fibre, carbohydrates and energy contents of QW, QD are depicted in Table 4.3 and discussed below.

Table 4.3: Proximate analysis of whole Quinoa seed flour (QW), Dehulled Quinoa seed flour (QD)

S.N.	Treatment	Nutrients g/100g													
		Moisture		Fat		Ash		Protein		Fibre		CHO		Energy(Kcal)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	QW	4.09	0.610	4.6	0.156	3.6	1.67	12.52	0.73	8.98	8.84	65.25	1.45	361.49	7.11
2	QD	2.89	0.455	3.88	0.735	2.88	1.81	12.23	3.09	7.99	12.385	63.56	1.99	377.04	3.59

The chemical analysis of Quinoa seed for proximate composition for moisture, fat, ash, protein, fibre and energy. Moisture content was higher in QW (4.09g/100g) followed by QD (2.89g/100g).

Highest amount of crude fat content was exhibited in QW (4.6g/100g) followed by QW (3.88g/100g). Ruales and Nair (1992) reported that Quinoa seeds have approximately 9% fat on a dry weight basis. Quinoa fat has a high content of oleic acid (24%) and linoleic acid (52%). Whole seed or dehulled seeds of Quinoa seed contain 5-6% total lipids. Protein, the body building nutrient, According to results protein was 12.23g/100g in QD and 12.52g/100g in QW. Gonzalez *et al.,* (1989) conducted a study and results revealed that the seeds have a higher nutritive value than most cereal grains. Quinoa also contains all ten essential amino acids, and its protein content ranges from 12.9 to 16.5%. Of primary interest is the high lysine value, an essential amino acid that is deficient in many grains. The protein content of about 15% in quinoa is much higher than that found in cereals such as wheat, barley, oats, rice, and sorghum.

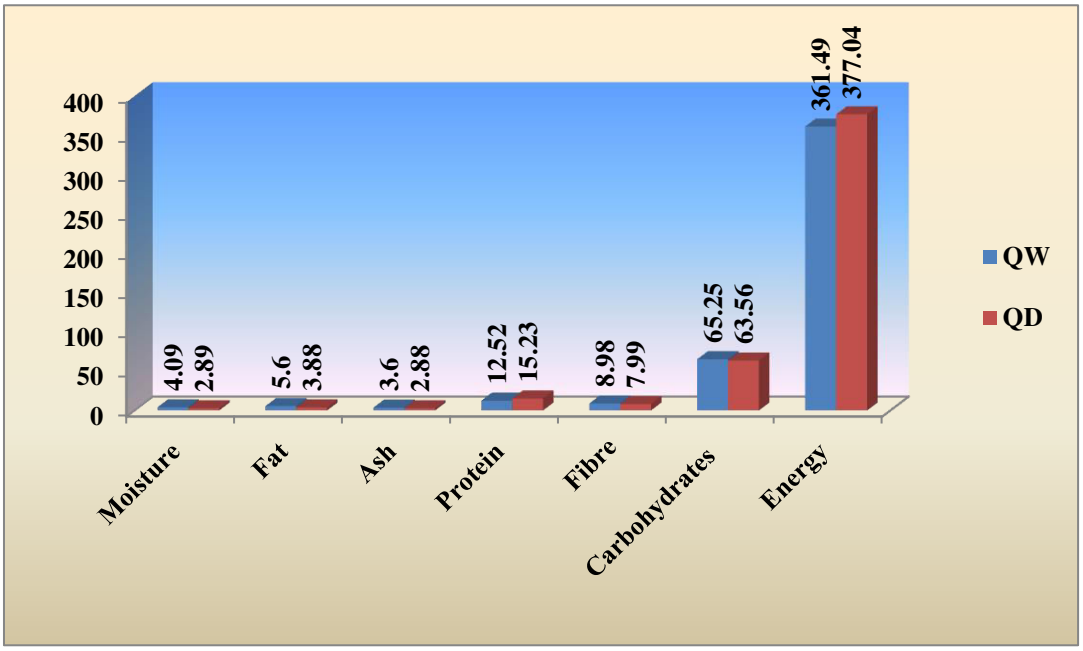


Fig:4.1 Proximate analysis of whole Quinoa seed (QW), Dehulled Quinoa seed (QD)

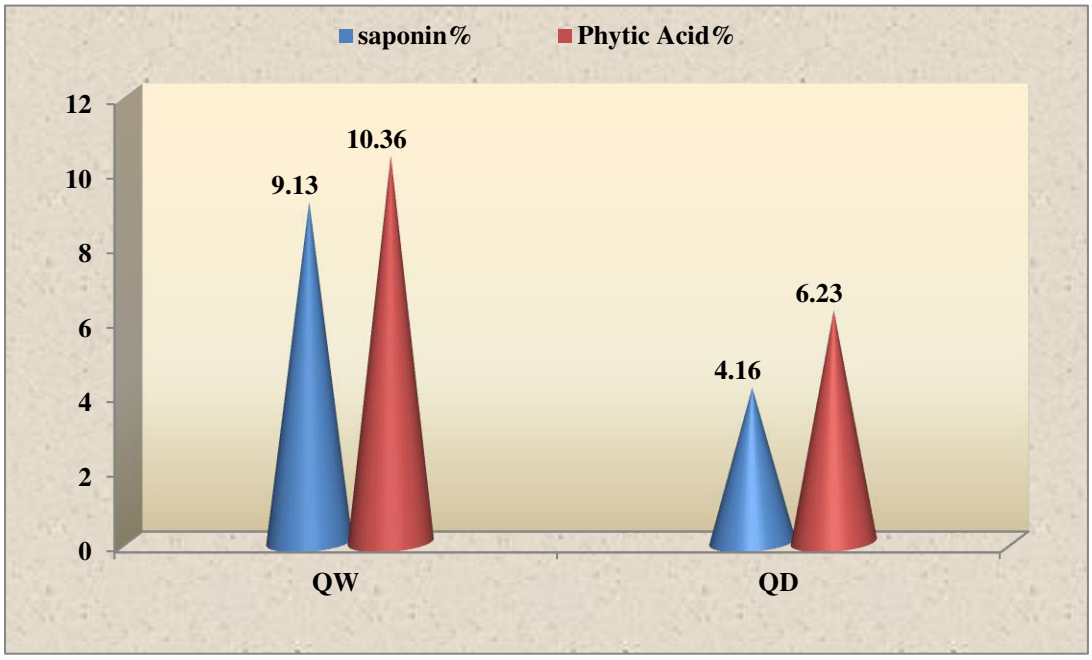


Fig:4.2 Antinutritional analysis of whole Quinoa seed (QW), Dehulled Quinoa seed flour (QD)

The soluble protein contents in quinoa are similar to those in barley and higher than those in wheat and maize. Total ash was found in QW and QD (3.6g/100g) and (2.88g/100g). Ogungbenle (2009) studied the Nutritional evaluation and Nutritional properties of quinoa (Chenopodium quinoa) flour the content of ash was found between the range of 1.2%-4.08% among flour.

QW and QD showed higher content of crude fibre (8.98g/100g and 7.99g/100g) respectively Lamothe (2015) Greater consumption of fiber-rich whole grains is associated with a lower risk of type 2 diabetes and cardiovascular disease. Quinoa is an excellent source of dietary fiber, comprising about 2.6%-10% of the total weight of the grain; about 78% of its fiber content is insoluble and 22% soluble. It was observed that all two variations of Quinoa seed exhibited carbohydrate content of QW and QD which ranged from 63.56 g to 65.25/100g. Yao (2014) found that Starch, as a carbohydrate, provides the major source of physiological energy in the human diet. The content of starch in quinoa ranges from 58.1% to 64.2% of dry matter, of which 11% is amylose. The energy values can also be seen to be varying possibly due to protein and carbohydrate content among QW and QD. The values ranged from 361.49 kcal in QW to 377.04 kcal in QD.

The total content of components depends on the variety or environmental factors Meneguetti *et al.,* (2011).

Mineral Profile:

Quinoa Seed are also rich in micronutrients such as minerals and vitamins. Table 4.4 shows the mineral composition of quinoa seed whole (QW), quinoa seed dehulled (QD). The main minerals are calcium, iron, zinc potassium, phosphorus. (Table 4.4).

The major mineral contents for QW, QD are presented in Table 4.4. The difference was found between flours for calcium, Iron, Zinc, potassium, phosphorus. In case of calcium, QW recorded higher value 86.3mg than QD (55.1). Abdelazim Sayed and Abdelazim Abdellatif (2018) Quinoa flour and quinoa flat bread had the balanced minerals content as (mg/100 gm) Magnesium 502 and 560, Potassium 732 and 755, Manganese 444 and 489, Copper 0.75 and 0.88, Iron 10.5 and 15.56, Phosphorous 411 and 487, Zinc 4.1 and 5.66, calcium 86.3 and 89.56 and Sodium 2.44 and 1130.55 mg/100 gm respectively. The distribution of minerals in quinoa

seeds revealed that phosphorus and magnesium were localized in embryonic tissue, while calcium and potassium were present in the pericarp. (Kiaus., *et al.*, 2012 and *Konishi., et al.*, 2004 Mohammad *et al.,* 2017) found that abrasion of quinoa seeds (for saponin elimination) caused specifically a decrease in calcium content. Calcium (83.33 mg/100g), magnesium (202.17 mg/100g), zinc (4.23 mg/100g) and acid were also higher in raw flour. The total content of minerals in amaranth, quinoa and oats is about twice as high as in other cereals (Dyner *et al*., 2007 and Sadiq *et al.,* 2008).

Table 4.4: Mineral composition of Quinoa seed whole (QW), Quinoa seed Dehulled (QD):

S. N.	Treatment	Calcium(mg)		Iron(mg)		Zinc(mg)		Potassium (mg)		Phosphorus (mg)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	QW	86.3	0.6	15.0	0.1	4.0	0.1	732.0	5.5	411.0	4.1
2	QD	55.1	0.4	14.2	0.1	4.0	0.1	656.0	4.3	404.9	3.0

Iron content was higher in QW (15.0 mg) followed by QD (14.2 mg). Among two flours zinc content was found no difference in QW and QD (4.0 mg). Potassium was higher in QW (732.0 mg) than QD (656.0 mg). Phosphorus was also higher in QW (411.0 mg). Koziol (1992) has summarized that the contents of K (927 mg/100 g), Ca (149 mg/100 g), Mg (250 mg/100 g), P (384 mg/100 g), S (150–220 mg/100 g), Fe (13.2 mg/100 g), and Zn (4.4 mg/100 g) in quinoa seeds are much higher than those of cereals such as wheat and rice. Konishi *et. al.* (2004) studied the content of Ca, K, Mg, Fe, Zn,P were analyzed in the whole Quinoa seed and Dehulled Quiona seed. There is relatively small difference in the content.

Anti-nutritional analysis:

The anti-nutritional factors viz saponin and phytic acid were analyzed in QW and QD. The results obtained are presented in Table 4.5 and discussed below:-

Table 4.5: Anti- nutritional analysis of Quinoa seed whole (QW), Quinoa seed Dehulled (QD)

S.N.	Treatment	Saponin%		Phytic acid%	
		Mean	**SD**	**Mean**	**SD**
1	QW	9.13	0.80	10.36	1.90
2	QD	4.16	1.00	6.23	2.40

The saponin content in quinoa seed was 0.14% to 2.3%. These values are higher than those in soybean and oat, but lower than in green pea. (Mastebroek *et al.,*2000; Guclu-Ustundag and Mazza, 2007). Saponin content was found to be higher in QW (9.13) than QD (4.16). Ridout (1991) reported that Quinoa contains about 1.0% to 1.2% saponins, which are bitter and have antinutritional effects. To be edible, quinoa grains must have the saponins removed, since they affect the colour and palatability of the products. The phytic acid content was lower in QD (6.23 %) than QW (10.36%). Phytic acid is not only present in the outer layers of Quinoa seeds, as in the case of rye and wheat, but is also evenly distributed in the endosperm. Ranges of 10.5 to 13.5 mg/g of phytic acid for five different varieties of quinoa were reported by Koziol, similar to the range of 7.6 to 14.7 mg/g for other cereals. Depending on chemical analysis of Quinoa whole (QW) and Quinoa dehulled (QD), the Quinoa dehulled considered nutritionally dense due to its better macro and micronutrient and low anti-nutritional content than Quinoa whole. According to Vega-Galvez (2010) the content of phytic acid in quinoa is low and ranges from 10.5 mg to 13.5 mg, in comparison with corn that contains 720 mg, wheat 390 mg and rice 60 mg.

Total antioxidant activity:

DPPH is a free radical generating compound and has been widely used to evaluate the free radical scavenging ability of various antioxidants. Antioxidant activity was evaluated by measuring the DPPH radical scavenging activity of Quinoa whole (QW) and Quinoa dehulled (QD.

Bhaduri (2016) conducted a study on Antioxidant and Antiproliferative Activities of Quinoa and results revealed the antioxidant activity (1586 ± 41.42) and DPPH scavenging capacities (82.71 ± 0.03) of quinoa seed. The anti oxidant activity in quinoa seed whole and dehulled was 44.34 and 32.54.

Table 4.6: Total Anti- oxidant activity analysis of Quinoa seed whole (QW), Quinoa Dehulled (QD)

S.N.	Treatment	Total antioxidant activity	
		Mean	**SD**
1	QW	44.34	2.19
2	QD	32.54	0.94

4.2: PHASE2: PROCESSING OF WHOLE AND DEHULLED QUINOA SEED

Quinoa Seed Whole and Quinoa seed Dehulled were processed separately for soaking (6, 12, 18, 24 hr) and germination (12, 24, 36, 48 hr). Observation during soaking and germination was recorded and presented in the Table 4.7 to 4.9.

Soaking: As described that Quinoa seed whole and Quinoa seed dehulled soaked for 6, 12 and 18, 24 hr separately. Effect of soaking on proximate analysis, mineral profile and anti-nutrients total anti oxidant activity were analysed.

Table 4.7: Soaking of Quinoa Seed Whole (QW) and Quinoa Seed Dehulled (QD):

Sample	Time (hr)	Weight of sample before soaking (g)	Water Used (ml)	Wt of sample after soaking (g) (W^1)	Water left (ml)	Final weight (g)	
						Before drying (W^2)*	After drying (W^3)**
QSW	6	100	100	108	60	108	73
	12	100	100	109	50	110	73
	18	100	100	118	30	115	73
	24	100	100	125	20	95	73
QSD	6	100	100	131	25	107	70
	12	100	100	148	15	116	70
	18	100	100	163	15	120	70
	24	100	100	178	15	134	70

* W^2= weight of seed after spreading on aluminum foil for 30 min. ** (W^3) = weight of seeds after drying and grinding

During soaking of Quinoa seed whole and Dehulled, temperature ranged between 30.5 to 33.5^{0}C and humidity was 32 to 40% (Table4.7). Weight of both (QW and QD) seeds were increasing with soaking period. It was also found that Quinoa seed Dehulled absorbed more water than Quinoa seed whole during soaking.

Table 4.8: Germination of Quinoa seed whole (GQW):

Time (hr)	Weight of sample before soaking for 12 hr (g)	Water Used (ml)	Water left after. soaking for 12hr (g)	Weight of seeds* (g)			
				W^1	W^2	W^3	W^4
12	100	200	140	110	100	95	84
24	100	200	140	120	115	105	89
36	100	200	140	140	130	110	92
48	100	200	140	140	130	105	90

* Weight of seeds: W1= weight of seeds after soaking for 12 hr, W2=weight of seeds after germination and washing under tap water, W3= weight of seeds after spreading on aluminium foil for 30 min W4=weight of seeds after drying and grinding.

Quinoa whole seeds were germinated for 12, 24, 36 and 48 hr. Temperature and humidity ranged between 34.3-35.2^{0}C and 46 to 54% respectively (Table 4.8).

Table 4.9: Germination of Quinoa seed Dehulled (GQD):

Time (hr)	Weight of sample before soaking for 20 min (g)	Water Used (ml)	Water left after. soaking for 20 min (g)	Weight of seed* (g)			
				W^1	W^2	W^3	W^4
12	100	200	100	179	160	145	80
24	100	200	100	189	168	155	87
36	100	200	100	181	171	156	96
48	100	200	100	180	170	150	80

* Weight of seeds: W1= weight of seeds after soaking for 20 min, W2=weight of seeds after germination and washing under tap water, W3=weight of seeds after spreading on aluminium foil for 30 min W4=weight of seeds after drying and grinding.

Germination of Quinoa dehulled for 12,24,36 and 48 hr was followed by soaking for 1 hour Temperature ranged between 33.1-35^{0}C and humidity was 39-50%.(Table 4.9).

Germination: Quinoa whole and Quinoa dehulled were germinated for 12, 24, 36, 48 hr (Table 4.9 to 4.10) and effect of germination on chemical properties (proximate analysis, mineral profile and anti-nutrients, total anti oxidant activity) were analyzed. Analysis of variance for proximate analysis, mineral composition, anti-nutrients and

total anti oxidant activity between unprocessed and processed Quinoa seed whole (QW) and Quinoa seed dehulled (QD) are presented in

4.2.1: Quinoa whole:

Effect of soaking and germination treatments on chemical composition as proximate analysis, mineral profile and anti-nutrients, total anti-oxidant activity of quinoa seed whole are presented in Table 4.10 to 4.13. (QW) revealed that there was a significant difference in the moisture content among all processing which ranges from 3.5 to 4.9g/100g. This decrease in moisture is explained by subsequent drying after germination, in order to prevent growth of microorganisms (Khatun *et al.*, 2013). In the popped and roasted sorghum flour, the decrease in the moisture content may be attributed to the losses caused due to the rupture in cell wall due to application of heat during processing.

The Significant difference was observed in the fat content which was lower than unprocessed quinoa flour (5.6-0.156). The fat content of the soaked and germinated flour (0.90-2.45) was significantly lower ($p \leq 0.01$) as compared to the raw untreated unprocessed quinoa flour. Hydrolysis of lipid and oxidation of fatty acids take place during germination of seeds. The hydrolyzed products do not accumulate in the seed, but the glycerol becomes a part of carbohydrate pool and the fatty acids are oxidized through α and β oxidation, resulting in decrease in fat on malting (Mayer and Mayber, 1963 and Choudhary and Baroova, 2011).

Ash was significantly lower than unprocessed quinoa seed flour. These results are in agreement with Okrah (2008) who found that ash content of germinated sorghum varied from 0.28-1.70%. Gernah *et al.*, (2011) found that germination of grains decreases ash content. It was reported that germination processes caused significant decreases in ash content. The decrease in ash content of sprouted sorghum may be due to the consumption of ash during the growth of the germ.

In cereals and legumes, this increase is due to the presence of protein hydrolysis as well as the results of protease enzyme activity during germination of the seeds. Proximate composition of processed and unprocessed Quinoa seed whole (QW) is presented in Table 4.11. Difference was found in moisture content among soaking and germination treatments which ranges from 3.5 to 5.7 g/100g. The moisture content was found highest in 18 hr Soaking (Q3: 5.2 g/100g) indicating that

with increasing soaking time the moisture content increases. Abdulsalami *et. al.* (2010) investigated the effect of processing on the proximate and mineral composition of Bambara groundnut and found an increase in moisture content. Crude fat content of unprocessed Quinoa seed whole was found higher (Q0:5.6 g/100g) than processed Quinoa seed whole and there was decrease in fat content with soaking (Q1 to Q4) and germination (Q5 to Q8). Ocheme (2008) studied the effects of soaking and germination on some physico-chemical properties, of millet flour and sensory properties of porridges. It was reported that fat, decreased significantly as result of soaking and germination. The lower fat content of the germinated samples can be due to the breakdown of lipids that occurs during germination in order to obtain the energy required for the plant's development (Urbano *et. al.* 2005).

There was significant difference in ash content in Quinoa seed whole after processing (Q4 to Q8). A slight decrease in ash content was also observed on soaking (Q4, Q6, Q7, Q8). Abdulsalami *et. al.* (2010) also found slight decrease in ash content from 5.37 to 2.89 (g/100 dry wt) after processing methods. While soaking, biological breakdown of various complex compounds into simpler compounds takes place as suggested by Narsih et al. (2012) and thus a significant increase in total protein content was observed with enhancement of the soaking time from 22.60 g/100 g to 28.77 g/100 g. While soaking, biological breakdown of various complex compounds into simpler compounds takes place as suggested by while soaking, biological breakdown of various complex compounds into simpler compounds takes place as suggested by Significant difference was observed in the protein content of quinoa whole after soaking and germination (Q1 to Q8).

These results are in agreement with Muyanja and Kikafunda (2003) reported that increased protein content in malted and germinated & dried flour from non-germinated sorghum flour might be due to improved protein extractability and attributed to microbial protease activity, breakdown of anti-nutrients which are known to bind protein. Inyang and Zakari (2008) also noted that germination may increase the protein content. In cereals and legumes, this increase is due to the presence of protein hydrolysis as well as the results of protease enzyme activity during germination of the seeds. Germination can be used to improve the sensory and nutritional properties of cereal and pseudocereal grains. Inyang and Zakari (2008) also noted that germination may increase the protein content. While soaking, biological

breakdown of various complex compunds into simpler compounds takes place as suggested by Narsih and Harijono (2012) and thus a significant increase in total protein content was observed with enhancement of the soaking time from 22.60g/100g to 28.77g/100g.

Processed Quinoa whole Fibre content was lower after soaking and germination, (Q4 – Q8) as compare to unprocessed quinoa whole (Q0). On soaking and germination protein content was found to same (P>0.05) but it decreased germination. Abdulsalami *et al.,* (2010) also reported a decrease in fibre content after processing. A significant difference in carbohydrate content was observed after processing of quinoa whole. On germination and soaking of Quinoa whole carbohydrate content was found to decrease as compared to unprocessed Quinoa whole (Q0).

Table 4.10: Effect of soaking and germination on proximate analysis of Quinoa seed whole (QW):

Processing	Nutrients (g/100g)													
	Moisture (g)		**Crude Fat (g)**		**Total Ash (g)**		**Crude Protein (g)**		**Crude fibre (g)**		**Carbohydrates (g)**		**Energy (kcal)**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Q0	4.09	0.61	5.6	0.15	3.56	1.67	12.52	0.73	8.98	0.84	65.25	1.45	361.49	7.11
Q1	3.5	0.53	2.45	0.16	3.41	0.16	12.98	0.35	7.39	0.13	64.70	0.06	352.00	7.53
Q2	4.4	0.50	1.87	0.28	3.17	0.10	13.09	0.45	7.09	0.03	64.39	0.14	331.75	6.24
Q3	5.2	0.23	1.35	0.22	3.04	0.04	12.59	0.28	7.94	0.13	64.12	0.08	316.00	4.24
Q4	3.9	0.13	1.31	0.24	2.83	0.21	14.81	0.11	8.36	0.32	63.55	0.34	296.50	9.13
Q5	4.3	0.12	1.36	0.23	3.02	0.04	13.64	0.42	8.80	0.26	62.99	0.08	282.00	5.10
Q6	5.7	0.23	1.18	0.14	2.64	0.31	14.45	0.09	8.30	0.12	62.62	0.14	264.00	4.32
Q7	4.3	0.45	0.94	0.15	2.69	0.20	13.04	0.04	7.78	0.39	62.22	0.10	253.00	4.24
Q8	4.9	0.19	0.90	0.16	2.14	0.07	14.53	0.19	8.25	0.05	62.04	0.05	240.00	5.92
SE	0.27		0.24		0.04		0.13		0.09		0.84		1.76	
CD5%	1.58**		0.57**		0.23**		0.37**		0.25**		0.14**		5.18**	
CD1%	1.80*		0.78*		0.31*		0.50*		0.34*		0.19*		7.06*	
CV	7.04		7.77		5.56		2.39		2.85		0.15		1.20	

QW= Quinoa seed whole, Q0= No processing, Q1=6 hr Soaking, Q2=12 hr Soaking, Q3=18 hr Soaking, Q4=24 hr Soaking, Q5= 12hr germination, Q6= 24 hr Germination, Q7=36 hr Germination+, Q8= 48 hr Germination, ** significant and * significant at 5% and 1% level of significance, NS = Non significant.

This may be due to increase in content of starch on soaking and germination. There was a significant difference in energy content among quinoa whole flours. Energy content ranged between 361 kcal to 240 kcal respectively. The starch content

of horsegram flour decreased significantly with soaking 46.10g/100g (0h) to 31.85 g/100g (18 h) as during soaking, leaching of modification in structural components of the legume and therby increasing the availability of starch as reported. Another reason for the reduction in carbohydrate content can be due to the use of carbohydrate as source of energy for embryonic growth (Vidal-Valverde *et al.,* 2002).

The major mineral content as calcium, iron, zinc, Potassium and phosphorus in Quinoa whole after processing is presented in Table 4.11.

There was a significant difference in calcium content of quinoa whole after processing (Q1- Q8) and it was found lower than unprocessed quinoa whole (Q0). Zinc content of was found lower after soaking (Q1 – Q4) and higher after germination (Q5– Q8) as compared to unprocessed Quinoa whole (Q0). Saikia *et al.,* (1999) measured phytic acid, tannin and trypsin inhibitor activity and found that phytic acid lowers the availability of P, Zn, and calcium and other minerals. Processing techniques have been found to reduce significantly the level of phytate and tannin (Ahmed *et al.,* 2006). So, it can be said that the higher content of calcium and zinc after processing of Quinoa whole was because of decreased phytate.

4.11: Effect of soaking and germination on mineral composition of Quinoa seed whole (QW):

Processing	Calcium(mg)		Iron(mg)		Zinc(mg)		Potassium (mg)		Phosphorus (mg)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Q0	86.3	0.6	15.0	0.1	4.0	0.1	732.0	5.5	411.0	4.10
Q1	84.02	0.05	14.59	0.19	3.83	0.10	754.75	4.99	477.75	5.84
Q2	83.61	0.26	14.46	0.09	3.57	0.06	769.00	4.34	441.00	8.00
Q3	83.14	0.08	14.16	0.07	3.30	0.20	740.25	4.38	412.25	4.03
Q4	82.86	0.16	13.91	0.11	3.22	0.13	718.50	6.39	369.50	6.98
Q5	82.17	0.15	14.73	0.14	4.72	0.15	760.25	8.26	438.00	8.83
Q6	81.77	0.19	14.64	0.56	4.47	0.10	739.50	7.75	466.00	4.45
Q7	81.39	0.15	13.83	0.79	4.20	0.10	767.50	5.26	468.25	8.25
Q8	80.09	0.12	13.27	0.05	3.92	0.09	725.75	6.11	412.75	10.34
SE	0.04		0.18		1.00		7.41		8.52	
CD5%	0.11**		0.52**		0.13**		2.79**		5.06**	
CD1%	0.15*		0.708*		0.18*		9.67*		7.12*	
CV	0.096		2.12		2.35		1.984		3.913	

QW= Quinoa seed whole, Q0= No processing, Q1=6 hr Soaking, Q2=12 hr Soaking, Q3=18 hr Soaking, Q4=24 hr Soaking, Q5= 12hr germination, Q6= 24 hr Germination, Q7=36 hr Germination, Q8= 48 hr Germination, ** significant and * significant at 5% and 1% level of significance, NS = Non significant.

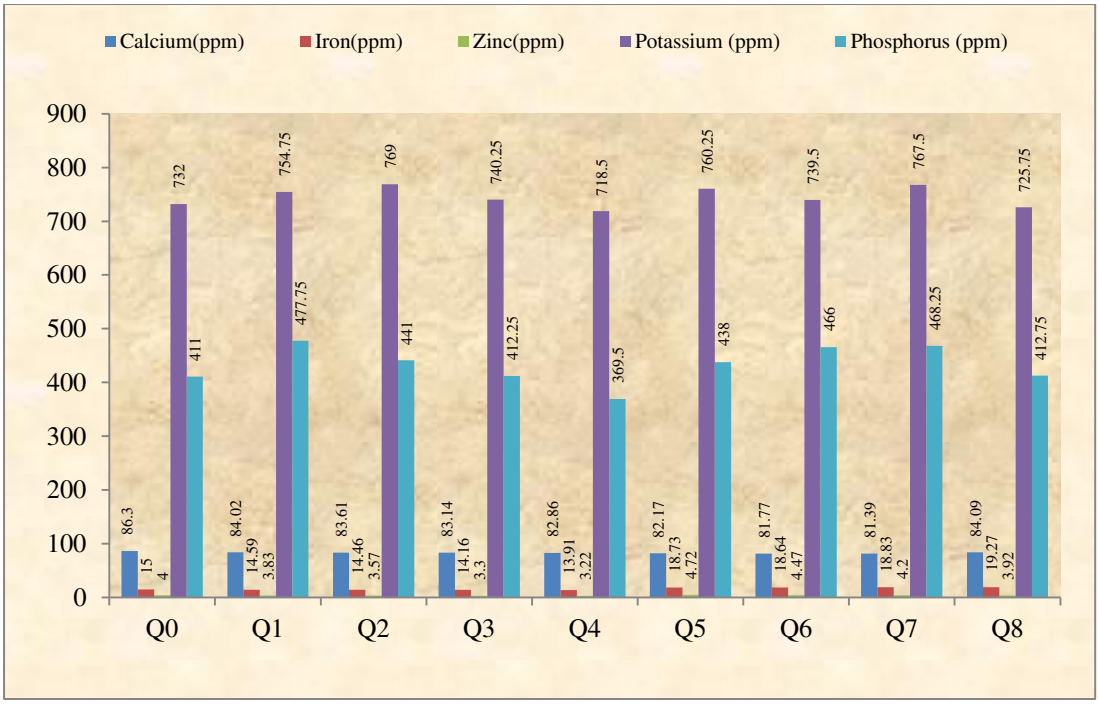


Fig:4.3 Effect of soaking and germination on mineral composition of Quinoa seed whole (QW):

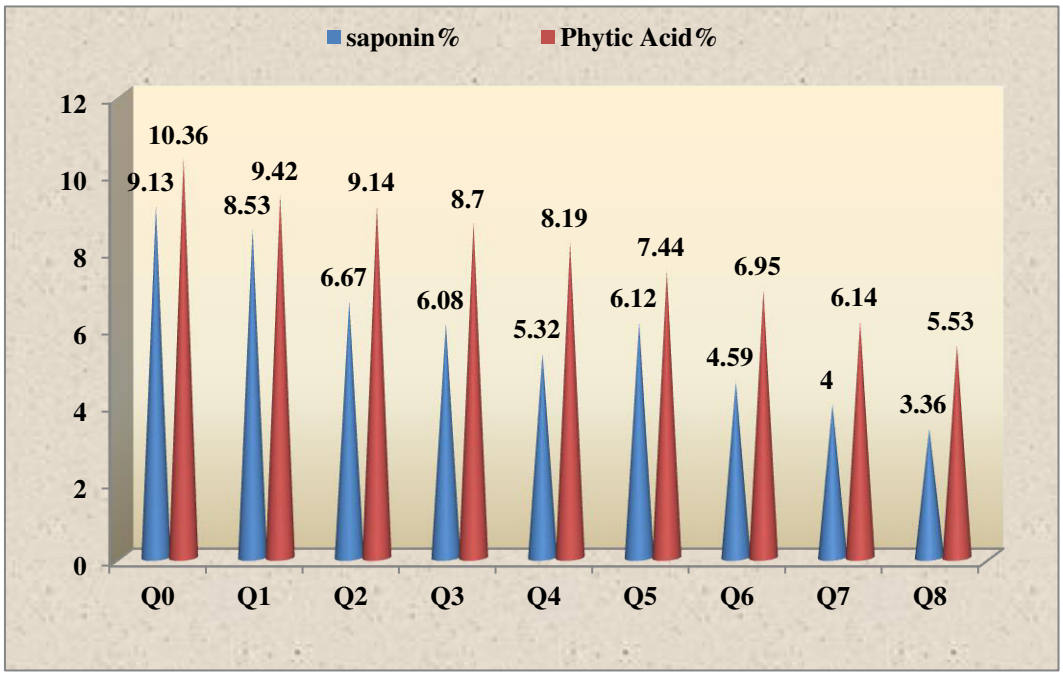


Fig. .4.4 : Effect of soaking and germination on antinutritients of Quinoa seed whole (QW):

Iron content of processed Quinoa whole was found lower in soaking and higher in germination as compare to unprocessed Quinoa whole (Q0:15). The iron content was found slightly lower in over soaking (18 hr, 24 hr) as compare to unprocessed flour. Saharan *et. al.,* (2001) studied the effects of cooking method on Ca, Fe, and P. It was reported that soaking and sprouting reduced the content of these minerals slightly, probably due to leaching into the soaking medium.

The Potassium content of Quinoa whole was found to increase with soaking duration of 6 hr,12hr ,18 hr and 24 hr (Q1, Q2, Q3) and germination 24 hr,36hr and 48hr (Q5, Q6, Q7, Q8) as compare to unprocessed Quinoa whole (Q0). The Phosphorus content of Quinoa whole was found to increase with soaking duration of 6 hr,12hr and lower in 18 hr and 24 hr and higher in germination 24 hr,36hr and 48hr as compare to unprocessed Quinoa whole (Q0).Saharan *et. al.* (2001) reported that inexpensive and simple processing treatments had significant positive in part on *in vitro* availability of the minerals, most likely due to a reduction in anti-nutrients as phytic acid.

The Findings of anti-nutrients as saponin and phytic acid in Quinoa whole after processing are reported in Table 4.12.

Table 4.12: Effect of soaking and germination on anti-nutrients of Quinoa whole (QW):

	Saponin%		**Phytic Acid%**	
	Mean	**SD**	**Mean**	**SD**
Q0	9.13	0.80	10.36	1.90
Q1	8.53	0.19	9.42	0.11
Q2	6.67	0.29	9.14	0.10
Q3	6.08	0.11	8.70	0.24
Q4	5.32	0.18	8.19	0.12
Q5	6.12	0.57	7.44	0.17
Q6	4.59	0.37	6.95	0.14
Q7	4.00	0.15	6.14	0.21
Q8	3.36	0.17	5.53	0.24
SE	0.08		1.21	
CD5%	0.23**		0.14**	
CD1%	0.31*		0.19*	
CV	2.84		0.05	

QW= Quinoa seed whole, Q0= No processing, Q1=6 hr Soaking, Q2=12 hr Soaking, Q3=18 hr Soaking, Q4=24 hr Soaking, Q5= 12hr germination, Q6= 24 hr Germination, B7=36 hr Germination, B8= 48 hr Germination, ** significant and * significant at 5% and 1% level of significance, NS = Non significant.

Though there was significant difference found in saponin content of Quinoa whole after processing gradually decreasing in Saponin was observed and was lowest in soaking for 24 hr (Q1: 8.53%) and in germination lowest was (Q8: 3.36%) as compared to unprocessed Quinoa whole (Q0:9.13%). As compared to unprocessed Quinoa whole (Q0) a continuous degradation was observed in phytic acid after processing (Q1 to Q8). Shimelis and Rakshit (2007) also obtained a notable reduction (over 75%) in phytic acid in three kidney bean varieties after germination.

Processing techniques as soaking, cooking, germination and fermentation have been found to reduce significantly the level of phytate and tannin by exogenous and endogenous enzyme formed during processing. Germination of seeds decreases tannin and phytic acid contents of the guar gum seeds with decrease in albumin fraction (Ahmed *et al*., 2006).The findings of total anti-oxidant activity in Quinoa whole after processing are reported in Table 4.13. Though there was Non significant difference found in anitioxidant activity of Quinoa whole after processing increase activity was observed and was lowest in soaking for 6 hr (Q1: 85.34%) and maximum in 24 hr (Q4 : 92.26%)as compared to unprocessed Quinoa whole (Q0:44.34). Quinoa whole after processing Shows that increase in activity was observed with germination (Q5 to Q8) As compared to unprocessed Quinoa whole (Q0) a continuous up degradation was observed in anti oxidant after processing (Q1 to Q8). It shows that germination for long duration is more beneficial. Intelli *et al.,* (2016) Domestically processed, mainly by germination is reported to be rich in antioxidants, vitamin C and higher phenolic content. The results suggest use of domestic processing of seeds to retain nutrient value and also infer dietary importance of Indian Chenopodium . Pawel Pasko *et al.,* (2009). In sprouts grown in the daylight and in the darkness we observed some significant changes of total phenolic contents (TP) and anthocyanins contents and antioxidant activity. Amaranth and seeds and sprouts can be used in food, because it is a good source of ANT and TP with high antioxidant activity.

Table 4.13: Effect of soaking and germination on Total antioxidant activity of Quinoa whole (QW):

Flour	Treatment	Total antioxidant activity	
		Mean	SD
QW	Q0	44.34	2.19
	Q1	85.34	0.45
	Q2	89.92	0.07
	Q3	91.17	0.15
	Q4	92.26	0.24
	Q5	92.34	0.23
	Q6	95.59	0.28
	Q7	96.65	0.19
	Q8	97.72	0.14
	SE	13.05	
	CD5%	8.365 **NS**	
	CD1%	12.234 **NS**	
	CV	28.168	

QW= Quinoa seed whole, Q0= No processing, Q1=6 hr Soaking, Q2=12 hr Soaking, Q3=18 hr Soaking, Q4=24 hr Soaking, Q5= 12hr germination, Q6= 24 hr Germination, Q7=36 hr Germination, Q8= 48 hr Germination, ** significant and * significant at 5% and 1% level of significance, NS = Non significant.

4.2.2: Quinoa Dehulled (QD):

Effects of processing methods on anti nutrients of Quinoa Dehulled are presented in Table 4.14. Effect of processing methods on chemical composition as proximate analysis, mineral profile and anti nutrients of Quinoa Dehulled are presented in Table 4.14 to 4.16.Proximate composition of Quinoa Dehulled is presented in Table 4.14. Moisture content of Quinoa Dehulled was found significantly decreased after soaking increased after germination. Fat content was significantly decreased after germination and slightly decrease after soaking for 24hr as compared to unprocessed Quinoa Dehulled (Q0: 3.88 g/100g).

Table 4.14: Effect of soaking and germination on proximate analysis of Quinoa seed Dehulled (QD)

Processing	Nutrients g/100g													
	Moisture		Fat		Ash		Protein		Fiber		CHO		Energy(Kcal)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Q0	2.89	0.45	3.88	0.735	2.56	0.81	12.23	0.09	7.99	0.38	63.56	1.99	377.04	3.59
Q1	1.19	0.40	3.36	0.33	2.27	0.15	14.81	0.11	7.22	0.16	62.99	0.08	365.00	4.76
Q2	0.95	0.06	2.80	0.19	2.25	0.22	14.53	0.11	6.51	0.34	62.62	0.14	354.75	6.88
Q3	1.81	0.19	3.14	0.21	2.11	0.09	15.26	0.18	6.35	0.19	62.22	0.10	332.75	4.50
Q4	1.02	0.17	2.47	0.34	2.20	0.11	14.31	0.16	6.94	0.14	62.04	0.05	319.50	2.89
Q5	2.48	0.39	1.52	0.25	1.80	0.26	15.07	0.09	6.70	0.24	61.71	0.17	291.25	10.72
Q6	3.22	0.25	1.37	0.10	1.64	0.24	15.86	0.06	6.11	0.09	61.30	0.11	254.25	9.43
Q7	3.67	0.32	1.39	0.35	1.28	0.15	15.52	0.11	7.83	0.14	61.11	0.06	239.50	7.72
Q8	4.69	0.20	1.06	0.27	1.25	0.08	15.50	0.11	7.08	0.11	60.16	0.57	242.00	12.45
SE	0.14		0.13		0.08		2.01		0.08		0.09		4.71	
CD5%	0.40**		0.393**		0.243**		0.538**		0.224**		0.256**		13.855**	
CD1%	0.549*		0.535*		0.330*		0.392*		0.305*		0.349*		11.863*	
CV	1.527		2.507		8.926		3.818		2.452		0.282		3.142	

Q0= No processing, Q1=6 hr Soaking, Q2=12 hr Soaking, Q3=18 hr Soaking, Q4=24 hr Soaking, Q5= 12hr germination, Q6= 24 hr Germination, Q7=36 hr Germination, Q8= 48 hr Germination, ** significant and * significant at 5% and 1% level of significance, NS = Non significant.

There was a significant decrease in ash content after processing of Quinoa Dehulled ranged from Q4 (2.20g/100g) to Q8 (1.25g/100). Significant difference was observed in protein content after processing. Fibre analysis of Quinoa Dehulled after soaking and germination revealed a significant decrease as compared to unprocessed Quinoa Dehulled (Q0). The range of fiber content was observed between 7.99g/100 to 6.11 g/100g in processed Quinoa Dehulled.

Ocheme and Chinma (2008) reported a significant increase in protein content after soaking and germination, while Abdulsalami *et al.,* (2010) also found a substantial recovery of crude protein after processing from 20.27 to 23.63 (g/100 dry weight) and decreased crude fibre content 6.85 to 4.64 (g/ 100g.dry weight). A significant difference was observed in carbohydrate content of Quinoa Dehulled after soaking and germination. Carbohydrate was observed slightly decreased after soaking

(Q1 to Q8) and germination as compared to unprocessed Quinoa Dehulled (Q0). During soaking, starch content leached out in the form of slime, as during soaking and germination steps of Quinoa seed, slime was washed with running tap water to remove unfavourable smell. Lower carbohydrate content may be due to continuous washing of Quinoa seed during soaking and germination steps. This also reflects as energy content after soaking and germination of Quinoa seed ranged from (377 Kcal to 239 kcal. Abulsalami *et al.,* (2010) also observed a significant increase in moisture content after processing.

Ocheme and Chinma (2008) studied the effects of soaking and germination on some physico-Chemical properties of millet flour and found a significantly decreased level in fat content as a result of soaking and germination.

Mineral composition of Quinoa Dehulled after soaking and germination is presented in Table 4.15. A significant difference was observed in calcium content after processing of Quinoa Dehulled. It was observed that calcium content gradually decreased after soaking and germination (Q1 – Q8) as compared to unprocessed Quinoa Dehulled (Q0). Saharan *et al.,* (2001) studied the effects of cooking methods on Ca, Fe and P and observed that inexpensive and simple treatments had significant positive impact on the *in vitro* availability of the minerals, most likely due to a reduction in anti-nutrients such as phytic acid.

Iron content was significantly ($P< 0.05$) decreased in 6 hr to 24 hr soaking (13.63 ppm to 11.84 ppm) and was found increase in germination for 24 hr to 36 hr (14.75 ppm, 16.45 ppm). Saharan *et al.,* (2001) reported that soaking and sprouting reduced the content of iron slightly, probably due to leaching into soaking medium. Zinc content of Quinoa Dehulled was found to be significantly decreased after soaking and (Q1-Q4) increased after germination (Q5-Q8) as compared to unprocessed Quinoa Dehulled (Q0). The Potassium content of Quinoa whole was found to increase with soaking duration and germination as compare to unprocessed Quinoa whole (Q0). The Phosphorus content of Quinoa Dehulled was found to increase with soaking duration and higher in germination as compare to unprocessed Quinoa whole (Q0).

Table 4.15: Effect of soaking and germination on mineral composition of Quinoa seed Dehulled (QD):

Processing	Calcium(mg)		Iron(mg)		Zinc(mg)		Potassium (mg)		Phosphorus (mg)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Q0	55.1	0.4	14.2	0.1	4.0	0.1	656.0	4.3	404.9	3.0
Q1	54.42	0.11	13.63	0.12	4.11	0.07	753.25	6.29	437.75	10.69
Q2	54.15	0.06	13.33	0.11	3.89	0.12	749.75	7.79	419.75	8.30
Q3	53.84	0.14	13.05	0.06	3.63	0.07	759.75	7.58	386.00	10.80
Q4	53.39	0.14	11.84	0.14	3.41	0.07	759.75	6.42	357.00	9.20
Q5	53.08	0.08	14.75	0.16	6.51	0.19	842.50	7.06	446.00	9.38
Q6	45.25	0.63	12.26	0.23	6.13	0.10	814.50	4.18	425.50	4.43
Q7	52.45	0.20	13.70	0.24	5.72	0.23	782.75	3.62	409.25	7.04
Q8	51.83	0.25	13.45	0.33	5.23	0.11	748.25	9.88	364.00	8.15
SE	2.04		0.04		0.04		12.58		4.35	
CD5%	0.323**		6.013**		0.121**		5.00**		12.792**	
CD1%	0.440*		8.187*		0.165*		5.375*		7.416*	
CV	0.420		1.706		1.706		3.241		2.144	

Q0= No processing, Q1=6 hr Soaking, Q2=12 hr Soaking, Q3=18 hr Soaking, Q4=24 hr Soaking, Q5= 12hr germination, Q6= 24 hr Germination, Q7=36 hr Germination , Q8= 48 hr Germination, ** significant and * significant at 5% and 1% level of significance, NS = Non significant.

Results of effect of processing on anti-nutritional factors of Quinoa Dehulled are presented in Table 4.16. Doss *et al.,* (2011) studied the effects of processing at different methods like soaking, cooking and autoclaving on the contents of anti-nutritional compounds and crude protein and found that soaking and cooking decreases the levels of anti nutrients .

As described previously that soaking and germination increases the availability of minerals due to reduction in anti nutritional factors. Results of effect of processing on anti nutritional factors of Quinoa Dehulled are presented in Table 4.16. Doss *et al.,* (2011) studied the effects of processing at different methods like soaking, cooking and autoclaving on the contents of anti-nutritional compounds and crude protein and found that soaking and cooking decreases the levels of anti nutrient

Table: 4.16: Effect of soaking and germination on anti-nutrients of Quinoa seed Dehulled (QD)

Processing	Saponin%		Phytic Acid%	
	Mean	SD	Mean	SD
Q0	4.16	1.00	6.23	2.40
Q1	2.61	0.28	5.17	0.15
Q2	2.17	0.10	4.48	0.25
Q3	1.67	0.24	4.05	0.06
Q4	1.16	0.07	3.64	0.29
Q5	2.36	0.19	4.11	0.15
Q6	1.78	0.27	3.58	0.27
Q7	1.42	0.07	2.97	0.14
Q8	1.10	0.08	2.25	0.24
SE	0.06		0.05	
CD5%	0.184**		0.141**	
CD1%	0.250*		0.191*	

Q0= No processing, Q1=6 hr Soaking, Q2=12 hr Soaking, Q3=18 hr Soaking, Q4=24 hr Soaking, Q5= 12hr germination, Q6= 24 hr Germination, Q7=36 hr Germination, Q8= 48 hr Germination, ** significant and * significant at 5% and 1% level of significance, NS = Non significant.

Phytic acid content in Quinoa Dehulled was found highest in soaking for 6hr (Q1) and germination for 12 hr (Q5). Phytic acid was found lowest in 48 hr germination (Q8). It was also found that phytic acid was reduced more in germination as compared to soaking for 6 hr (Q3) to 24 hr (Q4). Germination of seeds decreases phytic acid contents of the guar gum seeds with decrease in albumin fraction (Ahmed *et al*., 2006).

The findings of total anti oxidant activity in quinoa dehulled after processing are reported in Table 4.17. Though there was significant difference found in anitioxidant activity of Quinoa dehulled after processing increased activity was observed and was lowest in soaking for 6 hr (Q1: 85.82%) and maximum in 24 hr (Q4 : 95.34%)as compared to unprocessed Quinoa dehulled (Q0:44.34). Quinoa whole after processing shows that maximum increase in activity was observed with germination (Q5 to Q8) as compared to unprocessed Quinoa dehulled (Q0) a continuous up gradation was observed in anti oxidant after processing (Q1 to Q8). It

shows that germination for long duration is more beneficial. Intelli *et al.,* (2016) in this study antioxidant activity of germinated seeds (after 4 days or 48 hours) was found to increase by 90% (calculated by DPPH method). The result is supported by findings of Carciochi *et al.,* (2014) which showed 100% increase in antioxidant activity of germinated Quinoa seeds as evaluated by DPPH method. Similarly, increase in antioxidant activity of germinated Quinoa seeds has also been reported by Pawel *et al.,* (2009). FRAP values of germinated Quinoa seeds increased by 89%. Domestically processed , mainly by germination is reported to be rich in antioxidants, vitamin C and higher phenolic content. The results suggest use of domestic processing of Quinoa seeds to retain nutrient value and also infer dietary importance of Indian Chenopodium.

Table 4.17: Effect of soaking and germination on total antioxidant activity of Quinoa Dehulled seed (QD):

Flour	Treatment	Total antioxidant activity	
		Mean	**SD**
QW	Q0	32.54	0.94
	Q1	85.82	0.15
	Q2	94.30	0.21
	Q3	94.83	0.13
	Q4	95.34	0.28
	Q5	91.17	0.80
	Q6	96.69	0.19
	Q7	97.09	0.15
	Q8	97.54	0.19
	SE	0.12	
	CD5%	0.342**	
	CD1%	0.466*	
	CV	0.247	

Q0= No processing, Q1=6 hr Soaking, Q2=12 hr Soaking, Q3=18 hr Soaking, Q4=24 hr Soaking, Q5= 12hr germination, Q6= 24 hr Germination, Q7=36 hr Germination , Q8= 48 hr Germination, , ** significant and * significant at 5% and 1% level of significance, NS = Non significant

The Quinoa whole and Quinoa Dehulled were processed separately as soaking (6, 12, 18, 24 hr) and germination (12,24,36,48 hr). Chemical properties were also analysed

and on the basis of nutritional composition and minimum anti-nutrients, 24hour germination processed Quinoa Dehulled was most acceptable.

4.3: PHASE3: DEVELOPMENT OF PRODUCT

4.3.1: Selection and preparation of products –

In the present investigation 12 products was developed, namely *Chapati, Biscuit, Namkeen, Khakhra, Handwa, ladoo, patty, chilla, sattu, utapam, khaman, cake* were selected for incorporating Quinoa dehulled flour (QD)in proportion of 40, 60, 80, 100 percent.

4.3.2: Organoleptic Evaluation and Nutritional Quality evaluation -

Sensory evaluation is a scientific discipline that analyses and measures human responses to the composition and nature of foods and drink. A scientific discipline used to evoke, measure, analyze and interpret reactions to those characteristics of food and materials as they are perceived by senses of sight, smell, taste, touch and hearing. (**INSTITITE OF FOOD TECHNOLOGISTS; USA**) Perceivable sensory characteristics have always been recognized to be the deciding factor in the acceptance and enjoyment of referred by masses and have an edge over other equally important nutritional and safety aspects. Therefore, all developed products were subjected to sensory evaluation (colour, appearance, flavour, texture, taste and overall acceptability on nine point hedonic rating scale by panel of 30 members. Sensory scores as assigned by the panel members for individual sensory attributes and overall acceptability were statistically analyzed and are presented in Table 4.18 to 4.29 for products *Chapati, Biscuit, Namkeen, Khakhra, Handwa, Ladoo, Patty, Chilla, Sattu, Utapam, Khaman, Cake* respectively.

Chapati:

Quinoa seed dehulled flour and scores assigned for sensory attributes by panel members are present in Table 4.18. Highest score for colour was assigned to incorporated Quinoa seed dehulled Quinoa flour *Chapati* (8.20 ± 0.66) followed by 40% per cent, (8.83± 0.87), 60 percent (7.60±0.56), 80 percent and (7.50±0.94) 100 percent.

Table 4.18: Sensory evaluation of *Chapati* with incorporation of Quinoa seed dehulled flour at various levels:

Variations	Sensory attributes											
	Colour		Appear		Texture		Aroma		Taste		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	9.00	0.78	8.47	0.86	8.47	0.78	8.50	0.57	8.30	0.70	8.33	0.68
40%	8.20	0.66	8.07	0.87	8.43	0.57	8.50	0.56	8.63	0.56	8.39	0.51
60%	8.83	0.87	8.67	0.89	7.93	0.83	8.47	0.65	8.87	0.90	8.85	0.74
80%	7.60	0.56	7.23	0.77	7.87	0.86	7.67	0.71	7.73	0.83	7.69	0.61
100%	7.50	0.94	6.70	0.79	7.03	0.80	7.87	1.07	7.97	0.67	7.78	0.78
SE	0.11		0.09		1.67		0.15		0.11		0.02	
CD5%	0.48*		0.40*		0.44*		0.69*		0.49*		0.23*	
CD1%	0.53**		0.65**		0.50**		0.42**		0.33**		0.30**	

* Significant and ** significant at 5% and 1% level of significance, NS = Non significant

Sensory score for appearance was observed highest for 60 percent incorporated Quinoa seed dehulled flour *Chapati* (8.67±0.89) followed by 40 percent, 80 percent and 100 percent. Highest Score for texture was found in *Chapati* incorporated with 40 percent (8.43 ± 0.57) Quinoa seed dehulled flour followed by 60 percent (7.93 ± 0.83), 80 percent (7.87 ± 0.86) and 100 percent (7.03 ± 0.80). Aroma of *Chapati,* was found highly acceptable (8.50 ± 0.57) for 40 percent, and 60 percent (8.47 ± 0.65) incorporation of Quinoa seed dehulled flour. *Chapati* containing 60 percent Quinoa seed dehulled flour was found most acceptable for taste (8.87 ± 0.56) as compared to 40, 80, 100 percent.

Overall acceptability of 60 per cent Quinoa seed dehulled flour incorporated *Chapati* was highest among *Chapati.* Significant difference between variations (40, 60, and 80,100) for all sensory attributes was observed in the *Chapati*. As per sensory attributes the *Chapati* replacing 60 percent flour is considered best for recommendation.

Biscuit:

The present table shows that Highest score for colour was assigned to incorporated Quinoa seed dehulled flour *Biscuits* (8.20±0.66) followed by 40% per cent (7.83 ± 0.87), 60 percent (7.60± 0.56) 80 percent (7.00±0.94)100 percent.

Table 4.19: Sensory evaluation of *Biscuit* with incorporation of Quinoa seed dehulled flour at various levels:

Variations	Sensory attributes											
	Colour		Appear		Texture		Aroma		Taste		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	8.27	0.78	8.66	0.86	8.78	0.78	8.80	0.57	8.39	0.70	8.83	0.68
40%	8.20	0.66	8.07	0.87	8.43	0.57	8.47	0.57	8.63	0.56	8.39	0.51
60%	7.83	0.87	7.67	0.84	7.93	0.83	7.83	0.65	7.87	0.90	7.85	0.74
80%	7.60	0.56	7.23	0.77	7.87	0.86	7.67	0.71	7.73	0.83	7.69	0.61
100%	7.00	0.94	6.70	0.79	7.03	0.85	7.87	1.07	7.97	0.67	7.78	0.78
SE	0.10		0.01		0.15		0.19		0.23		0.32	
CD5%	0.41**		0.37**		0.12**		0.46**		0.39**		0.47**	
CD1%	0.54*		0.58*		0.50*		0.52*		0.51*		0.35*	

* Significant and ** significant at 1% and 5% level of significance, NS = Non significant

Sensory score for appearance was observed highest for 40 percent incorporated Quinoa seed dehulled flour *Biscuits* (8.07±0.87) followed by 60 percent, 80 percent and 100 percent. Highest Score for texture was found in *Biscuits* incorporated with Quinoa seed dehulled flour followed by 40 percent (8.43 ± 0.57), 60 percent (7.93 ± 0.83) 80 percent (7.87 ± 0.86) and decrease in texture was observed at 100 per cent level (7.03 ± 0.85). Aroma of *Biscuits,* was found highly acceptable (8.47 ± 0.57) for 40 percent incorporation of Quinoa seed dehulled flour. A slight decrease in scores of aroma was observed in 60 percent, 80 percent and 100 percent proportions of *Biscuits*. *Biscuits* containing 40 percent Quinoa seed dehulled flour (QDF) was found most acceptable for taste (8.63 ± 0.56) as compared to 60, 80, 100 percent.

Overall acceptability of 40 per cent Quinoa seed dehulled flour incorporated *Biscuit* was highest among *Biscuits.* Significant difference between variations (40, 60, and 80,100) for all sensory attributes was observed in the biscuits. As per sensory attributes the biscuits replacing 40 percent flour is considered best for recommendation.

Namkeen:

Namkeen was prepared through incorporation of 40, 60, 80, 100 per cent Quinoa seed dehulled flour and sensory evaluation of each percent is presented in Table 4.20. Between all proportions colour was found highly acceptable in 60 percent QDF incorporated *Namkeen* (8.30 ± 0.798). As 40 percent QDF incorporated *Namkeen* was highly acceptable in terms of appearance as compare to other (40, 60, 80, 100 percent) proportions.

Table 4.20: Sensory evaluation of *Namkeen* with incorporation of test flour at various levels:

Variations	Sensory attributes											
	Colour		Appear		Texture		Aroma		Taste		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	8.67	0.79	8.73	0.90	8.07	0.98	8.57	0.94	8.43	0.50	8.84	0.53
40%	8.54	0.87	8.30	0.66	8.20	0.99	8.40	1.04	8.57	0.97	8.60	0.72
60%	8.30	0.58	7.80	0.71	8.27	0.87	8.13	0.73	8.37	0.81	8.68	0.50
80%	8.00	1.14	7.57	0.50	7.07	1.14	7.67	0.84	7.40	1.10	7.87	0.96
100%	7.27	0.78	7.53	0.78	6.33	0.71	7.40	0.62	7.30	0.71	7.35	0.58
SE	0.03		0.11		0.05		0.22		0.04		0.10	
CD5%	0.31**		0.22**		0.40**		0.34**		0.44**		0.30**	
CD1%	0.44*		0.35*		0.76*		0.42*		0.53*		0.13*	

* significant and ** significant at 1% and 5% level of significance, NS = Non significant

Sensory evaluation of texture of 60 percent QDF *Namkeen* revealed the highest score (8.27 ± 0.87) among other proportions. (40, 80, 100 percent). But 80 percent level of incorporation of QDF in *Namkeen* was observed "like moderately" for appearance and texture. Sensory score of QDF incorporated *Namkeen* in 60 to 100 per cent proportions were liked slightly by panel members in term of colour. Aroma was observed highly acceptable in 40 and 60 percent QDF incorporated *Namkeen* (8.40 ± 1.04 and 8.13 ± 0.73) as compared to other proportions.Sensory evaluation of 40 percent and 60 percent QDF taste of incorporated *Namkeen* was liked very much

(8.57 ± 0.97), (8.37±0.81) among all proportions. Taste of 80, 100 percent QDF incorporated was liked moderately (7.40 ± 1.10, 7.30±0.71). Overall acceptability was found highest in 60 percent QDF incorporated *Namkeen* (8.68± 0.50) followed by 60 percent. In view of results 60 percent considered best for commercialization .

Khakhra:

Sensory evaluation of *Khakhra* incorporated with QDF in different proportions are presented Table 4.21. Sensory score of colour was found highest in 40 percent QDF incorporated *Khakhra* (8.67 ± 0.64) as compared to 60, 80, 100 percent. Appearance of 40 percent *Khakhra* incorporated with QDF was "liked very much" (8.37 ± 0.87) followed by 60 percent (8.23 ± 0.84) and 100 percent (8.10 ± 0.79). Sensory scores of texture was observed highest for 40 per cent QDF incorporated *Khakhra* and 60, 80 percent variation was Also liked very much ,while texture of *Khakhra* 100 per cent QDF was liked very much. Overall acceptability of *Khakhra* incorporated with 40 percent QDF was highest, as compared to 60, 80,100 percent. Sensory evaluation of *Khakhra* revealed that 40 percent incorporation of QDF was most acceptable percentage among all proportions.

Table 4.21: Sensory evaluation of *Khakhra* with incorporation of test flour at various levels:

Variations	Sensory attributes											
	Colour		Appear		Texture		Aroma		Taste		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	8.50	0.63	8.47	0.86	8.33	0.76	8.47	0.86	8.47	0.86	8.45	0.73
40%	8.67	0.64	8.37	0.87	8.20	0.66	8.39	0.78	8.23	0.63	8.38	0.59
60%	8.53	0.72	8.23	0.84	8.10	0.88	8.25	0.89	8.38	0.82	8.23	0.73
80%	8.27	0.51	8.13	0.77	8.03	0.90	8.11	0.99	8.23	1.01	8.19	0.73
100%	8.13	0.63	8.10	0.79	8.00	0.78	8.06	0.62	8.17	0.86	8.03	0.56
SE	0.01		0.19		0.10		0.04		0.02		0.12	
CD5%	0.71**		0.36**		0.49**		0.36**		0.43**		0.23**	
CD1%	0.24*		0.85*		0.46*		0.22*		0.33*		0.63*	

* significant and ** significant at 1% and 5% level of significance, NS = Non significant

Handwa:

Results of the sensory evaluation of the *Handwa* prepared with 40, 60, 80 ,100 per cent incorporation of Quinoa seed dehulled flour. Scores were observed to be highest for all the sensory characteristics with an overall acceptability of 8.65±0.73 suggesting that the control *Handwa* was "Liked very much" by the panel members. Sensory evaluations of *Handwa* incorporated with QDF in different proportions are presented Table 4.22. Sensory score of colour was found highest in 40 percent QDF incorporated *Handwa* (8.17 ± 0.60) as compared to 60, 80, 100 percent. Appearance of 40 percent *Handwa* incorporated with QDF was "liked very much" (8.07 ± 0.85) followed by 60 percent (8.03 ± 0.88). Sensory scores of texture was observed highest for 40 per cent QDF incorporated *Handwa* and 60 percent variation was Also liked very much ,while texture of *Handwa* 100 per cent QDF was liked moderately . Overall acceptability of *Handwa* incorporated with 40 percent QDF was highest, as compared to 60, 80,100 percent. Sensory evaluation of *Handwa* revealed that 40 percent incorporation of QDF was most acceptable percentage among all proportions.

Table 4.22: Sensory evaluation of *Handwa* with incorporation of test flour at various levels:

Variations	Sensory attributes											
	Colour		Appear		Texture		Aroma		Taste		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	8.34	0.63	8.27	0.86	8.83	0.76	8.76	0.86	8.77	0.86	8.65	0.73
40%	8.17	0.60	8.07	0.85	8.20	0.66	8.39	0.78	8.23	0.63	8.38	0.59
60%	8.03	0.72	8.03	0.88	8.00	0.88	8.05	0.89	8.08	0.82	8.13	0.73
80%	8.00	0.51	7.95	0.77	7.33	0.90	8.00	0.99	7.23	1.01	7.79	0.73
100%	7.89	0.63	7.10	0.79	7.00	0.78	7.76	0.62	7.17	0.86	7.43	0.56
SE	0.05		0.11		0.09		0.04		0.17		0.10	
CD5%	0.21**		0.42**		0.32**		0.69**		0.60**		0.39**	
CD1%	0.56*		0.65*		0.36*		0.22*		0.03*		0.13*	

* significant and ** significant at 1% and 5% level of significance, NS = Non significant

Ladoo:

Sensory evaluation of dehulled Quinoa seed incorporated *Ladoo* in different proportion along with control has been presented in Table 4.23. The overall mean score of dehulled Quinoa seed added *Ladoo* ranged from 7.43±0.19 to 8.08±0.05. This indicated that the dehulled Quinoa seed added *Ladoo* were found to fall under the category of "Liked very much" to liked moderately". As it can be seen from the Table (4.23) and that control *Ladoo* obtained highest overall acceptability scores (8.39±0.05) as compared to other Variations of *Ladoo i.e.,* 8.08±0.54 (40%), 8.13±0.70 (60%), 8.09±0.43 (80%), 7.43±0.86 (100%) dehulled Quinoa seed respectively. Amongst the all treatments, sensory scores of *Ladoo* prepared with 40 per cent level of Quinoa seed dehulled flour highest for all sensory attributes *i.e.,* 8.00±0.65 for colour, 8.07±0.35 for appearance, 8.20±0.36 for texture, 8.19±0.78 for aroma, 8.13±0.69 for taste and 8.08±0.54 for overall acceptability then *Ladoo* prepared with 40, 60, 80, 100 per cent level of QDF. Further it can be discerned that there was general decrease in all sensory attribute with increase in the incorporation level (60%, 80% and 100%) of dehulled Quinoa seed.

Table 4.23: Sensory evaluation of *Ladoo* with incorporation of test flour at various levels:

Variations	Sensory attributes											
	Colour		Appear		Texture		Aroma		Taste		Overall	
	Me]an	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	8.23	0.56	8.43	0.80	8.80	0.66	8.56	0.76	8.66	0.56	8.39	0.05
40%	8.00	0.65	8.07	0.35	8.20	0.36	8.19	0.78	8.13	0.69	8.08	0.54
60%	8.23	0.75	7.44	0.38	8.00	0.58	7.05	0.89	8.48	0.67	8.13	0.70
80%	7.03	0.53	7.22	0.74	7.13	0.70	6.60	0.99	7.23	1.08	8.09	0.43
100%	7.87	0.68	7.03	0.39	7.02	0.68	7.56	0.62	7.76	0.83	7.43	0.86
SE	0.04		0.19		0.22		0.14		0.04		0.02	
CD5%	0.41**		0.42**		0.42**		0.39**		0.40**		0.23**	
CD1%	0.24*		0.35*		0.46*		0.22*		0.43*		0.63*	

* significant and ** significant at 1% and 5% level of significance, NS = Non significant

Patty:

Table 4.24 shows the result of sensory scores of *Patty* incorporated with different levels of Quinoa dehulled seed. The overall mean score of Quinoa dehulled seed *Patty* ranged from 7.01±0.30 to 8.27±0.11. Perusal of the data in Table 4.24 reveals that maximum scores for all sensory attributes *i.e*., 8.89±0.53 for colour, 8.60±0.26 for taste 8.56±0.46 for texture, 8.29±0.22 for aroma 8.02±0.25 for appearance and 8.23±0.56 for overall acceptability were obtained by control as compared to all other treatments. Among the all treatments, (60% dehulled Quinoa seed) showed that the highest score for all the sensory attributes *i.e.,* 8.00±0.55 (colour), 8.65±0.69 (aroma), 8.18±0.65 (taste), 8.30±0.68 (texture), 8.01±0.38 (appearance) and 8.34±0.67 (overall acceptability) than the *Patty* prepared with 40.80,100 per cent level of dehulled Quinoa seed.

Table 4.24: Sensory evaluation of *Patty* with incorporation of test flour at various levels:

Variations	Sensory attributes											
	Colour		Appear		Texture		Aroma		Taste		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	8.89	0.53	8.44	0.83	8.56	0.46	8.76	0.36	8.60	0.26	8.69	0.35
40%	8.09	0.62	8.02	0.25	8.29	0.62	8.29	0.22	8.23	0.65	8.23	0.56
60%	8.00	0.55	8.01	0.38	8.30	0.68	8.65	0.69	8.18	0.65	8.34	0.67
80%	7.83	0.58	7.22	0.84	7.43	0.74	7.60	0.99	7.43	0.88	7.39	0.44
100%	7.77	0.68	7.13	0.29	7.02	0.78	7.56	0.52	7.26	0.53	7.43	0.66
SE	0.01		0.19		0.11		0.04		0.13		0.08	
CD5%	0.32**		0.52**		0.27**		0.69**		0.56**		0.30**	
CD1%	0.94*		0.25*		0.46*		0.72*		0.33*		0.93*	

* significant and ** significant at 1% and 5% level of significance, NS = Non significant

Chilla:

The present table shows that Highest score for colour was assigned to incorporated Quinoa seed dehulled flour *Chilla* (8.24±0.63) followed by 40% per cent (8.33 ± 0.88), 60 percent (8.20± 0.50) 80 percent (7.90±0.93)100 percent .

Table 4.25: Sensory evaluation of *Chilla* with incorporation of Quinoa **seed dehulled flour at various levels:**

Variations	Sensory attributes											
	Colour		Appear		Texture		Aroma		Taste		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	8.27	0.74	8.66	0.89	8.78	0.68	8.80	0.53	8.39	0.78	8.83	0.68
40%	8.24	0.63	8.07	0.77	8.43	0.87	8.97	0.67	8.23	0.54	8.45	0.51
60%	8.33	0.88	8.67	0.54	8.33	0.53	8.83	0.45	8.37	0.99	8.43	0.74
80%	8.20	0.50	8.23	0.32	8.20	0.82	8.67	0.78	8.33	0.73	8.39	0.61
100%	7.90	0.93	7.70	0.45	7.89	0.43	7.87	0.23	7.97	0.67	7.78	0.78
SE	0.01		0.05		0.11		0.04		0.17		0.12	
CD5%	0.41**		0.65**		0.52**		0.89**		0.50**		0.73**	
CD1%	0.44*		0.27*		0.34*		0.12*		0.30*		0.23*	

* significant and ** significant at 1% and 5% level of significance, NS = Non significant

Sensory score for appearance was observed highest for 60 percent incorporated Quinoa seed dehulled flour *Chilla* (8.67±0.54) followed by 40 percent, 80 percent and 100 percent. Highest Score for texture was found in *Chilla* incorporated with Quinoa seed dehulled flour followed by 40 percent (8.43 ± 0.87), 60 percent (8.33 ± 0.53), 80 percent (8.20 ± 0.82) texture was observed at 100 per cent level (8.03 ± 0.85). Aroma of *Chilla,* was found highly acceptable (8.47 ± 0.57) for 40 percent incorporation of Quinoa seed dehulled flour. *Chilla* containing 40 percent . 60 per cent, 80 percent Quinoa seed dehulled flour (QDF) was found most acceptable for taste (8.63 ± 0.56) as compared to 60, 80, 100 percent.

Overall acceptability of 60 per cent Quinoa seed dehulled flour incorporated *Chilla* was highest among *Chilla's.* Significant difference between variations (40, 60, and 80,100) for all sensory attributes was observed in the *Chilla*. As per sensory attributes the biscuits replacing 40, 60, 80 percent flour is considered best for recommendation.

Sattu

Sensory evaluation of QDF incorporated *sattu* in different proportion along with control has been presented in Table 4.26. The overall mean score of QDF added *sattu* ranged from 7.54±0.19 to 8.57±0.05. This indicated that the QDF added *sattu* were found to fall under the category of "Liked very much" to liked moderately". As it can be seen from the Table (4.25) and) that (60%) *sattu* obtained highest overall acceptability scores (8.53±0.73) as compared to other variations of *sattu i.e.,* 8.48±0.59 (40%), 8.39±0.73 (80%), 7.83±0.56 (100%). Sensory scores of *sattu* prepared with 60 per cent level of Quinoa seed dehulled flour highest for all sensory attributes *i.e.,* 8.33±0.82 for colour, 8.45±0.89 for aroma, 8.38±0.82 for taste, 8.45±0.86 for texture, 8.43±0.78 for appearance and 8.53±0.73 for overall acceptability then *sattu* prepared with 40, 60 and 100 per cent level of QDF. Further it can be conclude that the 100% variations was also liked moderately.

Table 4.26: Sensory evaluation of *Sattu* with incorporation of test flour at various levels:

Variations	**Sensory attributes**											
	Colour		**Appear**		**Texture**		**Aroma**		**Taste**		**Overall**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Control	8.54	0.63	8.67	0.46	8.53	0.78	8.56	0.67	8.57	0.36	8.57	0.33
40%	8.37	0.60	8.57	0.65	8.44	0.56	8.39	0.57	8.23	0.63	8.48	0.59
60%	8.33	0.82	8.43	0.78	8.45	0.86	8.45	0.89	8.38	0.82	8.53	0.73
80%	8.20	0.61	7.85	0.57	8.47	0.49	8.30	0.66	8.30	1.01	8.39	0.73
100%	7.89	0.83	7.60	0.49	7.55	0.68	7.86	0.60	7.69	0.86	7.83	0.56
SE	0.05		0.18		0.10		0.09		0.05		0.12	
CD5%	0.31**		0.72**		0.22**		0.79**		0.20**		0.53**	
CD1%	0.72*		0.05*		0.46*		0.22*		0.50*		0.20*	

* significant and ** significant at 1% and 5% level of significance, NS = Non significant

Utapam

The table 4.27 shows that highest score in colour was obtained by 40% i.e. 8.17±0.60 followed by 60% (7.89±0.72), 80% (7.23±0.54) and 100% (7.00±0.03). The *Utapam* scored in the range of 7.17±056 to 8.03±0.33 in terms of taste attribute. The texture of *Utapam* 40% (8.02±0.23) was "liked very much" and 60% (8.00±0.80) and 80% (7.12±0.09) were "liked moderately" by the panel members.

The aroma of *Utapam* (40%) was "liked very much" by the panel members and the scores ranged between 8.09±0.18. The appearance of the *Utapam* (40%) was "liked very much" by the panel members and were acceptable with overall acceptability scores of 8.08±0.59 (40%) followed by 7.77±0.73 (60%), 7.59±0.73 (80%) and 7.13±0.56 (100%). The scores overall reveal that the (40%) *Utapam* were "liked very much" by the judges.

Table 4.27: Sensory evaluation of *Utapam* with incorporation of test flour at various levels:

Variations	**Sensory attributes**											
	Colour		**Appear**		**Texture**		**Aroma**		**Taste**		**Overall**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Control	8.34	0.62	8.47	0.78	8.45	0.56	8.66	0.06	8.29	0.84	8.75	0.73
40%	8.17	0.60	8.07	0.05	8.02	0.23	8.09	0.18	8.03	0.33	8.08	0.59
60%	7.89	0.72	7.03	0.88	8.00	0.80	7.25	0.89	7.48	0.72	7.77	0.73
80%	7.23	0.54	7.25	0.74	7.12	0.09	7.00	0.91	7.23	1.01	7.59	0.73
100%	7.00	0.03	7.10	0.79	7.00	0.78	7.16	0.60	7.17	0.56	7.13	0.56
SE	0.10		0.06		0.11		0.01		0.18		0.10	
CD5%	0.11**		0.22**		0.47**		0.79**		0.80**		0.35**	
CD1%	0.94*		0.35*		0.66*		0.22*		0.83*		0.30*	

* significant and ** significant at 1% and 5% level of significance, NS = Non significant

Khaman

Sensory evaluation of *Khaman* incorporated with QDF in different proportions are presented Table 4.28. Sensory score of colour was found highest in 40 percent QDF incorporated *Khaman* (8.18 ± 0.59) as compared to 60, 80, 100 percent. Appearance of 40 percent *Khaman* incorporated with QDF was "liked very much" (8.97 ± 0.87) followed by 60 percent (7.03 ± 0.84), 80 percent (7.00± 0.79) 100 percent (7.00 ± 0.78) were “like moderately”. Sensory scores of texture was observed highest for 40 per cent QDF incorporated *Khaman* and 60, 80 percent variation was Also liked moderately. Overall acceptability of *Khaman* incorporated with 40 percent QDF was highest, as compared to 60, 80, 100 percent. Sensory evaluation of *Khaman* revealed that 40 percent incorporation of QDF was most acceptable percentage among all proportions .

Table 4.28: Sensory evaluation of *Khaman* with incorporation of test flour at various levels:

Variations	Sensory attributes											
	Colour		Appear		Texture		Aroma		Taste		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	8.40	0.63	8.27	0.26	8.23	0.66	8.40	0.06	8.70	0.56	8.55	0.72
40%	8.07	0.04	8.97	0.87	8.02	0.66	8.09	0.78	8.03	0.63	8.18	0.59
60%	7.56	0.52	7.03	0.84	7.78	0.88	7.25	0.09	7.38	0.82	7.23	0.03
80%	7.23	0.31	7.00	0.77	7.53	0.90	7.05	0.99	7.23	1.01	7.19	0.73
100%	7.12	0.73	7.00	0.79	7.00	0.78	7.00	0.62	7.17	0.86	7.03	0.56
SE	0.09		0.03		0.11		0.05		0.17		0.12	
CD5%	0.61**		0.26**		0.32**		0.49**		0.70**		0.30**	
CD1%	0.86*		0.67*		0.26*		0.52*		0.33*		0.83*	

* significant and ** significant at 1% and 5% level of significance, NS = Non significant

Cake

Sensory evaluation of *Cake* incorporated with QDF in different proportions are presented Table 4.29. Sensory score of colour was found highest in 40 percent QDF incorporated *Cake* (8.77 ± 0.54) as compared to 60, 80, 100 percent. Appearance of 40 percent *Cake* incorporated with QDF was "liked very much" (8.37 ± 0.77) followed by 60 percent (7.93 ± 0.34), 80 percent (7.04± 0.47) 100 percent (7.02 ± 0.29) were “like moderately”. Sensory scores of texture was observed highest for 40 per cent QDF incorporated *Cake* and 60, 80 percent variation was Also liked moderately. Overall acceptability of *Cake* incorporated with 40 percent QDF was highest, as compared to 60, 80, and 100 percent. Sensory evaluation of *Cake* revealed that 40 percent incorporation of QDF was most acceptable percentage among all proportions.

Table 4.29: Sensory evaluation of *Cake* with incorporation of test flour at various levels:

Variations	**Sensory attributes**											
	Colour		**Appear**		**Texture**		**Aroma**		**Taste**		**Overall**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Control	8.60	0.63	8.77	0.86	8.27	0.74	8.70	0.03	8.75	0.36	8.59	0.70
40%	8.77	0.54	8.37	0.77	8.32	0.64	8.59	0.73	8.04	0.63	8.38	0.56
60%	8.46	0.22	7.93	0.34	7.38	0.88	7.35	0.09	7.33	0.32	7.93	0.06
80%	7.73	0.71	7.04	0.47	7.43	0.90	7.05	0.93	7.23	0.31	7.39	0.73
100%	7.62	0.83	7.02	0.29	7.00	0.74	7.03	0.62	7.67	0.96	7.23	0.58
SE	0.10		0.09		0.01		0.03		0.11		0.18	
CD5%	0.51**		0.72**		0.22**		0.49**		0.60**		0.29**	
CD1%	0.84*		0.35*		0.86*		0.32*		0.63*		0.83*	

* significant and ** significant at 1% and 5% level of significance, NS = Non significant

4.3.2 Nutritional Quality evaluation

Table 4.30 represents the results of proximate composition of the developed and selected products. The moisture content of the product was ranged from *Chapati,* (2.33±0.67) *Biscuit* (4.88±1.32), *Namkeen* (1.82±0.85), *Khakhra* (1.87±0.52), *Handwa* (5.10±1.33), *Ladoo* (4.13±0.45), *Patty* (4.46±0.38), *Chilla* (3.03±0.63), *Sattu* (1.98±1.05), *Utapam* (4.26±1.07), *Khaman* (2.96±0.19), *Cake* (3.78±0.19).

The table further illustrates that the crude protein content was highest in *Chapati,* (10.23±1.12) *Biscuit* (12.16±1.24), *Namkeen* (11.81±0.50), *Khakhra* (9.54±4.95), *Handwa* (13.04±0.65), *Ladoo* (7.35±0.62), *Patty* (11.29±2.47), *Chilla* (15.23±3.09), *Sattu* (11.29±1.24), *Utapam* (10.00±0.61), *Khaman* (9.54±4.95), *Cake* (10.41±2.47) per 100 g on dry weight basis, respectively.

Data on crude fat content of the food products revealed that the highest value was found in *Chapati,* (3.67±0.09) *Biscuit* (10.549±1.03), *Namkeen* (18.77±0.665), *Khakhra* (7.48±3.96), *Handwa* (11.18±0.22), *Ladoo* (3.69±0.38), *Patty* (6.63±2.78), *Chilla* (9.68±1.38), *Sattu* (10.36±3.6), *Utapam* (7.37±0.29), *Khaman* (7.48±3.96), *Cake* (12.65±3.12).

Ash content is an indirect indicator of the mineral level of food stuffs (Fouzia, 2009). Regarding the total ash content of the products, it was found that *Chapati,* (2.34±0.08) *Biscuit* (3.23±0.2) *Namkeen* (4.74±0.1), *Khakhra* (0.76±1.0), *Handwa* (4.82±0.06), *Ladoo* (2.42±0.11), *Patty* (5.02±0.37), *Chilla* (4.23±0.04), *Sattu* (2.31±0.01), *Utapam* (0.76±2.01), *Khaman* (3.12±0.51), *Cake* (1.29±2.75). *R3* had the highest value, i.e. 3.25± 0.11g per 100g and lowest ash content was found in *R1* with the value of 2.26± 0.08g per 100 g, on dry weight basis. 2.34±0.08

Fiber is an important dietary component in preventing overweight, constipation, cardiovascular disease, and diabetes and colon cancer. The results show that the crude fibre content of the products ranged from 3.09 ± 0.05g to 8± 2.34 g per 100g.

Table 4.30: Proximate composition of suitable variation of products (mean ±SD)

Nutrients (per 100 g)	Moisture (g)	Protein (g)	Fat (g)	Ash (g)	fibre (g)	Carbohydrates (g)	Energy(kcal)
Chapatti 60%	2.33±0.67	10.23±1.12	3.67±0.09	2.34±0.08	3.09±0.05	62.34±1.00	427±2.78
Biscuit (40%)	4.88±1.32	12.16±1.24	10.549±1.03	3.23±0.2	3.33±2.94	65.85±2.02	406.98±3.45
Namkeen(60%)	1.82±0.85	11.81±0.50	18.77±0.665	4.74±0.1	3.2±1.09	59.67±2.11	454.83±2.98
Khakhara(40%)	1.87±0.52	9.54±4.95	7.48±3.96	0.76±1.0	4.34±3.00	76.02±0.09	409.54±3.45
Handwa (40%)	5.10±1.33	13.04±0.65	11.18±0.22	4.82±0.06	3.45±2.09	62.42±1.01	402.44±1.23
Ladoo (40%)	4.13±0.45	7.35±0.62	3.69±0.38	2.42±0.11	6.56±2.00	75.85±1.00	366.02±2.67
Patty (60%)	4.46±0.38	11.29±2.47	6.63±2.78	5.02±0.37	6.7±1.39	66.17±0.06	369.49±1.98
Chilla (60%)	3.03±0.63	15.23±3.09	9.68±1.38	4.23±0.04	6.7±1.006	61.13±1.09	392.54±2.67
Sattu (60%)	1.98±1.05	11.29±1.24	10.36±3.6	2.31±0.01	6.23±2.34	66.06±2.09	402.62±1.90
Uttpam (40%)	4.26±1.07	10.00±0.61	7.37±0.29	0.76±2.01	5.67±2.45	67.58±0.07	376.63±3.56
Khaman (40%)	2.96±0.19	9.54±4.95	7.48±3.96	3.12±0.51	5.67±2.34	76.02±0.23	409.54±3.0
Cake (40%)	3.78±0.19	10.41±2.47	12.65±3.12	1.29±2.75	3.42±2.99	68.44±0.57	429.27±2.90

Carbohydrate content of the Products was calculated by difference method. The values were *Chapati,* (62.34±1.00) *Biscuit* (65.85±2.02), *Namkeen* (59.67±2.11), *Khakhra* (76.02±0.09), *Handwa* (62.42±1.01), *Ladoo* (75.85±1.00), *Patty* (66.17±0.06), *Chilla* (61.13±1.09), *Sattu* (66.06±2.09), *Utapam* (67.58±0.07), *Khaman* (76.02±0.23), *Cake* (68.44±0.57).

Table 4.23 further delineates the energy value of the Products. Energy was found in the *Chapati,* (427±2.78 kcal) *Biscuit* (406.98±3.45 kcal), *Namkeen* (454.83±2.98 kcal), *Khakhra* (409.54±3.45 kcal), *Handwa* (402.44±1.23 kcal), *Ladoo* (366.02±2.67 kcal), *Patty* (369.49±1.98 kcal), *Chilla* (392.54±2.67 kcal), *Sattu* (402.62±1.90 kcal), *Utapam* (376.63±3.56 kcal), *Khaman* (409.54±3.0 kcal), *Cake* (429.27±2.90 kcal) per 100g on dry weight basis.

4.4: PHASE 4 –SHELF LIFE ASSESSMENT OF QUINOA DEHULLED FLOUR:

The shelf life of any food product is affected by a number of factors and analysis of these factors is essential while product development. Storage studies include the product keeping qualities as well as its sensory appeal during the storage period. In the present study High density polyethylene (HDPE) pouches were used for the storing the prepared flours and products. The findings of the quality attributes have been compiled and presented to below:

In this section, data regarding the Peroxide value and functional properties of Quinoa seed dehulled flour have been analyzed and the findings has been compiled and presented below:

4.1 Effect of storage on Functional properties of Quinoa seed dehulled flour.

Water absorption capacity is an important functional characteristic in the development of ready to eat food from cereal grains, since high water absorption capacity may assure product cohesiveness. Water absorption capacity is the ability to retain water against gravity, and includes bound water, hydrodynamic water, capillary water and physically entrapped water (Moure *et al.,* 2006). Water absorption capacity of Quinoa seed flour was found 143.3% on 0 day. WAC % decreased significantly from 143.3% to 138.09 in polyethylene over a period of 6 months. Significant reduction in WAC was observed in both the samples after 6 months of storage period Hence, the water absorption capacity depends on protein content, nature and type of proteins, hydrophilic properties of proteins which in turn related to polar groups such as carbonyl, hydroxyl, amino, carboxyl and sulfhydryl groups, also varies with the number and type of polar groups (Kuntz, 1971). Crude protein and crude fibre contributed to higher water absorption in maize flour, Paul and Ayernor (2002).

The oil absorption capacity is a critical assessment of flavor retention and increases the palatability of foods (Kinsella 1976). The initial OAC of the flour was 78.30% and it increased significantly over a period of 6 months. The oil absorption capacity (OAC) of Quinoa seeds flour was low but gradually increase significantly in the first 3 month of storage and decreased significantly in the last month (6^{th} month).Oil absorption is mainly attributed to the physical entrapment of oil and is related to the number of non polar side chains of fats (Kinsella 1976; Lin *et al.,* 1974)

Gelation may be defined as protein aggregation phenomenon in which polymer-polymer and polymer-solvent interactions, attractive and repulsive forces are so balanced that a tertiary network or matrix is formed and which is capable of immobilizing or trapping large amounts of water. Further gelation is affected by protein concentration, other protein components in a complex food system, non protein components, pH, reducing agents and heat treatment condition (Schmidt 1981). Least Gelatinization concentration of Quinoa dehulled flour was found 14% at 0day. There was a marginal difference in LGC values over the months. The least gelation concentration (LGC) indicates the gelation capacity and the lower the LGC, the better the gelling ability of proteins. Gelling ability is a function of the ability of the flour to absorb water and swell. Gelation is not only based on protein quantity but appears to be related to the type of protein as well as to non-protein components.

Table 4.31: Effect of storage on Functional properties of quinoa seed dehulled flour

Functional properties						
Storage Days	**Water Absorption Capacity (%)**		**Oil Absorption Capacity (%)**		**Least Gelatinization concentration (%)**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
0 Day	143.30	0.80	78.30	0.56	14	0.02
30 days	140.11	1.60	83.67	0.33	17	0.08
60 Days	139.23	0.63	87.35	1.02	21	1.45
90 Days	138.09	0.27	80.09	0.23	24	0.67
180 Days	130.45	1.52	78.55	1.04	30	0.92
SE	5.27		1.89		1.09	
CD1%	7.67**		3.45**		0.04**	

All the values are (mean ±SD) of three observations

SE- Standard Error **significant at 1% level

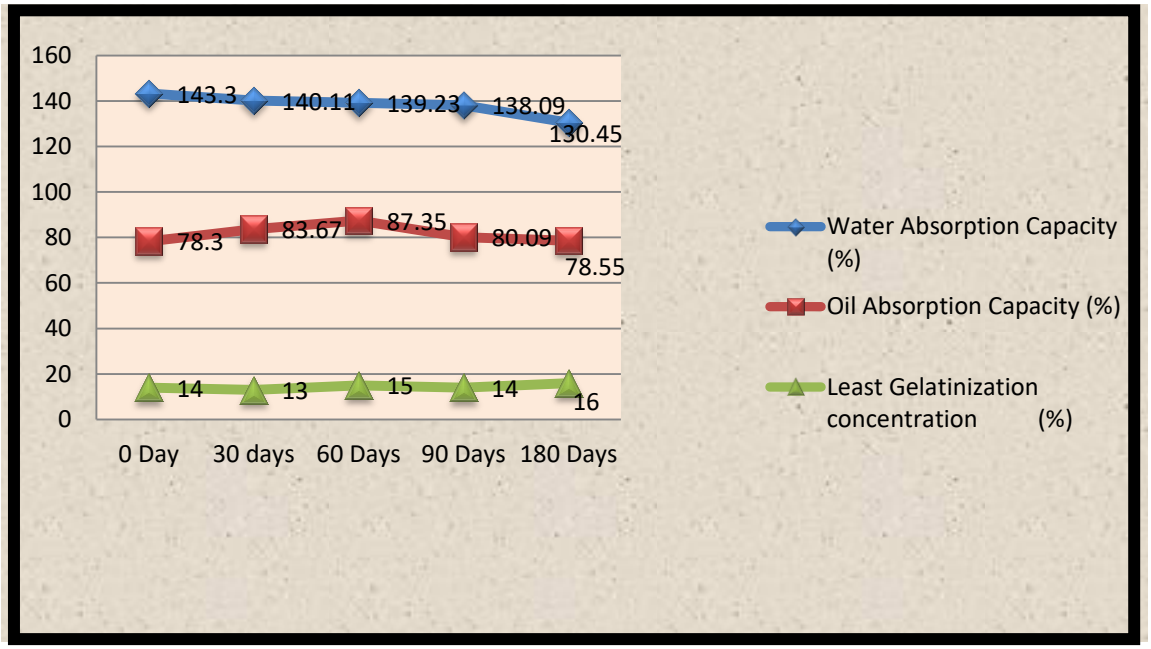


Fig. 4.5 : Effect of storage on Functional properties of quinoa seed dehulled flour

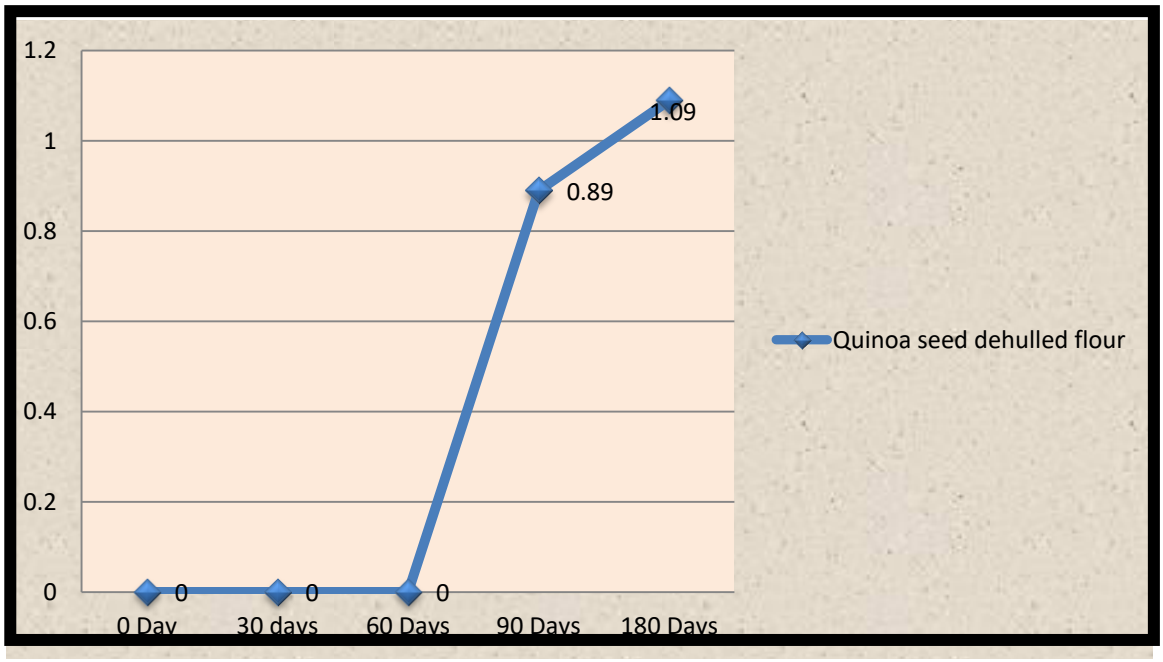


Figure 4.6 : Effect of storage on peroxide value (meq/kg) of Quinoa seed dehulled flour

4.2 Effect of storage on peroxide value of Quinoa seed dehulled flour

The peroxide value reflects the storage quality of the Quinoa seed dehulled flour and is the most useful measure of the degree of oxidation in free fatty acids and the production of hydro-peroxides. The hydro-peroxides break down at a certain level into volatile products responsible for a variety of undesirable odor and flavor reactions known as oxidative rancidity.

Table 4.32 illustrates the peroxide value of the Quinoa dehulled flour. The peroxide value was not recorded during the initial storage period. It could only be detected at 90 days and 180 days of storage interval, with the values 0.89±0.03 meq/kg and 1.09±0.08 meq/kg respectively, on dry weight basis. The difference in peroxide value of the formulated mixes was found to be significant at $p \leq 0.01$. The values for peroxide value of the Quinoa dehulled flour were much lower than the safe limit for peroxide value in foods, i.e. <10 meq/kg fat. (Aylward, 1999).

Kotnala (2009) while studying peroxide 5value of extruded products reported that peroxide value could be detected at the end of third and fourth month of storage.

In a study by Mamta (2015) on pearl millet based convenience foods, a significant increase in peroxide value was observed in the three types of idli, dhokla and upma mixes prepared, but, all types of mixes were in the permissible limits of palatablity.

Table 4.32: Effect of storage on peroxide value (meq/kg) of Quinoa seed dehulled flour

Storage Days	**Quinoa seed dehulled flour**	
	Mean	**SD**
0 Day	**Nil**	**Nil**
30 days	**Nil**	**Nil**
60 Days	**Nil**	**Nil**
90 Days	0.89	0.03
180 Days	1.09	0.08
SE	0.02	
CD1%	0.07**	

All the values are (mean ±SD) of three observations

SE- Standard Error **significant at 1% level

4.3: Cost of developed foods: Cost of foods was calculated per 100 g on the basis of market price of raw ingredients details are given in Table 4.33.

The cost of the product which were chosen on the basis of organoleptic evaluation. The total cost of the product was calculated considering the cost of raw ingredients at the time when research was conducted including 20% overhead and 20% processing charges. Cost of the product *Chapati (60%), Biscuit(40%), Namkeen(60%), Khakhra(40%), Handwa(40%), ladoo(40%), patty(60%), chilla(60%), sattu(60%), utapam(40%), khaman(40%), cake(40%)* were per serving, i.e. 100g. The cost of the product may vary according to the present market rates of the ingredients.

Table 4.33: Cost of Developed product per serving (100g)

S. No.	Products	Major Ingredients	Amount	Total Cost(Rs)
1.	*Chapatti*	Quinoa dehulled flour	60g	3
		Wheat flour	40g	0.3
		Salt	0.5g	1
				7 (Rs.2 were added as processing cost)
2.	Biscuit	Quinoa seed Flour	40g	2.5
		Refined Wheat flour	60g	0.4
		Amul Butter	25	5
		Baking Power	1/4tsp	1
		Baking Soda	1/8 tsp	1
		Milk	10ml	0.5
		Powdered Sugar	25g	2
				14(Rs.2 were added as processing cost)
3.	*Namkeen,*	Quinoa seed flour	60g	3
		Gram Flour	40g	1.5
		Oil	10g	2
		Green Chilli paste	2gm	0.5
		Salt	2gm	0.5
				10(Rs.2 were added as processing cost)

4.	*Khakhra*	Quinoa seed flour	40 g	2.5
		Wheat flour	60 g	3
		Salt	2gm	0.50
		Red Chilli	¼ tsp	0.50
		Cumin seeds	1/4tsp	0.25
		Kasoori methi	1¼ tsp	0.50
				10(Rs.2 were added as processing cost)
5.	*Handwa*	Quinoa seed flour	40 g	2.5
		Semolina	60 g	2
		Curd	10ml	1
		Bottle gourd	5gm	0.25
		Green peas	5gm	0.25
		Carrot	5gm	0.25
		Ginger-green chilli paste	2gm	0.50
		Mustard seeds	1 tsp	0.50
		Chilli	¼ tsp	0.50
		Cumin seeds	1/4tsp	0.50
		Sesame seeds	0.5gm	0.50
		Asafoetida	300ml	0.50
		Curry leaves	0.5gm	0.50
				12(Rs.2 were added as processing cost)
6.	*Ladoo*	Quinoa seed	80 g	5
		Ground nut	20 g	3
		Sesame seed	5gm	1
		Jaggery	50gm	2
		Ghee	10gm	2
		Cardamon	¼ tsp	.50
				18(Rs.4 were added as processing cost)

7.	*Patty*	Quinoa seed	40 g	4
		Potato	60 g	1
		Green peas	5gm	1
		Ginger	1gm	.25
		Green Chilli	2gm	.25
		Cumin seeds	1/4tsp	.25
		Garam masala	1/4tsp	.25
		Coriander leaves	1gm	.25
		Red chilli powder	1/4tsp	.25
		Onion	5gm	.50
				10(Rs.2 were added as processing cost)
8.	*Chilla*	Quinoa seed flour	60 g	4
		Gram flour	40 g	2
		Curd	10ml	1
		Onion	5gm	.50
		Salt	1 tsp	.50
		Green Chilli	1gm	.50
		Cumin seeds	1/4tsp	.50
				12(Rs.2 were added as processing cost)
9.	*Sattu*	Quinoa seed flour	60 g	3
		Wheat flour	40 g	2
		Ghee	30gm	5
		Jaggery	50gm	2
		Cardamom powder	¼ tsp	1
				17(Rs.4 were added as processing cost)
10.	*Utapam*	Quinoa seed flour	40 g	3
		Semolina	60 g	2
		Salt	1 tsp	.50
		Curd	10ml	1
		Green Chilli	1gm	.50
		Cumin seeds	1/4tsp	.25
		Tomato	5gm	.50
		Onion	5gm	.50
				10(Rs.2 were added as processing cost)

11.	*Khaman*	Quinoa seed flour	40 g	3
		Gram flour	60 g	2
		Sugar	1/2tsp	.25
		Salt	1 tsp	.25
		Curd	10ml	1
		Oil	1tsp	.25
		Curry leaves	1gm	.25
		Mustard seeds	1/4tsp	.25
		Cumin seed	1/4tsp	.25
		Coriander leaves	1gm	.25
		Soda /Eno (fruit salt)	1/4tsp	.25
		Green chilli	1gm	50
				12(Rs.4 were added as processing cost)
12.	*Cake*	Quinoa seed flour	40 g	3
		Wheat flour	60 g	2
		Baking soda	1/2tsp	.50
		Salt	1 tsp	.25
		Milk	100ml	2
		Vanilla essence	1-2 drop	.50
		Ghee	30gm	5
		Sugar	30gm	1
				17(Rs.4 were added as processing cost)

The cost of developed convenience foods was ranged between 10 to20 Rs per 100g of product.

Based on the results of organoleptic, nutritional and chemical evaluation, it can be concluded that the products and Quinoa dehulled flour are nutritionally sound and recommended for use in daily meal. The products are low-cost and developed using simple household technology. The shelf-life of Quinoa dehulled flour examination revealed that the flour is safe for consumption up to six months of storage at ambient temperature.

4.5: PHASE: PREPARATION OF INFORMATION MATERIAL

In order to prepare Booklet, in-depth literature was reviewed to gather information related to Quinoa. On the basis of information collected, one major topic was finalised for designing the Booklet under the guidance of subject matter specialists. The topics were for booklet "Nutritious product of Quinoa". An outline for each Booklet was prepared. Subject matter was organized in accordance with outline by arranging it into headings and sub-headings. In support to the content of Booklet, illustrations were collected and captured in real situations by the investigator. Finally, the booklet was designed using graphic designing software 'Corel Draw'.

To assess the appropriateness, the designed Booklet was subjected to evaluation by a panel of 10 experts from different disciplines. The assessment was done on five point continuum from 'excellent' to 'poor' with scores 5 to 1, respectively. The experts evaluated Booklet on various criteria like relevance to topic, subject matter coverage, layout, subtitle, continuity, accuracy, language, illustrations, size of pamphlets and overall presentation.

The information regarding expert's evaluation of booklet presented in Table 4.34 reveal that overall mean weighted score (MWS) of booklet was 4.0 out of total score of 5, which shows that the booklet was judged very good by experts. Further, Table 4.34 indicates that for Booklet various criteria were rated between good to excellent as the mean weighted score for all criteria ranged from 3.8 to 4.5. None of the criterion was rated as fair or poor. The reason for such findings might be that the Booklet was prepared under the constant guidance of experts and suggestions were incorporated during development of booklet. Majority of the experts appreciated the booklet and assigned scores ranging from 4-5. Few suggestions in layout of booklet were recommended by them which were incorporated by the investigator.

Table 4.34 Criteria wise evaluation of designed booklet by the experts

n=10

S. No.	Title of the aids	Mean weighted score (MWS)											Overall MWS
		Relevance to topic	Subject matter coverage	Layout	Sub title	Continuity/ sequence	Accuracy	Language*			Illustration	Size	Overall presentation	
								A	B	C				
	BOOKLET													
1.	Nutritious products of Quinoa	4.5	4.1	4.1	3.8	4.1	3.8	4.1	4.0	3.9	3.8	3.9	4.0	**4.0**

*Language- A: Clarity, B: Selection of words, C: Sentence structure

The findings are in line with Jain (2017) who in a study on development and field testing of flipbook on 'Vegetable in diet' for rural women concluded that the flipbook was rated as good to excellent by the experts for different aspects like clarity of visuals, subject matter, organization and continuity etc.

The findings of the study elucidate that the developed booklet was evaluated as very good by the experts. All the necessary steps were followed in content collection, outlining, preparing, expert's evaluation, modification with the users of the booklet. Thus the booklet can be recommended for use by any welfare organization or extension worker as a standardized communication material to generate awareness among rural people

SUMMARY AND CONCLUSION

The study entitled **"Development and Quality evaluation of value added products based on quinoa seed."**was planned with the objectives to assess physico-chemical characteristics, effects of processing on anti-nutrients, development of convenience foods and quality evaluation of developed foods. For the purpose Quinoa whole and dehulled were collected from local market of Udaipur. Samples were cleaned and stored in air tight container at room temperature. The study was conducted in four phases.

1) Physico-Chemical Analysis Of Dehulled Quinoa Seed
2) Processing Of Whole And Dehulled Quinoa Seed
3) Development of Product
4) Shelf Life Assessment Dehulled Quinoa Flour
5) Preparation Of Information Material

1) Physico-Chemical Analysis Of Dehulled Quinoa Seed

The physical characteristics like number of seeds in 10g, weight of 100 seeds, size of seed etc. and functional characteristics like water absorption capacity, oil absorption capacity, emulsifying activity, capacity etc. were studied. Nutritional quality of whole and dehulled quinoa seed was also conducted. The seed length and width was 0.075 mm diameter was 0.024mm. No. of seeds in 10 g was 269.06 and weight of 100 seeds was found 1.14 g. The shape of Quinoa seed is similar to a flattened sphere. Seed volume seed density and bulk density of Quinoa whole seed was found 9.6 ml, 0.86 g/ml, and 0.72 respectively. Hydration capacity and Hydration index of Dehulled Quinoa seed was 0.002 ml/seed and 0.18 respectively.

Water absorption capacity of Quinoa seed flour was found 143.3%. Oil absorption capacity of Quinoa seed flour was 183.33 percent .The higher oil absorption capacity of flour is equally important as it improves the mouth feel and retains the flavour. Least Gelatinization concentration of Quinoa dehulled flour was found 14%.

The chemical analysis of Quinoa seed for proximate composition for moisture, fat, ash, protein, fibre and energy. Moisture content was higher in QW (4.09g/100g) followed by QD (2.89g/100g). Highest amount of crude fat content was exhibited in QD (6.88g/100g) followed by QW (5.6g/100g). Protein, the body building nutrient, was significantly higher in QD (15.23g/100g) than QW (12.52g/100g). Total ash was found in QW and QD (3g/100g). QW and QD showed higher content of crude fibre (8.98g/100g and 7.99g/100g). QS are also rich in micronutrients such as minerals and vitamins. The major mineral contents for QW, QD flours for calcium, Iron, Zinc, potassium, phosphorus. In case of calcium, QW recorded higher value 86.3 ppm than QD (55.1). Iron content was higher in QW (15.0 ppm) followed by QD (14.2 ppm). Among two flours zinc content was found higher in QW (4.0 ppm) than QD (4.0 ppm). Potassium was higher in QW (732.0 ppm) than QD (656.0 ppm). Phosphorus was higher in QW (411.0 ppm).

The anti-nutritional factors viz saponin and phytic acid were analyzed. Saponin content was found to be highest in QW (9.13) than QD (4.16) and there difference was found in the content of Saponin. The phytic acid content was lower in QD (6.23 %) than QW (10.36%). **The anti oxidant activity** The anti oxidant activity in quinoa seed whole and dehulled was 44.34 and 32.54. Anti oxidant activity was found to be highest in QW than QD and there difference was found in the anti oxidant activity.

2) Processing of Quinoa seed:

In second phase Quinoa whole and Quinoa Dehulled seed were processed as soaking and germination for 6, 12, 18, 24 hr and 12, 24, 36, 48 hr respectively and were subjected for chemical analysis (proximate, minerals, anti-nutrients) to find out the effect of processing on anti-nutrients with nutritional profile. Proximate composition of processed and Quinoa whole (QW) revealed that there was a significant difference in moisture content among all processing which ranges from 3.5 to 4.9g/100g.

In cereals and legumes, this increase is due to the presence of protein hydrolysis as well as the results of protease enzyme activity during germination of the seeds. Proximate composition of processed and unprocessed Quinoa seed whole (QW) is presented in Table 4.11. Difference was found in moisture content among soaking and

germination treatments which ranges from 3.5 to 5.7 g/100g. The moisture content was found highest in 18 hr Soaking (Q3: 5.2 g/100g) indicating that with increasing soaking time the moisture content increases. Abdulsalami *et. al.* (2010) investigated the effect of processing on the proximate and mineral composition of Bambara groundnut and found an increase in moisture content. Crude fat content of unprocessed Quinoa seed whole was found higher (B0:5.6 g/100g) than processed Quinoa seed whole and there was decrease in fat content with soaking (B1 to B4) and germination (B5 to B8). Ocheme (2008) studied the effects of soaking and germination on some physico-chemical properties, of millet flour and sensory properties of porridges. It was reported that fat, decreased significantly as result of soaking and germination. The lower fat content of the germinated samples can be due to the breakdown of lipids that occurs during germination in order to obtain the energy required for the plant's development (Urbano *et. al.* 2005). There was significant difference in ash content in Quinoa seed whole after processing (B4 to B8). A slight decrease in ash content was also observed on soaking (Q4, Q6, Q7, Q8). Abdulsalami *et. al.* (2010) also found slight decrease in ash content from 5.37 to 2.89 (g/100 dry wt) after processing methods. While soaking, biological breakdown of various complex compounds into simpler compounds takes place as suggested by Narsih et al. (2012) and thus a significant increase in total protein content was observed with enhancement of the soaking time from 22.60 g/100 g to 28.77 g/100 g.

While soaking, biological breakdown of various complex compounds into simpler compounds takes place as suggested by While soaking, biological breakdown of various complex compounds into simpler compounds takes place as suggested by No significant difference was observed in the protein content of Quinoa whole after soaking (Q1 to Q8). Fibre content was decreased gradually on soaking and germination, (Q4 – Q8) as compare to unprocessed Quinoa whole (Q0). Significant difference was observed in the Fat content which was lower than unprocessed quinoa seed ranged between (2.45-0.90). A significant difference in carbohydrate content was observed after processing of whole. On germination and soaking of whole carbohydrate content was found to decrease as compared to unprocessed Quinoa whole (Q0).

There was a significant difference in calcium content of whole (Q0) after processing (Q1- Q8) and was found higher than unprocessed whole (Q1). Zinc

content of was found lower after soaking (Q1 – Q4) and higher after germination (Q5– Q8) as compared to unprocessed whole (Q0). Iron content of processed Quinoa whole was found lower in soaking (Q4:13.91) and higher in germination for 48 hr (Q8:19.27) as compare to unprocessed whole (Q0:15). The iron content was found slightly lower in over soaking (18 hr, 24 hr) as compare to unprocessed flour. The Potassium content of whole was found to increase with soaking duration of 6 hr,12hr ,18 hr and 24 hr (Q1, Q2, Q3, Q4) and germination 24 hr,36hr and 48hr (Q5, Q6, Q7, Q8) as compare to unprocessed whole (Q0). The Phosphorus content of whole was found to increase with soaking duration of 6 hr,12hr and lower in 18 hr and 24 hr and higher in germination 24 hr,36hr and 48hr as compare to unprocessed whole (Q0). Significant difference was observed in Saponin content of Quinoa whole after processing. A continuous degradation was observed in phytic acid with soaking and germination. Non significant difference found in anitioxidant activity of whole after processing.

Moisture content of Quinoa Dehulled was found significantly decreased after soaking increased after germination. Fat content was significantly decreased after germination and slightly decrease after soaking for 24hr as compared to unprocessed Quinoa Dehulled (Q0: 3.88 g/100g). There was a significant difference in ash content after processing of Quinoa Dehulled ranged from Q4 (2.20g/100g) to Q8 (1.25g/100). No significant difference was observed in protein content after processing. Fibre analysis of Dehulled after soaking and germination revealed a significant decrease as compared to unprocessed Quinoa Dehulled (Q0). Carbohydrate was observed slightly decreased after soaking (Q1 to Q8) and germination as compared to unprocessed Quinoa Dehulled (Q0). This also reflects as energy content after soaking and germination of seed ranged from (365 Kcal to 242 kcal). A significant difference was observed in calcium content after processing of Dehulled. Iron content was significantly ($P< 0.05$) decreased in 6 hr to 24 hr soaking (13.63 ppm to 11.84 ppm) and was found increase in germination for 24 hr to 36 hr (14.75 ppm, 16.45 ppm). Zinc content of Dehulled was found to be significantly decreased after soaking and (Q1-Q4) increased after germination (Q5-Q8) as compared to unprocessed Dehulled (Q0). The Potassium content of whole was found to increase with soaking duration and germination as compare to unprocessed whole (Q0). The Phosphorus content of Quinoa whole was found to decrease with soaking duration and higher in germination

as compare to unprocessed whole (Q0). Significant difference observed in saponin content after processing while phytic acid was found lowest in germination and soaking . Though there was significant difference found in anitioxidant activity of dehulled after processing

The Quinoa whole and Quinoa Dehulled were processed separately as soaking (6, 12, 18, 24 hr) and germination (12,24,36,48 hr). Chemical properties were also analysed and on the basis of nutritional composition and minimum anti-nutrients, 24hour germination processed Quinoa Dehulled was most acceptable.

3) Development of Product

In phase twelve, products namely *Chapati, Biscuit, Namkeen, Khakhra, Handwa, ladoo, patty, chilla, sattu, utapam, khaman, cake* were selected for incorporating Quinoa Dehulled flour in proportion of 40, 60, 80, 100 percent. The purpose of Quinoa Dehulled flour (QDF) in selected products was to find out the best level of acceptance of QDF in convenience foods Products. Therefore, all developed products were subjected to sensory evaluation (colour, appearance, flavour, texture, taste and overall acceptability) on nine point hedonic rating scale by panel of 30 members.

While selecting the best percentage for development of Product, (*Chapati, Biscuit, Namkeen, Khakhra, Handwa, ladoo, patty, chilla, sattu, utapam, khaman, cake)* from Quinoa Dehulled flour (QDF). Chapati (60% percent), Biscuit (40% percent), Namkeen (60% percent), Khakhra (40% percent), Handwa (40% percent), Ladoo (40% percent), Patty (60% percent), Chilla (60% percent), Sattu (60% percent), Utapam (40% percent), Khaman (40% percent), Cake (40% percent) found acceptable as comparable to other percentage (40,60,80,100) in all products.

Nutritional Quality evaluation

All products were found high in moisture, protein, fat, ash and fibre, carbohydrates, energy. Biscuit was high in protein 12.16gm Sattu was high in fibre 8±2.34. Results show that Namkeen was high in energy 454.83 Kcal.

4) Shelf Life Assessment Dehulled Quinoa Flour

Phase four was the quality evaluation of dehulled quinoa flour were packed in HDPE bags, in vacuum packaging and stored at room temperature for 6 months. The quality attribute functional roperties and peroxide value were assessed. Water absorption capacity of Quinoa seed flour was found 143.3% on 0 day. WAC % decreased significantly from 143.3% to 138.09 in polyethylene over a period of 6 months. The initial OAC of the Quinoa flour was 78.30% and it increased significantly over a period of 6 months. The oil absorption capacity (OAC) of seeds flour was low but gradually increase significantly in the first 3 month of storage and decreased significantly in the last month (6th month). Least Gelatinization concentration of Quinoa dehulled flour was found 14% at 0day. There was a marginal difference in LGC values over the months. The peroxide value was not recorded during the initial storage period. It could only be detected at 90 days and 180 days of storage interval, with the values 0.89±0.03 meq/kg and 1.09±0.08 meq/kg respectively, on dry weight basis.

5) Preparation of Information Material

Booklet on 'Nutritious product of Quinoa' received the highest overall MWS (4.0) Results indicates that for booklet various criteria were rated between good to excellent as the mean weighted score for all criteria ranged from 3.6 to 4.6. The findings of the study elucidate that the developed booklet was evaluated as very good by the experts. This developed booklet was found easy to read by the respondents as their readability was found better. The findings further indicate that the overall comprehension of this booklet was excellent. All the necessary steps were followed in content collection, outlining, preparing, experts evaluation, modification with the users of the booklet. Booklet can be recommended for use by any welfare organization or extension worker as a standardized communication material to generate awareness among rural people.

Recommendations-

- Other processing techniques can be tried for reducing the anti-nutritional properties
- Popularization and commercialization of the developed food can be done in collaboration with self help groups at village level.
- Further studies can be taken on storage of Qunioa flour.
- Nutritonal intervention studies can be undertaken for exploring the health benefits of Quinoa.
- The storage stability of antioxidants in heat seal packaging can be assessed for longer duration of storage.
- Qualiative and quantative analysis of major individual antioxidant in Quinoa.
- It is exceedingly essential to create awareness among people regarding Quinoa benefits and nutritive properties. Inclusion of Quina would prosper their health.

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APPENDIX :I

EVALUATION CARD FOR HEDONIC RATING TEST

Name of recipe: …….

Name of Respondent: ……..

Taste these samples and check how much you like or dislike each one. Please rate the samples for quality attributes according to the 9- point hedonic scale given below:

1. Like Extremely- 9
2. Like Very Much- 8
3. Like moderately 7
4. Like Slightly- 6
5. Neither like nor Dislike 5
6. Dislike Slightly- 4
7. Dislike Moderately- 3
8. Dislike Very Much- 2
9. Dislike Extremely- 1

Sample No.	**Sensory Attributes**					
	Colour	**Appearance**	**Texture**	**Aroma**	**Taste**	**Overall Acceptability**

Remarks, if any: 1.

2.

APPENDIX- II

Evaluation of developed booklet by Experts

EVALUATION SHEET

Name of Expert: **Department:** **Date:**

Criteria for scoring: Excellent: 5, Very good: 4, Good: 3, Fair: 2, Poor: 1

S. No.	Topic	Relevance to topic	Subject matter coverage	Layout	Sub title	Continuity/ sequence	Accuracy	Language*			Illustration	Size	Overall presentation	Remarks if any
								A	B	C				
	BOOKLET													
1.	Nutritious product of Quinoa													

*__Language__: A: Clarity, B: Selection of words, C: Sentence structure

Suggestions for improvement: **Signature**