INTRODUCTION

Nutrition and health are the most important contributory factors for human resource development in India. Since independence the country faced two major nutritional problems – one was the threat of famine and acute starvation due to low agricultural production and lack of appropriate food distribution system, and the other was chronic energy deficiency because of low dietary intake mainly due to poverty and poor purchasing power. Poor environmental sanitation and lack of access to safe drinking water led to high prevalence of infection.

The large sections of Indian population were suffered from varying degrees of protein energy deficiency. The most vulnerable group regarding health and nutritional status was preschool children living in rural as well as in urban slum areas, within which the tribal preschool children were the main victims of undernourishment.

Status of malnutrition among children in Madhya Pradesh

<table>
<thead>
<tr>
<th>Year</th>
<th>Total children</th>
<th>Normal weight children</th>
<th>Low weight children</th>
<th>Very low weight children</th>
<th>Total malnourished children</th>
</tr>
</thead>
<tbody>
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<td>2009-10</td>
<td>6969894</td>
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<td>5356599</td>
<td>1436075</td>
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</table>

(Ref., Govt. of Madhya Pradesh, 15.03.2013, VidhanSabha Record, Bhopal)

Biscuit is defined as a small thin crisp cake made from unleavened dough (Fayemi, 1981). The production of biscuit as a mixture of flour and water but may contain fat, sugar and other ingredients mixed together into dough which is rested for the period and then passed between rollers to make sheet, described by Okaka (1997). Biscuits were assumed as sick man’s diet in early days. Biscuits are very easy to carry, tasty to eat, cholesterol free and reasonable at cost. Biscuits are more amenable to develop different combination to meet a huge range of consumer’s demand with respect
to taste and nutritional requirements. Biscuits provide an effective additional tool of improving the supply to dietary protein to overcome the Protein Energy Malnutrition among Indian population.

The protein and micro-nutrients especially minerals are gaining more importance because of their deficiencies are recognised as major health problem. Conventional biscuits contain low level of the poor quality protein (Rajor et. al., 1989). The basic ingredient of biscuit is wheat flour which contains about 12 per cent protein, 71.2 per cent of carbohydrates, 1.5 per cent of minerals and 1.2 per cent of fibre however, deficient in the essential amino acid lysine.

In India, wheat is grown in an area of 25.68 Mha with an annual production of 74.04 Mt, and in Madhya Pradesh it is grown in an area of 2.69 Mha with an annual production of 3.89 Mt.

Amaranth is easy to grow, nutrient rich and underutilized pseudo cereal can play an important part in quest against malnutrition and hunger that occur due to low rainfall and poor soil conditions. Amaranth grows well and has a high tolerance to water stress conditions along with poor soils where traditional cereals cannot be grown.

Amaranth is one of the few multi-purpose crops which can supply grain and tasty leafy vegetable of high nutritional quality as a food and animal feed, and additionally, because of attractive inflorescence colouration, amaranth can be cultivated as an ornamental plant. Grain amaranth belongs to a group of cereal-like grain crop or pseudo cereals. Pseudo cereals are dicotyledonous species which are not closely related to each other or to the monocotyledonous true cereals.

Amaranth seeds with their phenomenal nutritional profile provide several important nutrients like that are on an average composed of 13.1 to 21.0 % of crude protein; 5.6 to 10.9 % of crude fat; 48 to 69 % of starch; 3.1 to 5.0 % of dietary fibre and 2.5 to 4.4 % of ash. The proximate composition is inconsistent among and within the species. Prevalence of protein energy and micronutrient malnutrition, FAO/UN launched its "Composite Flour Programme" already in 1964.
The main problem in the use of amaranth as a component replacing wheat in the blends arises from the fact that it does not contain gluten. However, irrespective of nutritive values and loaf appearance the acceptance of any product is a function of its sensory qualities.

A judicious combination of wheat and amaranth could provide an excellent nutritious biscuits with balanced protein and minerals and may become useful in improving the nutritional status of the population. This study tries to develop protein, calcium, phosphorus and iron rich biscuits with the scope of utilization of amaranth flour. Till now no recommendation has been formulated for the product. Thus in the light of above background, the present investigation “Process standardization for the development of value added product based on amaranth and it’s quality evaluation” was taken under with the following objectives-

- To standardize the product developed from amaranth.
- To study the physic-chemical properties of developed product.
- To study the acceptability on the basis of organoleptic properties of developed product.
REVIEW OF LITERATURE

In this chapter, an attempt has been made to assimilate the previous works within the framework of present study, which were helpful in interpretation of results. The literature referred to planning and executive of present investigation and for discussion of results. The review has been presented as follows.

2.1 Protein rich biscuits:

Tseng et al. (1971) reported that a mixture of wheat flour fortified with 12% defatted soy flour increased the lysine content by two times of wheat alone and the protein content of bread made from such a blended flour increased by approximately 35%.

Rao et al. (1984) stated that the protein rich biscuits of acceptable quality were prepared using jowar (sorghum), soybean and skim milk (in 60:30:10 proportion). The method of manufacture consisted of pregelatinization of 30 parts of jowar flour and dry-mixing remainder 30 parts with 30 parts of full-fat soy flour, 10 parts of skim milk powder, 0.5 parts CMC and 1.0 parts of baking soda. The vegetable fat (9.35 parts for low fat and 24.2 parts for high fat biscuits) was rubbed with ground sugar (36.0 parts for low fat and 44 parts for high fat biscuits) to creamy consistency and mixed with pregelatinized jowar flour and other dry-mix ingredients. The dough was worked and then rolled to 3mm thickness, cut into small pieces, and baked at 170±5°C for 15-20 min.

Rajput et al. (1988) reported that laboratory studies on the preparation of high protein biscuits indicated that some of the unconventional protein sources such as mustard protein concentration (MPC), cotton seed flour (CSF), or cotton seed protein isolate (CSPI) could be conveniently used to increase the protein content in biscuits from 5.9 to 11.3-18.1%. In general, incorporation of different protein concentrates affected the crispness, taste and overall acceptability, as indicated by the sensory scores but increased the spread ratio and spread factor, which depend on the level of incorporation. The optimum level of incorporation was found to be 15% in case of MPS.
or CSPI and 10% in case of CSF. The quality of high protein biscuits could be improved by incorporation of 0.5% sodium steroyl-2-lactylate in the formulation.

Singh et al. (1993) reported the development of high protein biscuits from composite flour prepared by wheat, green gram, Bengal gram and black gram.

Onweluzo and Lwezu (1998) Reported that cassava soybean flours biscuit (1:1) had higher protein and calorific value than wheat flour biscuit. Wheat: soybean (1:1) biscuit had twice the protein value of the wheat flour biscuit and higher calorific value

Srivastava et al. (2002) developed the biscuits by incorporating 40% finger millet/barnyard millet for diabetics.

Gupta and Grewal (2003) incorporated the carrot powder at 5, 10, 15 and 20% in different types of biscuits to improve the protective nutrients.

Kaul et al. (2003) Developed high protein high energy baked snacks using wheat, ragi, jowar, corn, soy, groundnut and sesame.

SatyanarayanaSwamy et al. (2003) Developed calcium rich non traditional cereal based cookies using finger millet, wheat flour, soybean flour and starch.

Tripathi et al. (2003) Reported that in order to increase the nutritional value of cookies, the wheat flour was fortified with full fat soy flour in the ratio of 95:5, 90:10, 85:15, 80:20, 75:25, 70:30.

Garuda (2004) found that in addition to amaranths outstanding nutritional value, it contains very low sodium content and contains no saturated fat.

Sindhuja et al. (2005) Studies were carried out on composite flour cookies by incorporating amaranth seed (Amaranthus gangeticus) flour, which is rich in protein at 0–35% levels, showed a small reduction in water absorption capacity from 58.0 to 56.5%, a considerable reduction in Farinograph stability from 3.0 to 1.5 min and increase in the mixing tolerance index from 40 to 120 BU of the dough. Incorporation of amaranth flour improved the colour of the cookies from pale cream to golden brown.
Solve et al. (2010) reported that 100% incorporation of rajKeera sweet flour in sweet and salt biscuit was most acceptable lable. Addition of rajKeera enhances the content of protein, iron and calcium and also found organoleptically acceptable.

Nidhi and Indira (2012) reported that amaranth flour supplemented recipes are more nutritious with added advantage of a significant elevation in the protein, calcium and iron content with adequate carbohydrates there by, alleviating the problem of malnutrition. The results of the organoleptic scoring of grain amaranth flour supplemented biscuits were best evaluated when blended up to 30 per cent, though acceptable even up to 50 per cent.

2.2 Calcium rich biscuits:

Sehecie and dragojevic (2005) Studied to evaluate some hard biscuits produced in Croatia as a source of different minerals, nutrition, micro-elements Ca, Mg, Na and K determined by inductively coupled plasma atomic emission spectroscopy (ICP-AES) in sweet classic white wheat flour biscuits and in enriched dietetic sweet and salted biscuits. Ca and Mg contents in different kinds of biscuit ranged from 20.43 up to 87.92 mg/100 g and from 17.29 to 59.53 mg/100 g, respectively.

Singh et al. (2006) the research revealed that all types of biscuit were organoleptically acceptable, with good mineral profile and low amount of anti-nutrients. However, biscuit prepared from blanched flour had high calcium, phosphorus, iron and manganese content as compared to that prepared from malted flour. Low anti-nutrient content and high in vitro digestibility were observed in biscuit prepared from blanched flour. Addition of soybean flour to biscuit also helps to increase the mineral profile as compared to that prepared without incorporation of soybean flour.

2.3 Chemical constituents:

I.S.I. (1974) recommended the specialization for protein rich biscuits as moisture 6.0%, protein 13.0% (min.), fat 12.0% (min.) and calcium 450 mg% (min.).

Rao et al. (1984) prepared protein rich biscuits using jowar, soybean and skim milk and had composition 4.4-4.5% moisture, 13.25, 15.18% protein, 12.50-19.50% fat, 2.86-3.60% ash, 59.81-64.25% total carbohydrates and 575-605mg % calcium.
Dreher and Patek. (1984) studied that chemical characteristics of control high-protein navy bean fortified (10 to 30%) cookies. The ash content ranged from 1.38 to 1.89 5% with the control having the lowest value and the bean flour cookies having increasing ash content directly related to the level of bean flour. The lipid content ranged from 34.08 to 36.52 %, with the control having slightly more oil content. The protein content ranged from 7.04-9.42% with the control cookies having the lowest value and the 30% high protein flour cookies having the highest value.

France. (1988) Analyzed 10 samples of industrially prepared chocolate biscuits. The range of constituents reported were: protein 5-7.8, lipid 16.9-27.0, carbohydrates 60.8-76.5%, energy 443-522 kcal/100g, calcium 20.6-106.6, and sodium 32-547 mg/100g.

Reddy et el. (1990) reported that the addition of amaranth (rajKeera) seed flour increased the content of crude protein, fibre, ash, fat, iron and calcium in sweet biscuit and salt biscuits.

Leelavathi et al. (1993) reported the use of wheat bran to develop high fibre biscuits. Flour could be substituted up to 30% without affecting overall biscuit quality. The dietary fibre content of the finished biscuits was 7 times higher than the control.

Semwal et al. (1996) Evaluated various commercial biscuits and reported that 25 brands of glucose biscuits and 7 other varieties had 2.47-8.75% moisture, 1.04-24.60 % fat, 5.46-8.90% protein, 0.9-1.4% ash, 800-4950 mg/kg sodium and 450-1720 mg/kg potassium, 120-1800 mg/kg calcium while total energy values ranged between 365 and 501 k cal.

Evgeny N. Ofitserov (2001) Amaranth contains a unique protein composition, starch with granule size not less than 1 micron, vitamins (A, B, C, E, P), carotenoids, substantial amounts of pectin, micro- and microelements, calcium in great quantities, highly unsaturated oil, having squalene in its content (up to 8%) and a number of other bioactive substances. The role of these substances in functioning of organism and their use in non-conventional medicine have been discussed in brief.
Ferreira and Areas (2004) the objective of this study was to evaluate the protein quality of raw, toasted and extruded amaranth. Each of the extruded amaranth diet reached greater net protein ratio (NPR) values than casein control and raw and toasted amaranth diets. On the other hand, the true digestibility (TD) was similar to the raw and all processed grains, extruded and toasted diet, and lesser than casein control diet.

Akubugwo et al. (2007) The Proximate analysis showed the percentage moisture content, ash content, crude protein, crude lipid, crude fibre and carbohydrate of the leaves as 84.48, 13.80, 17.92, 4.62, 8.61 and 52.18%, respectively while its calorific value is 268.92 Kcal/100 g. Elemental analysis in mg/100 g (DW) indicated that the leaves contained sodium (7.43), potassium (54.20), calcium (44.15), Magnesium (231.22), Iron (13.58), Zinc (3.80) and phosphorus (34.91). The vitamin composition of the leaves in mg/100 g (DW) was -carotene (3.29), thiamine (2.75), riboflavin (4.24), niacin (1.54), pyridoxine (2.33), ascorbic acids (25.40) and -tocopherol (0.50). Seventeen amino acids (isoleucine, leucine, lysine, methionine, cysteine, phenylalnine, tyrosine, threonine, valine, alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, proline and serine) were detected. The chemical composition in mg/100 g (DW) for alkaloid, flavonoid, saponin, tannins, phenols, hydrocyanic acid and phytic acid were 3.54, 0.83, 0.49, 0.35, 16.99 and 1.32, respectively. Comparing the nutrient and chemical constituents with recommended dietary allowance (RDA) values, the results reveal that the leaves contain an appreciable amount of nutrients, minerals, vitamins, amino acids and phytochemicals and low levels of toxicants.

Mlakar et al. (2009) the present paper briefly describes crop importance, botany and chemical composition, including new findings on nutritive value and properties of grain amaranth processed as food. Especially the rheological properties of composite flours containing amaranth and their suitability for making fortified bread are discussed.

Mlakar et al. (2010) This involution has increased the vulnerability of agriculture, reduced genetic diversity, provoked some environmental problems and impoverished the human diet. The mentioned facts stimulate the retrieving of alternative crops into the production. The present paper briefly describes crop importance, botany, nutritional value and utilization of grain amaranth.
Barca et al. (2010) Gluten-free bakery foodstuffs are a challenge for technologists and nutritionists since alternative ingredients used in their formulations have poor functional and nutritional properties. Therefore, gluten-free bread and cookies using raw and popped amaranth, a grain with high quality nutrients and promising functional properties were formulated looking for the best combinations. The best formulation for bread included 60–70% popped amaranth flour and 30–40% raw amaranth flour which produced loaves with homogeneous crumb and higher specific volume (3.5 ml/g) than with other gluten-free breads. The best cookies recipe had 20% of popped amaranth flour and 13% of whole-grain popped amaranth. The expansion factor was similar to starch-based controls and the hardness was similar (10.88 N) to other gluten-free cookies. Gluten content of the final products was around 12 ppm. The functionality of amaranth based dough was acceptable although hydrocolloids were not added and the final gluten free products had a high nutritional value.

Kumar et al. (2011) studied the nutritional contents and medicinal properties of wheat. They were concluded that wheat is good source of protein, minerals, B-group vitamins and dietary fiber i.e. an excellent health-building food. It contains carbohydrate 78.10%, protein 14.70%, fat 2.10%, minerals 2.10%, and considerable properties of vitamins (thiamin and vitamin-b) and minerals (zink, iron). The wheat germ, which was removed in the process of refining, is also rich in essential vitamin E.

Mburu et al. (2012) Amaranth grain product was rich in protein with 0.5 g/10g of lysine, a limiting amino acid in cereals, and methionine, a limiting amino acid in pulses. The product had good amount 44.4 mg/100g of α-tocopherols important for infant development. The product was also rich in oleic acid (36.3%) and linoleic acid (35.9%) with some amounts of linolenicacid (3.4%) that are important for infant growth. It also had good amounts of minerals of importance such as potassium (324.4 mg/100g), phosphorous (322.8 mg/100g), calcium 189.1 (mg/100g), magnesium (219.5 mg/100g), iron (13.0 mg/100g) and zinc (4.8 mg/100g). Considering amaranth grain product fed to infant three times a day, at a reconstitution of 15% product, the levels of magnesium, manganese and tocopherol were far above the recommended intakes, while protein, phosphorous, iron, zinc, riboflavin and niacin were above the average requirements.
Therefore, reconstituting the product with milk would enrich the deficient nutrients, especially for iron and zinc which are crucial nutrients for infants.

Emire and Arega (2012) reported that protein, fat, ash, iron, zinc, phosphorus and calcium contents in the blends increased significantly with an increase in amaranth substitution. It was concluded that the flour blends containing up to 10% of amaranth and baked at 220 degree Celsius for 18 minutes can be used in industrial bread production. The substitution of wheat flour with amaranth one can contribute to improvement of food security and production of various gluten-free value added products.

2.4 Sensory evaluation:

Rao et al. (1984) Used jowar (sorghum), soybean and dry skim milk in 60:30:10 proportion in production of biscuits. Vegetable fat 9.35 part for low fat and 24.2 part for high fat biscuits was rubbed with ground sugar (36.0 parts for low fat and 44 parts for high fat biscuits) and 1 part baking soda to a creamy consistency and mixed with the dry ingredients. Use of CMC and baking soda at 0.5 and 1.0 % respectively improved biscuit texture. The increase in fat percent of biscuits improved the texture of biscuit.

Singh et al. (1993) Observed that wheat flour containing Bengal gram flour adversely affected the top grain texture and colour of biscuits.

Singh et al. (1996) Prepared biscuits from the blends containing varying proportion of defatted soy flour using traditional creamery method and evaluated for diameter, thickness, spread ratio, spread factor, hardness and sensory characteristics. The thickness of soy fortified biscuits increased, whereas diameter spread ratio and spread factor of biscuits decreased with increasing level of DSF.

Singh et al. (1997) The results of sensory evaluation revealed that the scores for texture and overall acceptability in control as well as in soy biscuits improved up to 30% fat level and thereafter decreased. However, the effects of increasing levels of sugar on the texture and overall acceptability scores increased up to 37% in control biscuits and thereafter decreased, whereas in soy biscuits improving effects were observed up to maximum level of sugar.
Kotwaliwale et al. (2001) Reported that replacement of wheat flour up to 40% level with defatted soy flour in the standard sweet biscuits recipe increased the protein content from 6.5 to 14.8%. Sensory evaluation results showed that all of the biscuits from various blends were acceptable with no significant differences among them.

Shrivastava et al. (2002) Evaluated sensory parameters and revealed that all three types of biscuits barnyard, finger millet and control were liked very much.

Gupta and Grewal. (2003) Reported that the melting moments, sweet biscuit and sweeten salty biscuit containing 10% carrot powder were liked very much; those containing 15% were liked moderately and the biscuit containing 20% carrot powder were neither liked nor disliked by the judges.

Mishra and Kulshrestha. (2003) Results of the sensory (appearance, colour, flavour, texture, taste and overall acceptability) evaluation revealed that the 'OP-1' variety was rated higher for texture, taste and overall acceptability than the other two varieties. Biscuits prepared from the fresh flour rated better in colour, texture and taste than the biscuits prepared from the flour stored at refrigerated temperature for six months.

Sadana and Chabra (2004) conducted a research on the development and sensory evaluation of low cost weaning food formulations. They concluded that germinated and supplemented grain flour weaning food formulation were more acceptable as compared to control products prepared from ingeminated wheat flour.

Ljubica et al. (2009) Extruded amaranth grain products have specific aroma and can be used as snack food, supplement in breakfast cereals, or as raw material for further processing. Extruded products of corn-amaranth grits blends, containing 20% or 50% amaranth grain grits, were produced by extrusion-cooking using a laboratory Brabender single screw extruder 20 DN. Extrudates with various texture were obtained. During extrusion process starch granules are partially degraded, hence rheological properties were examined. All samples exhibited thixotropic flow behaviour. Those samples in which part of the corn grits was replaced with amaranth one had lower viscosity and exhibited lower level of structuration during storage.
2.5 Shelf life:

Leelavathi (1993) Stated that biscuits had a shelf life of approximately 90 days when wrapped in 100 gauge polypropylene pouches and stored at 27±2 c and 60±2 % RH.

Sinha and Ali (1993) Reported that supplementation of wheat flour with DSF improved the shelf life of baked goods in addition to increase in protein content.

Raoef al (1995) Among packaging material used paper aluminium foil polyethylene laminated pouch sample were more stable and acceptable.

Awasthi and Yadav (1998) the biscuits were packed in two different types of packaging materials viz., high density polypropylene film (160gauge) and laminate of cellophane (150 gauge) and stored under ambient conditions. The average minimum and maximum relative humidity were 62±15.2 and 84.1 ±9.9%, respectively. The biscuit samples packed in laminated packaging materials stored well for 30 days, whereas those packed in polypropylene films could be kept for 45 days.

Singh et al., (2002) stated that during storage moisture content, peroxide value and free fatty acid contents of biscuit increased whereas hardness, crispiness and overall sensory acceptability scores of biscuit decreased gradually. They also suggested that polypropylene proved to be a better packaging material for biscuit then the laminated one and biscuit packed in it could be stored for 45 days under ambient conditions whereas, in laminated packaging, the shelf life of biscuit was 30 days.

Elizabeth (2010) observed that amaranths are being used in breakfast food, bakery products, gluten free foods and extruded foods. For making a leavened food, they must be blended with wheat.
MATERIALS AND METHODS

The present investigations on “Process standardization for the development of value added product based on Amaranth and its quality evaluation” was carried out in the Department of Food Science and Technology, College of Agriculture, J.N.K.V.V., Jabalpur (M.P.) during the year 2013-2014. The chapter therefore describes the materials and various methodologies used in the investigation.

3.1 Materials.

Refined wheat flour, Amaranth flour and various ingredients such as Sugar, Glucose, Sodium bicarbonate, Ammonium bicarbonate, Vegetable oil, Baking powder, Vanilla essence and Salt were purchased from the local market.

3.2 Preparation of Amaranth fortified cookies.

Sweet cookies from wheat flour (control) and Blends Amaranth flour (composite of, Sugar Fat, Baking Powder and water) were prepared using the traditional creamery method as described by Whitley (1970) following general formula has been used for product preparation. The required quantity of sugar, fat flavour (vanilla) was creamed well. To this, well mixed blends of remaining ingredients were added along with a required amount of water. The contents were mixed further for 2 min. to make dough of desired consistency. Using a wooden rolling pin, dough was rolled into a sheet of uniform thickness of approximately 5mm. Then biscuits were cut into round shape pieces and placed on greased tray. The tray was kept in baking oven at 300°C for 3-4 min.

Different combinations for preparation of Amaranth fortified cookies.
### Table: Combinations of Wheat and Amaranth

<table>
<thead>
<tr>
<th>Combinations</th>
<th>Wheat %</th>
<th>Amaranth %</th>
</tr>
</thead>
<tbody>
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<td>$T_1$</td>
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<td>20</td>
</tr>
<tr>
<td>$T_5$</td>
<td>70</td>
<td>30</td>
</tr>
</tbody>
</table>

### Flow sheet for preparation of Amaranth fortified cookies.

1. **Refined wheat flour and Amaranth flour (90:10)**
2. 
   Blended and sieved (60 mesh)
3. Thoroughly mixed with sugar, fat, and little
   **Amount of baking powder**
4. Little water added to make dough
5. Rolled into a sheet of uniform thickness, cut into round pieces and placed on greased tray
6. Kept in baking oven at 300º C for 3-4 min.
7. Cookies
3.4 Analytical methods.

The following methods were used for various determinations.

3.4.1 Physical properties of Amaranth fortified cookies.

3.4.1.1 Weight

Six biscuit of uniform size and thickness were selected and weighed. The average weight was expressed as g.

3.4.1.2 Diameter (D):

The Diameter of biscuits was measured by lying of 6 biscuits edge to edge and measuring to the nearest mm (A.A.C.C. 1967). The biscuits were rotated at 900 and their diameter was remeasured as a check determination the average diameter of biscuits was reported in mm.

3.4.1.3 Thickness (T):

Thickness of 6 biscuits was measured by placing the biscuits edge to edge and by staking one above the other respectively measurement by rearranging and restaking were made and average values were taken and expressed as mm (A.A.C.C. 1967).

3.4.1.4 Spread factor (D/T):

The spread factor was calculated by dividing the average value of diameter (D) by average value of thickness (T) of biscuits (AACC, 1967).

3.4.2 Chemical properties of Amaranth fortified cookies.

3.4.2.1 Moisture.

The moisture content in the sample was estimated according to the method of AOAC (1984). 5 gm of sample was taken in pre-weighed moisture box, dried at 105°C for 24 hrs in hot air oven, cooled in desiccators again weighed. The difference in weight of moisture box represents the moisture content of the sample.

\[
\text{Moisture} \, (\%) = \frac{\text{Difference in the weight}}{\text{X 100}}
\]
3.4.2.2 Protein.

The protein content in sample was determined by using conventional Micro-Kjeldhal digestion and distillation procedure as given in AOAC (1984).

**Reagents**

- Catalyst mixture- A mixture of 100 gm K$_2$SO$_4$, 20gm of CuSO$_4$ and 2.5 gm of SiO$_2$.
- Sodium hydroxide 40% (w/v)
- Boric acid 2 % (w/v).
- Concentrated sulphuric acid AR (spgr 1.81)
- Mixed indicator 2 parts 0.2 % (w/v) Methyl red and 1 parts 0.2% (w/v) methyl blue in absolute alcohol.
- Standard sulphuric acid (0.1N)

**Procedure**

0.5 gm of sample was weighed accurately and transferred to a Kjeldhal flask taking care to see that the material did not stick to the neck of the flask. The catalyst mixture of about 1g and concentrated sulphuric acid (5ml) were added. Then the flask in an inclined position in digestion chamber was heated for about 4-6 hours till the liquid became clear (green blue colour).

**Distillation**

The content in the flask were allowed to cool and the digestion material was transferred quantitatively to a vacuum jacketed flask of micro Kjeldhal distillation apparatus and the ammonia liberated by the addition of 10 ml of 40% NaoH on heating was absorbed in 20 ml boric acid containing 2-3 drops of mixed indicator in 100ml conical flask. The distilled off ammonia was titrated against 0.1N sulphuric acid. The blank was also run in a similar way.
Normality of $\text{H}_2\text{SO}_4$ X Volume of 0.1N $\text{H}_2\text{SO}_4$ X 14

\[
N(\%) = \frac{\text{Weight of sample X 1000}}{\text{Normality of } \text{H}_2\text{SO}_4 \times \text{Volume of 0.1N } \text{H}_2\text{SO}_4 \times 14} \times 100
\]

Crude protein (\%) = $N \times 6.25$

3.4.2.3 Fat.

The fat content of the sample was determined by the procedure as described in AOAC (1984). 5 gm of sample was weighed accurately, placed in thimble and plugged with cotton. The extractor-containing thimble was placed over a pre weighed extraction flask (A). Fat content was determined by extracting the sample with solvent petroleum ether (AR grade 60-80°C) for 8 hr. using sox lets extraction procedure. After extraction the excess of solvent was distilled off and the residual solvent was removed by heating at 80°C in oven for 4-6 hours. The fat content was determined as below:

\[
\text{Crude fat (\%) = } \frac{\text{Weight of flask (b)-weight of flask (A)}}{\text{Weight of sample}} \times 100
\]

3.4.2.4 Carbohydrate.

Total carbohydrate in the samples was estimated by hydrolysis method as described in AOAC (1984).

Reagents:

- Conc. HCl (AR spgr 1.25)
- Fehling’s solution
- Fehling’s solution A: 34.64 gm of CuSO$_4$.5H$_2$O was dissolved in 500ml of distilled water.
- Fehling’s solution B: 173 gm of sodium potassium tartarate and 50 g of sodium hydroxide were dissolved in 500 ml of distilled water. The Fehling’s solution was
prepared by mixing the equal volume of solution A and solution B. It was prepared fresh daily.

- Sodium Hydroxide 40 % (w/v).
- Methyl blue indicator 0.1 % (w/v) in 95% alcohol.
- 3N HCl – 68.18 ml concentrated HCl was made up to 250 ml with distilled water.
- Dextrose 1% - 1 gm of dextrose was dissolved in 100 ml distilled water.

**Procedure:**

2.5gm sample was taken in the flask and suspended in 200 ml of distilled water. 20ml of 3N HCl was added refluxed in an air condenser for 3 hrs. On cooling, it was neutralized with alkali to pH 7.0, filtered and volume was made to 250 ml with distilled water.

The total carbohydrate in the filtrate was determined by titrating it with Fehling's solution (A & B, %ml each) using 1 ml of methyl blue indicator. Factor was worked out by titrating 1% dextrose with Fehling's solution. In each titration Fehling's solution in the conical flask was heated with a constant flame and titration was done with filtrate in the burette until the end point (Brick-Red colour) was obtained. The total carbohydrate content was calculated as under.

\[
\text{Dextrose } \% = \frac{\text{Factor} \times 250}{\text{Titrated value} \times \text{weight of sample}} \times 100
\]

Total carbohydrate (%) = Dextrose % \times 0.9

**3.4.2.5 Crude fibre.**

The fibre content was determined by fibra plus – operational procedure for crude fiber.

- Weigh the sample accurately and note down the weights (W).
- Transfer the weighed sample into oven dried crucibles.
- Place the crucible in the metal adapter of fibra plus hot extraction unit and ensure proper sealing of crucible against the adapter rubber.

**Acid Wash**
- Pour 150 ml of 1.25 % H₂SO₄ into the extractors from the top for each sample.
- Don't leave any place without crucible.
- Switch on the instrument and set the initial temperature to 500°C.
- After boiling starts, reduce the temperature to 400°C.
- Allow the samples to boil for 45 minutes in acid.
- After 45 minutes boiling, drain the acid and wash the samples twice or thrice with distilled water.
- During draining, ensure that the knob is vacuum mode.
- If the draining is not effective due to clogging of sample in the crucible, then, keep the knob in pressure mode, press the pressure button twice or thrice and immediately turn the knob to vacuum mode.

**Alkali Wash**
- Pour 150 ml of 1.25 % NaOH into the extractors from the top for each sample.
- Don't leave any place without crucible.
- Switch on the instrument and set the initial temperature to 500°C.
- After boiling starts, reduce the temperature to 400°C.
- Allow the samples to boil for 45 minutes in alkali.
- After 45 minutes boiling, drain the alkali and wash the samples twice or thrice with distilled water.
- During draining, ensure that the knob is vacuum mode.
• If the draining is not effective due to clogging of sample in the crucible, then, keep the knob in pressure mode, press the pressure button twice or thrice and immediately turn the knob to vacuum mode.

• After alkali wash take out crucibles and dry them in hot air oven @ 100°C until the crucibles are free from moisture.

• Cool down the hot crucible to room temperature using a desiccator.

• Weigh the crucibles and record the reading (CWBA=W1)

• Place all the crucibles in the muffle furnace at 400°C for ashing.

• Cool down the all hot crucibles after ashing to room temperature using a desiccator.

• Now weigh the crucibles and record the readings (CWAA=W2)

**CALCULATION**

Sample weight = W  
CWBA = W1  
CWAA = W2  
W3 = (W1-W2)  
% of Crude Fiber = (W3/W) X100

**3.4.2.6 Total Ash.**

The ash content in the sample was estimated according to AOAC (1984).

**Procedure**

5 gm of sample was weighed accurately into pre weighed porcelain (which has previously been heated to about 600 oC and cooled). The crucible was heated in a muffle furnace for 6-8 hours at 600-700 ºC. It was then cooled in desiccators and weighed. To ensure completion of ashing, the crucible was again heated in a muffle furnace for 1-2 hour, cooled and weighed. This was repeated till the consecutive weights were the same and the ash was almost grayish-white in colour.
3.4.3 Estimation of Minerals.

Minerals content of cookies were obtained by calculation using table values (Gopalan et al., 1996). In this case, percentage mineral content was calculated based on the mineral content of different ingredients used in the formulation of the cookies.

3.4.3.1 Energy Value:

The total energy values were calculated by using values 4, 4, and 9 for protein, carbohydrate and fat respectively as follows: Total energy (kcal/100g) = \[\text{% available carbohydrates} \times 4 + \text{% protein} \times 4 + \text{% fat} \times 9\]

3.4.4 Sensory evaluation.

The organoleptic properties of amaranth fortified cookies were evaluated by the panel of 10 judges based on the sensory attributes of colour and appearance, aroma, taste, texture, crispness, and overall acceptability. The evaluation was done on a nine point hedonic scale as described by Amerine et al. (1965).

3.4.4.1 SENSORY EVALUATION SCORE CARD.

Give the rating of the food products provided on the sensory attributes based on the following ratings:

- Like extremely: 9
- Like very much: 8
- Like moderately: 7
- Like slightly: 6
- Neither like nor dislike: 5
- Dislike slightly: 4

Ash (\%) = \frac{\text{Weight of ash} \times 100}{\text{Weight of sample}}
Dislike moderately 3
Dislike very much 2
Dislike extremely 1

<table>
<thead>
<tr>
<th>Sensory Attributes</th>
<th>Code 1</th>
<th>Code 2</th>
<th>Code 3</th>
<th>Code 4</th>
<th>Code 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour &amp; Appearance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aroma</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crispness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall acceptability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

3.5 Storage studies.

The shelf-life studies of amaranth fortified cookies were carried out in polyethylene and laminated pouches for a period of 3 months at ambient temperature. 100 g of best three combinations of amaranth fortified cookies and control samples were packed and kept at room temperature for 90 days. All samples were drawn periodically after 0, 30, 60, 90, days and analyzed moisture, colour and crispness contents according to the standard procedures as described earlier in the chapter.

3.6 Statistical analysis.
The results/data of the analysis for different parameters were analyzed statistically to assess the degree of variation within the treatments as compared to the control. The data were subject to analysis of variance (ANOVA) and least significance difference to determine the difference between means, analyzed by Genstat computer package using Completely Randomized Design (CRD) at 5% level of significant.

The skeleton of analysis of variance

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Source of variance</th>
<th>d.f.</th>
<th>SS</th>
<th>MSS</th>
<th>F calculated</th>
<th>F table value (5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Treatments</td>
<td>(t-1)</td>
<td>TSS</td>
<td>TMS</td>
<td>TMS/EMS</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Error</td>
<td>(n-t)</td>
<td>ESS</td>
<td>EMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>(n-1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where,

- \( t \) = Number of treatments
- \( n \) = Number of observations
- d.f. = Degree of freedom
- T.S.S. = Treatment sum of square
- E.S.S. = Error sum of square
- T.M.S. = treatment mean sum of square
- E.M.S. = Error mean sum of square

\[
c. v. = \sqrt{\frac{EMG}{GM}} \times 100
\]

\[
SE(d) = \sqrt{\frac{2EMS}{r}}
\]
C.D. = t(0.05) x SE(d)

Where,

C.V. = Coefficient of variation
S.E.(d) = Standard error of difference
G.M. = Grand mean
C.D. = Critical difference
T(0.05) = t-value at 5% probability level
RESULTS

The present investigation was carried out in the Department of Food Science and Technology, College of Agriculture, JNKVV, Jabalpur for the “Process standardization and development of value added product based on amaranth and its quality evaluation”. The results obtained during the course of investigation have been presented in this chapter in the form of tables and graphs.

4.1 Qualitative and Physical properties of grains.

The physical property and proximates parameters were observed during the analysis of wheat and amaranth grains and they were used for the development of nutritious cookies.

Table- 4.1.1 Physical properties of grain

<table>
<thead>
<tr>
<th>Types of Grain</th>
<th>Bulk density (g/ml)</th>
<th>Water absorption capacity (%)</th>
<th>Moisture Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>0.72</td>
<td>38.17</td>
<td>11.00</td>
</tr>
<tr>
<td>Amaranth</td>
<td>0.84</td>
<td>46.40</td>
<td>6.47</td>
</tr>
</tbody>
</table>

As Table- 4.1.1 showed that the amaranth grains were lighter in weight and smaller in size so they were having higher bulk density (0.84 /ml) as compared with the wheat, amaranth gains showed the better water absorption capacity (46.40 %) may be because of less moisture content (6.47%) in the amaranth grains.

Table- 4.1.2 Quality attributes of grains.

<table>
<thead>
<tr>
<th>Type of grain</th>
<th>Proximate Parameters (%)</th>
<th>Energy (Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protein</td>
<td>Fat</td>
</tr>
<tr>
<td>Wheat</td>
<td>12.50</td>
<td>1.9</td>
</tr>
<tr>
<td>Amaranth</td>
<td>15.59</td>
<td>7.2</td>
</tr>
</tbody>
</table>
Quality attributes of wheat and amaranth grains depicted in the Table- 4.1.2, showed that amaranth grains are nutritionally in a better composition as compared to wheat grains i.e. as protein content (15.59 %), fat content (7.2 %), ash content (2.95 %), and fibre content (4.35 %) it was observed during the investigation. Wheat grains were found better in carbohydrate content (70.0 %) as compared with the amaranth grains.

Table- 4.1.3 Minerals content of grains.

<table>
<thead>
<tr>
<th>Types of Grain</th>
<th>Minerals mg/100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Calcium</td>
</tr>
<tr>
<td>Wheat</td>
<td>41.0</td>
</tr>
<tr>
<td>Amaranth</td>
<td>164.17</td>
</tr>
</tbody>
</table>

Table-4.1.3 showed the data regarding mineral composition of wheat and amaranth grains during the investigation. It was observed that amaranth grains having better mineral content in comparison with wheat grains. Calcium content (164.17 mg/100g), Phosphorus (466.0 mg/100g) and Iron (12.49 mg/100g) recorded with amaranth. However, wheat grains containing Calcium content (41.0 mg/100g), Phosphorus (306.0 mg/100g) and Iron (5.30 mg/100g) only.
4.2 Physical and functional characteristics of amaranth fortified cookies.

Table- 4.2.1 Physical properties of amaranth fortified cookies.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Weight (g)</th>
<th>Diameter (mm)</th>
<th>Thickness (mm)</th>
<th>Spread factor (D/T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>4.84</td>
<td>43.69</td>
<td>6.43</td>
<td>6.79</td>
</tr>
<tr>
<td>T2</td>
<td>5.13</td>
<td>42.68</td>
<td>6.32</td>
<td>6.76</td>
</tr>
<tr>
<td>T3</td>
<td>5.48</td>
<td>43.31</td>
<td>6.71</td>
<td>6.46</td>
</tr>
<tr>
<td>T4</td>
<td>5.10</td>
<td>45.32</td>
<td>7.14</td>
<td>6.34</td>
</tr>
<tr>
<td>T5</td>
<td>5.28</td>
<td>41.65</td>
<td>8.12</td>
<td>5.13</td>
</tr>
<tr>
<td>SEM ±</td>
<td>0.118</td>
<td>0.019</td>
<td>0.011</td>
<td>0.011</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.355</td>
<td>0.058</td>
<td>0.035</td>
<td>0.034</td>
</tr>
</tbody>
</table>

4.2.1 Weight

The weight of amaranth fortified cookies varied from 4.84 – 5.48 gm. The highest value was observed in the treatment T3 (5.48g) and the lowest value was observed in the treatment T1(4.84g). The highest value was found significantly superior over the control and other treatments.

4.2.2 Diameter

The diameter of amaranth fortified cookies varied from 41.65 – 45.32 mm. The highest value was observed in the treatment T4 (45.32 mm) and the lowest value was observed in the treatment T5 (41.65 mm). The highest value was found significantly superior over the control and other treatments.

4.2.3 Thickness

The thickness of amaranth fortified cookies varied from 6.32 to 8.12 mm. The highest value was observed in the treatment T5 (8.12 mm) and the lowest value was
observed in the treatment T2 (6.32 mm). The highest value was observed significantly superior over the control and other treatments.

### 4.2.4 Spread factor

The spread factor of amaranth fortified cookies was calculated as diameter divided by the thickness, varied from 5.13 to 6.79 D/T. The highest value was observed in the treatment T1 (6.79) and the lowest value was observed in the treatment T5 (5.13). The highest value was found significantly superior over the control and other treatments.

### 4.3 Qualitative attributes of amaranth fortified cookies.

The proximate analysis for amaranth fortified cookies based on wheat flour with amaranth flour in different ratios is given in Table 4.3.1

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Proximate Parameters (%)</th>
<th>Energy (Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protein</td>
<td>Fat</td>
</tr>
<tr>
<td>T1</td>
<td>8.01</td>
<td>17.21</td>
</tr>
<tr>
<td>T2</td>
<td>8.09</td>
<td>17.38</td>
</tr>
<tr>
<td>T3</td>
<td>8.19</td>
<td>17.55</td>
</tr>
<tr>
<td>T4</td>
<td>8.39</td>
<td>17.89</td>
</tr>
<tr>
<td>T5</td>
<td>8.59</td>
<td>18.23</td>
</tr>
<tr>
<td>SEM ±</td>
<td>0.008</td>
<td>0.009</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.024</td>
<td>0.027</td>
</tr>
</tbody>
</table>

### 4.3.1 Protein

The protein content of amaranth fortified cookies varied from 8.01 to 8.59 % as depicted in Table 5. The highest value was observed in the treatment T5 (8.59%) and
the lowest value was observed in the treatment T1 (8.01%). The highest value was found significantly superior over the control and other treatments.

4.3.2 Fat

The fat content of amaranth fortified cookies varied from 17.21 to 18.23% as given in Table 5. The highest value was observed in the treatment T5 (18.23%) and the lowest value was observed in the treatment T1 (17.21%). The highest value was found significantly superior over the control and other treatments.

4.3.3 Carbohydrate

The carbohydrate content of amaranth fortified cookies varied from 60.49 to 62.80g (Table 4.3.1). The highest value was observed in the treatment T1 (62.80%) and the lowest value was observed in the treatment T5 (60.49%). The highest value was found significantly superior over the control and other treatments.

4.3.4 Fibre

Data showed in the Table-5 revealed that the fibre content of amaranth fortified cookies varied from 1.66 to 1.99%. The highest value was observed in the treatment T5 (1.99%) and the lowest value was observed in the treatment T1 (1.66%). The highest value was found significantly superior over the control and other treatments.

4.3.5 Ash

The ash content of amaranth fortified cookies varied from 1.73 to 2.14% (Table 4.3.1). The highest value was observed in the treatment T5 (2.14%) and the lowest value was observed in the treatment T1 (1.73%). The highest value was found significantly superior over the control and other treatments.

4.3.6 Moisture

The moisture content of amaranth fortified cookies varied from 5.79 to 6.05% (Table 4.3.1). The highest value was observed in the treatment T1 (6.05) and the lowest value was observed in the treatment T5 (5.79%). The highest value was found significantly superior over the control and other treatments.
4.3.7 Energy

The calculated energy value of amaranth fortified cookies varied from 438.06 to 441.29 Kcal as presented in the (Table 4.3.1). The highest value was observed in the treatment T4 (441.29 Kcal) and the lowest value was observed in the treatment T1(438.06 Kcal). The highest value was found significantly superior over the control and other treatments.

4.4 Mineral composition of amaranth fortified cookies.

The wheat flour and amaranth flour had different effects on the mineral content of the amaranth fortified cookies as compared to control. The observed results for the mineral content of the amaranth fortified cookies are given in the Table 4.4.1

Table- 4.4.1 Minerals composition of amaranth fortified cookies.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Minerals (mg/100 gm)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Calcium</td>
<td>Phosphorous</td>
</tr>
<tr>
<td>T1</td>
<td>26.43</td>
<td>195.53</td>
</tr>
<tr>
<td>T2</td>
<td>30.37</td>
<td>200.55</td>
</tr>
<tr>
<td>T3</td>
<td>34.29</td>
<td>205.61</td>
</tr>
<tr>
<td>T4</td>
<td>42.13</td>
<td>215.68</td>
</tr>
<tr>
<td>T5</td>
<td>50.00</td>
<td>225.77</td>
</tr>
<tr>
<td>SEM ±</td>
<td>0.016</td>
<td>0.028</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.048</td>
<td>0.085</td>
</tr>
</tbody>
</table>

4.4.1 Calcium content

The calcium content of amaranth fortified cookies varied from 26.43 to 50.00 mg/100g (Table 4.4.1). The highest value (50.00 mg/100g) was observed in the treatment T5 and the lowest value (26.43 mg/110g) was observed in the treatment.
The highest value was found significantly superior over the control and other treatments.

### 4.4.2 Phosphorus content

Data shown in the table-6 revealed that phosphorus content of amaranth fortified cookies varied from 195.53 to 225.77 mg/100g. The highest value (225.77 mg/100g) was observed in the treatment T5 and the lowest value (195.53 mg/100g) was observed in the treatment T1. The highest value was found significantly superior over the control and other treatments.

### 4.4.3 Iron content

The iron content of amaranth fortified cookies varied from 3.38 to 4.74 mg/100g (Table 4.4.1). The highest value (4.74 mg/100g) was observed in the treatment T5 and the lowest value (3.38 mg/100g) was observed in the treatment T1. The highest value was found significantly superior over the control and other treatments.

### 4.5 Organoleptic properties of amaranth fortified cookies.

Different blends for cookies were developed from wheat flour and amaranth flour and they were subjected to sensory evaluation on 9 point hedonic scale by experts. From the sensory mean scores and the comments of the experts the best combinations were selected T3 (wheat + amaranth 90:10) and T2 (wheat + amaranth 95:05).

#### Table 4.5.1 Organoleptic properties of amaranth fortified cookies.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Appearance &amp; colour</th>
<th>Aroma</th>
<th>Taste</th>
<th>Texture</th>
<th>Crispness</th>
<th>Overall acceptability</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>8.32</td>
<td>8.12</td>
<td>8.13</td>
<td>8.67</td>
<td>7.80</td>
<td>7.70</td>
<td>8.13</td>
</tr>
<tr>
<td>T2</td>
<td>8.14</td>
<td>6.88</td>
<td>8.50</td>
<td>7.50</td>
<td>7.17</td>
<td>7.70</td>
<td>7.63</td>
</tr>
<tr>
<td>T3</td>
<td>8.31</td>
<td>7.63</td>
<td>8.23</td>
<td>8.73</td>
<td>8.80</td>
<td>8.63</td>
<td>8.40</td>
</tr>
<tr>
<td>T4</td>
<td>7.11</td>
<td>7.93</td>
<td>6.43</td>
<td>7.33</td>
<td>6.70</td>
<td>7.40</td>
<td>7.30</td>
</tr>
<tr>
<td>T5</td>
<td>7.11</td>
<td>6.33</td>
<td>6.70</td>
<td>6.27</td>
<td>5.90</td>
<td>6.27</td>
<td>6.40</td>
</tr>
</tbody>
</table>
4.5.1 Appearance and colour

The appearance and colour of amaranth fortified cookies varied from 7.11 to 8.32 (Table 4.5.1). The highest value (8.32) was observed under treatment T1 and the lowest value (7.11) was observed in treatment T4 & T5. The highest value of T1 was observed significantly superior over control and other treatments.

4.5.2 Aroma

The aroma of amaranth fortified cookies varied from 6.33 to 8.12 (Table 4.5.1). The highest value (8.12) was observed under treatment T1 and the lowest value (6.33) was observed in treatment T5. The highest value of T1 was observed significantly superior over control and other treatments.

4.5.3 Taste

The taste of amaranth fortified cookies varied from 6.43 to 8.50 (Table 4.5.1). The highest value (8.50) was observed under treatment T2 and the lowest value (6.43) was observed in treatment T4. The highest value of T2 was observed significantly superior over control and other treatments.

4.5.4 Texture

The texture of amaranth fortified cookies varied from 6.27 to 8.73 (Table 4.5.1). The highest value was observed under treatment T3 (8.73) and the lowest value was observed in treatment T5 (6.27). The highest value was observed significantly superior over control and other treatments.

4.5.5 Crispness

The crispness of amaranth fortified cookies varied from 5.90 to 8.80 (Table 4.5.1). The highest value was observed under treatment T3 (8.80) and the lowest value was
observed in treatment T5(5.90). The highest value recorded was significantly superior over the control and other treatments.

4.5.6 Overall acceptability

The overall acceptability of amaranth fortified cookies varied from 6.27 to 8.63 (Table 4.5.1). The highest value was found under the treatment T3 (8.63) and the lowest value was observed in treatment T5(6.27). The highest value was significantly superior over the control and other treatments.

4.5.7 Mean

The mean score value of amaranth fortified cookies varied from 6.40 to 8.40 (Table 4.5.1). The highest value was reported under the treatment T3 (8.40) and the lowest value was observed in treatment T5(6.40). The highest value was found significantly superior over all other treatments.

4.6 Shelf life of the amaranth fortified cookies.

4.6.1 Effect of storability on the overall acceptability of amaranth fortified cookies.

Mean scores value of overall acceptability of amaranth fortified cookies presented in above table 8. The maximum score (8.30) of overall acceptability of amaranth fortified cookies was recorded in treatment T3 (wheat 90%+amaranth 10%) at initial stage of storage in both the packaging materials. Minimum score value (7.78) was recorded in control (wheat) cookies after 90 days of storage in polyethylene bags. From the table evident of results it has been showed that overall acceptability of supplemented amaranth fortified cookies were decreased with increase the storage period but packaging material did not affect reasonably to overall acceptability of amaranth fortified cookies.
Table- 4.6.1 Effect of storability on the acceptability of amaranth fortified cookies

<table>
<thead>
<tr>
<th>Packaging material</th>
<th>Treatments</th>
<th>Period of storage (Days)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Polyethylene bags</td>
<td>T₁</td>
<td>8.08</td>
<td>8.00</td>
</tr>
<tr>
<td></td>
<td>T₃</td>
<td>8.30</td>
<td>8.27</td>
</tr>
<tr>
<td>Laminated pouches</td>
<td>T₁</td>
<td>8.07</td>
<td>8.03</td>
</tr>
<tr>
<td></td>
<td>T₃</td>
<td>8.30</td>
<td>8.28</td>
</tr>
</tbody>
</table>
DISCUSSION

The bakery industry is one of the largest and organized food industries all over the world and especially biscuits and cookies are one of the most popular products because of their convenience, ready to eat nature, and long shelf life. The nutritive value of baked products like cookies and biscuits can be improved by protein; minerals like calcium, phosphorus, iron, and fibre fortification hence, product can be used effectively in child nutrition programme (ICDS) and also as supplement to the diets of the elderly and weaker section of population. Amaranth flour being rich in protein and minerals (calcium, phosphorus, iron) can be utilized in preparation of cookies in order to improve the nutritional quality in terms of protein and minerals. Partial substitution grain amaranth flour with wheat and rice flour was found to be beneficial for NIDDM (Non Insulin Dependent Diabetes Mellitus) subjects because of its high amino acid, calcium and iron contents (Chaturvedi et al., 1997).

5.1 Sensory evaluation of amaranth fortified cookies:

In the present investigation, protein and mineral rich cookies were made from wheat flour and amaranth flour with all other essential ingredients. The blend ratio of wheat flour and amaranth flour were 100:00, 95:05, 90:10, 80:20, and 70:30 denoted as T1, T2, T3, T4, and T5 respectively. Cookies made from 100:00 refined wheat flour were used as control (T1). The results showed that the values for all sensory quality attributes viz., appearance and colour, aroma, taste, texture, crispness and overall acceptability were rated acceptable up to the level of 10 per cent of supplementation of amaranth flour. However, at the ratio of 20 and 30 per cent the values of various organoleptic parameters were observed to decrease. The above information indicates that blending of amaranth flour beyond 10 per cent slightly affect the sensory quality parameters. These findings were well supported by previous research workers (Emire and Arega 2012; Nidhi and Indira 2012; Elizabeth 2010; Reddy et. al 1990).

5.2 Proximate composition of amaranth fortified cookies:
The proximate composition of grain amaranth flour fortified cookies with wheat flour revealed that protein, fat, fibre and ash content varied significantly as compared to control. The 10 per cent grain amaranth flour fortified cookies exhibited protein 8.19%, fat 17.55%, fibre 1.77% and ash 1.91%. However, cookies made from refined wheat flour alone contained protein 8.01%, fat 17.21%, fibre 1.66% and ash content 1.73%. While the control treatment cookies were contained higher quantity of carbohydrates. There were trend observed that the addition of amaranth flour increases the proximate parameters except in carbohydrate content. The above findings were well supported by other workers (Emire and Arega 2012; Nidhi and Indira 2012; Elizabeth 2010; Reddy et. al 1990).

5.3 **Mineral composition of amaranth fortified cookies:**

The mineral composition of amaranth fortified cookies with refined wheat flour expressed that on addition of amaranth flour there were significant increasing trend among mineral like calcium, phosphorus and iron. The similar results were also reported other investigators Emire and Arega 2012; Nidhi and Indira 2012; Reddy et. al 1990).

5.4 **Shelf life of cookies:**

It has been observed that overall acceptability of supplemented amaranth fortified cookies were decreased with increase the storage period but packaging material did not affect reasonably to overall acceptability of amaranth fortified cookies. They were found best acceptable up to 30 days. It was concluded that laminated pouches could be considered better from storage point of view.
SUMMARY

Generally refined wheat flour has been used for the manufacturing or production of baked products like cookies, biscuit, bread, buns etc. but refined wheat flour considered nutritionally poor due to deficiency of certain essential amino acids like lysine.

Cookies are also one of the versatile and very acceptable ready to eat snack like by all age group.

The present investigation entitled “Process standardization for the development of value added product based on amaranth and its quality evaluation” was framed to develop the nutritious cookies enriched with protein and minerals like calcium and iron. The salient findings obtained during course of experiment have been summarized in the following points -

- Amaranth fortified cookies T3 (Wheat + Amaranth) at the ratio of 90:10 was the best formulated Amaranth fortified cookies, rich in nutrients and had excellent overall acceptability.

- Amaranth blended cookies had higher amount of calcium as compared to control refined wheat flour cookies.

- Fortification of 10% amaranth flour in wheat based amaranth fortified cookies could be recommended to increase and improve the biological value of protein and other nutrients such as calcium and phosphorus.

- During storage laminated pouches bags were found to be good as compared polyethylene bags for maintaining the good quality products under the period of 90 days.

- Shelf life of the T3 formulated amaranth fortified cookies (wheat+ amaranth, ratio 90:10) was found to be better in both the packaging materials for the period of the three months at ambient temperature.
6.2. Conclusion

On the basis of present investigation it was concluded that Amaranth flour being rich in protein and minerals (calcium, phosphorus, iron) can be utilized in preparation of delicious cookies in order to improve the nutritional quality in terms of protein and minerals. These cookies could be well kept in laminated pouches for safe storage.

6.3. Suggestions for further work

- The consumption of cookies incorporated with amaranth flour should be encouraged as they are beneficial for improving the nutritional and health status of the general population.
- Techno-economic feasibility of amaranth fortified cookies should be evaluated.
- To identify the various microorganisms during storage and packaging studies should be carried out for longer periods.
- Further use various types of packaging material to enhance the self-life of amaranth fortified cookies.
- Improved cultivars must be select to increase the nutritional value of amaranth fortified cookies.
REFERENCES


Gopalan C., Ramasastr B.V. and Balasubramanian S.C. (1996).Nutritive Value of Indian Food Indian Council of Medical Research, Hyderabad India.


Figure No 2.0  Quality attributes of amaranth fortified cookies
Figure No. 3.0    Mineral content of amaranth fortified cookies
Figur No 1.0 Physical properties of amaranth fortified cookies
Figure No 4.0  Organoleptic properties of amaranth fortified cookies
PLATE 1.0  Amaranth fortified cookies

T1 Wheat : Amaranth
(100 : 00)

T2 Wheat : Amaranth
(95 : 05)
PLATE 1.0  Amaranth fortified cookies
T5 Wheat : Amaranth

(70 : 30)

PLATE 1.0 Amaranth fortified cookies