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Antihemolytic activity of various fractions of methanolic extract of coriander (*Coriandrum sativum* L.) leaves and seeds: A comparative study

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Abstract

Foods rich in antioxidants play an essential role in the prevention of diseases. Coriander (*Coriandrum sativum* L.), a traditional annual herb is cultivated throughout India. On the basis of its traditional uses and literature, this plant was selected for assessing antihemolytic properties. Methanolic extract of leaves and seeds of coriander was sequentially fractionated with different solvents viz., hexane, benzene, ethyl acetate, n-butanol and water and all the fractions were examined for phenolics and antihemolytic activity. In both coriander leaf and seed fractions, ethyl acetate fraction possessed maximum amount of flavonoids and flavonols, while n-butanol fraction contained the highest tannin content. All the leaf and seed fractions of coriander (100-500µg/ml) exhibited significant antihemolytic activity in an individualized and concentration dependant manner. Interestingly, among the various fractions, n-butanol and ethyl acetate fractions of leaves (88, 83% respectively) and seeds (86, 73 % respectively) showed higher antihemolytic activity than all the other fractions at the concentration of 500µg/ml with IC_{50} of 81, 76 µg/ml and 83 and 75 µg/ml respectively.

Keywords: Antioxidants, antihemolytic, flavonoids, *Coriandrum sativum* L., n-butanol, ethylacetate fractions.

Introduction

Many plants have been known to produce biologically active substances, some of which are related to special flavour or taste and others are found to be useful as antioxidants and/or antimicrobial agents. Antioxidants decrease oxidative damage to cells and biomolecules caused by reactive oxygen/nitrogen species (ROS/RNS) (Fiorentino *et al*., 2006). During the past years, ROS and RNS have been implicated in the oxidative deterioration of food products as well as in the pathogenesis of several human diseases such as atherosclerosis, diabetes mellitus, chronic inflammation, neurodegenerative disorders, including Alzheimer's disease, and certain types of cancer (Valko *et al*., 2006). The putative protective effects of antioxidants against these deleterious oxidative stress-induced diseases have received increasing attention in recent times, especially within biological, medical, nutritional, and agrochemical areas. Among the dietary antioxidants, phenolic compounds, secondary metabolites from plants, are the most abundant natural antioxidants (Fiorentino *et al*., 2006). Phenolics act as antioxidants in a number of ways such as reducing agents, hydrogen donors, free radical scavengers, and singlet oxygen quenchers and, therefore, act as cell saviors (Fattouch *et al*., 2007).

Erythrocytes, which are the most abundant cells in the human body, possessing desirable physiological and morphological characteristics, are exploited extensively in drug delivery (Hamidi and Tajerzadeh, 2003). Oxidative damage to the erythrocyte membrane (lipid/protein) may be implicated in hemolysis associated with some hemoglobinopathies, oxidative drugs, transition metal excess, radiation, and deficiencies in some erythrocyte antioxidant systems (Ko *et al*., 1997). This assay is useful either for screening studies on various molecules and their metabolites, especially on one hand, molecules having an oxidizing or antioxidizing activity and on the other hand, molecules having a long-term action (Djeridane *et al*., 2007).

The present investigation was undertaken to assess antihemolytic activity of methanolic extract and various fractions of coriander leaves and seeds.

Materials and methods

Preparation of sample

Coriander (*Coriandrum sativum* L.) leaves and seeds were purchased from local market, shade dried, powdered and extracted with 80% methanol(Me), thrice (1:1, w/v), at room temperature (Petra *et al*., 1999). The combined extract was concentrated in a vacuum evaporator and the residue was dissolved in water and fractionated successively with hexane (He), benzene (Be), ethyl acetate (Ea), n-butanol (nBu) and water (Aq) and each fraction was evaporated to dryness. Before use, each fraction was redissolved in dimethyl sulfoxide (DMSO) at a concentration of 1mg/ml (Hashim *et al*., 2005).

Antihemolytic activity

Antihemolytic activity of methanolic extract and the fractions was assessed as described by Naim *et al.* (1976). Human venous blood samples collected in EDTA vials from well nourished healthy adults (25–30 yrs of age) were diluted with saline (0.9% NaCl), centrifuged at

1000xg for 10 min. The erythrocytes separated were then diluted with phosphate buffered saline (0.2M, pH7.4) to give 4% suspension. To 2 ml of the erythrocyte suspension, 100-500 µg of extract/ml of buffered saline was added and the volume was made up to 5 ml with buffered saline. The mixture was incubated for 5 min at room temperature and then 0.5 ml of H_2O_2 solution in buffered saline was added to induce oxidative degradation of the membrane lipids. In another set, quercetin (100-500 µg /ml) was taken as a reference compound and treated in the similar way. Thereafter, the tubes were centrifuged at 1000x g for 10 min and the colour density of the supernatant was measured spectrophotometrically at 540 nm. To achieve 100 per cent hemolysis (control), 2 ml of distilled water was added to 2 ml of RBC suspension. The relative hemolysis was calculated in comparison with the hemolysis in the control, which was taken as 100%. Each set of experiments was performed in triplicate and inhibitory activity of different fractions on hemolysis was calculated and expressed as per cent inhibition.

$$\% \text{ inhibition} = \frac{\text{Abs}^{\text{control}} - \text{Abs}^{\text{extract}} \times 100}{\text{Abs}^{\text{control}}}$$

Statistical analysis

The data was subjected to two-way analysis of variance (ANOVA) and the significance of the difference between means was calculated. Values expressed are mean of three independent samples analyzed in triplicate ± standard error of means (SEM) (Gupta, 1995).

Results and discussion

For thousands of years prior to the advent of modern allopathic medicine, herbs and substances derived from plants have been the mainstay of traditional medicines around the world. The phytochemicals present in commonly consumed plant foods are normally non-toxic and have the potential for preventing chronic diseases. The plant extracts encompass high concentration of flavonoids and phenolic compounds. As potent antioxidants, flavonoids are especially important for protection against human diseases. The multiple properties of these phytochemicals have made them more attractive, as they can modulate various aspects of disease like lipid peroxidation involved in atherogenesis, thrombosis, carcinogenesis, hepatotoxicity and a variety of disease conditions (Tiwari, 2001).

Erythrocytes are considered as major target for the free radicals owing to the presence of both high membrane concentration of polyunsaturated fatty acids (PUFA) and the oxygen transport associated with redox active hemoglobin molecules, which are potent promoters of activated oxygen species (Ebrahimzadeh *et al*., 2009). The extent of hemolysis was found to be much greater, when red blood cells were treated with hydrogen peroxide (toxicant). This could be attributed to the oxidizing nature of hydrogen peroxide with respect to the destruction of cell membrane and subsequent liberation of hemoglobin from the cells. Mobilization of Fe^{2+} by Ca^{2+} via Fenton reaction is also caused due to hydrogen peroxide which further leads to the production of OH radicals (Kupier-Goodman and Scott, 1989). All these factors, in unison, cause deterioration of cell membrane, which may, perhaps, be the key episode of the lysis of cell (Devjani and Verma, 2010). Nevertheless, the antihemolytic activity is the expression of collaborative action of the various antioxidant mechanisms which function in nature.

Phenolic compounds viz., flavonoids, flavonols and tannins estimated in the methanolic extract, hexane, benzene, ethyl acetate, n-butanol and aqueous fractions of methanolic extract of both leaves and seeds of coriander are presented in **Table 1**.

With respect to the fractions of coriander leaves, ethyl acetate fraction had the highest phenolic compounds followed by methanol, hexane, aqueous, benzene and n-butanol fractions. Flavonoids and flavonols were concentrated in ethyl acetate fraction followed by n-butanol, methanol, hexane, benzene and aqueous fractions. n-butanol had maximum tannin content followed by ethyl acetate, benzene, methanol, aqueous and hexane fractions.

In case of the fractions of coriander seeds, ethyl acetate fraction had the highest phenolic compounds followed by n-butanol, benzene, aqueous, methanolic and hexane fractions. Flavonoids were concentrated in ethyl acetate fraction followed by n-butanol, hexane, benzene, methanolic extract and aqueous fractions. Flavonol content was more in ethyl acetate followed by n-butanol, methanolic extract, hexane, benzene and aqueous fractions. n-butanol had maximum tannin content followed by ethyl acetate, methanol, benzene, hexane and aqueous fractions.

In both coriander leaf and seed fractions, ethyl acetate fraction was found to possess maximum amount of flavonoids and flavonols, while n-butanol fraction contained the highest tannin content. The variation in the phytochemicals in methanolic extract and other fractions is due to the variation in their solubility in different solvents of varying polarity.

In the present study, methanolic extract, hexane, benzene, ethyl acetate, n-butanol and aqueous fractions of methanolic extract of coriander leaves and seeds exhibited potent antihemolytic activity, among which n-butanol and ethyl acetate fractions of coriander leaves displayed significantly ($p<0.001$) higher activity than the other fractions of leaves and all the fractions of coriander seeds ($p<0.005$) at all the concentrations. At the concentration of 500µgml^{-1}, n-butanol fraction of coriander leaves (87.5 %) and seeds (85.7 %) exhibited highest antihemolytic activity with IC_{50} values of, 81 and 83 µg/ml respectively and ethyl acetate fraction of

Table 1: Phenolic compounds in methanolic extract and various fractions of coriander leaves and seeds

Sample extract	Total flavonoids (mg/100g) RE	Total flavonols (mg/100g) RE	Tannins (mg/100g) CE
Coriander leaves			
Methanol	3.68±0.5	1.44±0.2	0.38±0.2
Hexane	3.38±0.4	1.38±0.5	0.27±1.5
Benzene	3.30±0.7	1.02±0.8	0.75±0.8
Ethyl acetate	**4.82±1.1**	**1.83±0.6**	1.95±0.8
n-butanol	3.70±1.1	1.67±0.5	**2.80±0.5**
Aqueous	0.68±1.2	0.43±1.0	0.35±1.7
Coriander seeds			
Methanol	0.51±0.9	1.40±1.2	0.70±0.4
Hexane	2.21±0.5	1.35±0.4	0.02±1.4
Benzene	1.63±1.3	0.64±0.2	0.03±0.1
Ethyl acetate	**3.40±1.1**	**1.80±0.6**	0.76±0.6
n-butanol	3.30±1.9	1.60±0.7	**0.80±0.8**
Aqueous	0.50±1.4	0.26±1.3	0.02±1.3

Values are mean ± SEM of three replicates

Table 2: Antihemolytic activity of methanolic extract and various fractions of coriander leaves

Concentration (µg/ml)	Me	He	Be	Ea	nBu	Aq
100	39.7±0.3	53.9±0.3	50.2±1.9	65.1±1.5	60.2±0.3	62.2±1.4
200	45.9± 1.5	55.5±0.7	62.1±0.87	73.5±0.3	67.2±0.5	65.4±0.6
300	47.9±0.7	57.7±0.3	65.5±0.5	78.8±0.7	75.5±0.2	67.4±0.7
400	55.8±0.8	61.5±0.5	70.1±0.8	81.4±0.1	79.4±1.6	70.2±1.2
500	59.3±1.8	68.2±0.4	75.8±0.3	83.1±1.1	87.5±1.7	72.2±1.4
IC_{50} (µg/ml)	347	95	100	76	81	80

Values are mean ± SEM of three replicates
$p<0.001$

Me-Methanolic extract, He-Hexane fraction, Be- Benzene fraction, Ea-ethyl acetate fraction, nBu- n-butanol fraction, Aq- Aqueous fraction

Table 3: Antihemolytic activity of methanolic extract and various fractions of coriander seeds

Concentration (µg/ml)	Me	He	Be	Ea	nBu	Aq
100	49.2±1.4	32.3±0.3	42.9±0.3	60.3±1.9	61.5±0.3	30.4±1.3
200	55.5± 1.6	38.8±0.5	45.5±0.5	63.4±0.4	66.8±0.7	35.2±0.5
300	57.9±0.7	47±0.5	50.7±0.5	68.9±0.5	75.7±0.7	37.6±0.7
400	65.4±0.2	51.5±1.3	53.5±1.3	71.3±0.8	79.5±1.1	40.8±1.8
500	69.5±1.4	55.8±1.1	58.2±1.1	73.1±0.3	85.7±1.2	42.5±1.8
IC_{50} (µg/ml)	147	392	295	75	83	567

Values are mean ± SEM of three replicates
$p<0.005$

Me-Methanolic extract, He-Hexane fraction, Be- Benzene fraction, Ea-ethyl acetate fraction, nBu-n-butanol fraction, Aq- Aqueous fraction

coriander leaves and seeds exhibited higher activity with IC_{50} of 76, 75µg/ml respectively (**Table 2 & 3**). It has been reported that flavonols and their glycosides are efficient antioxidants which can guard human red blood cells from free radical mediated oxidative hemolysis (Dai *et al*., 2006). Also, binding of flavonoids to the red blood cell membranes significantly inhibits lipid peroxidation and at the same time, enhances their integrity against lysis (Chaudhuri *et al*., 2007). In this study, inhibition of H_2O_2-mediated hemolysis by all the fractions of methanolic extract of coriander indicates presence of radical scavenging phytochemicals viz. polyphenolic compounds, especially, flavonols, flavonoids and tannins in coriander and can be supported by the data obtained in the same study as depicted in **Table 1** as well as the composition of coriander as reported by www.ars-grin.gov/duke. However, maximum inhibition of hemolysis exhibited by n-butanol fraction of coriander leaves and seeds followed by ethyl acetate fractions of leaves and seeds indicate that the compounds extracted in n-butanol and ethyl acetate fractions viz., flavonoids, flavonols, tannins, etc. are potent antihemolytic agents as compared to the compounds extracted in the other fractions of coriander extract. In comparison, leaves exhibited slightly higher antihemolytic activity than the seeds which could be due to the presence of phytochemicals in concentrated form in the leaves.

The antihemolytic activity exhibited by ethylacetate, n-butanol, methanol, hexane, benzene and aqueous fractions indicate the presence of H_2O_2 scavengers extracted from coriander. In addition to the polyphenolic compounds extracted in ethyl acetate, hexane soluble compounds like coriandrin, linalool and benzene soluble compounds like aglycones, terpenoids etc. also prevented lysis of RBCs as they possessed scavenging activity. In fact, n-butanol fraction exhibited the highest anti-hemolytic activity indicating the concentration of more antihemolytic compounds than the other fractions of methanolic extract of coriander. Also, coriander contains a lot of bioactive compounds possessing strong anti-radical activities and thereby showed inhibitory effects on hemolysis. As expected, the compounds present in various fractions of coriander quenched H_2O_2 before it attacked the biomolecules of erythrocyte membrane to cause oxidative hemolysis as reported by Costa *et al*., (2009) on the effects of green tea.

Conclusion

Both leaves and seeds of coriander exhibited concentration-dependent inhibitory activity towards hydrogen peroxide-induced hemolysis of erythrocytes attributed to the bioactive constituents present in coriander leaves and seeds which exert protective effects against oxidative injury to biological macromolecules like lipids and proteins in the erythrocyte membrane. However, various fractions of leaf extract are more potent than that of seed owing to higher amounts of phytochemicals viz., flavonoids, flavonols and tannins. The potential of coriander leaves and seeds against erythrocyte damage, lead us to propose coriander leaf and seed (*Coriandrum sativum* L.) as a promising natural source of antioxidants suitable for application in nutritional and pharmaceutical fields.

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Effect of temperature, screw speed and moisture variations on extrusion cooking behavior of Maize (*Zea mays.* L)

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Abstract

In this study two maize grits samples were obtain from dent maize (R-2303) and a flint type of maize (R-2207). Different extruder variables applied were temperature, screw speed and moisture content. T_6 of (R-2207) was found most suitable among all treatments (T_6 150 ºC, 170 r.p.m, 18% m.c.). Temperature, screw speed and moisture content, these extruder variables considerably affected the product quality. Hardness and fracturability for R-2303 and R-2207 at three extrusion variables were extremely associated with each other and match up well with the hardness assessed by human mouthful. Extrudates with a high bulk density as T_0, T_1 and T_o of R-2303 were generally come with by some negative sensory characteristic, such as coarseness, solid curing, and uneven profile, as well as desiccated surface. Extrudates with low bulk density as T_3, T_4, T_5 and T_6 of R-2207 were typically come with by some positive sensory characteristic like good expansion, color and standard profile. Study also showed that the same instrumental variables were greatly connected with the same sensory variables. The method used in this study allowed us to end that the harder maize grits of R-2207 gives products with greater expansion values, elevated degree of cooking and lower mechanical resistance than the softer one of R-2303. Our findings give support to the fondness of the snack industry for harder-maize grits.

Keywords: Extrusion, Maize, Corn, Sensory,

Introduction

Extrusion cooking process has become a highly trendy process in the cereal, snack, and pet food industries that use starch and protein as raw materials to produce highly valuable food product (Lin *et al.,* 2000). Extrusion cooking process denatures detrimental enzymes; inactivates some anti nutritional components of food (trypsin inhibitors, tannins and phytates); disinfect the final product; and maintain normal colors and flavors of food (Bhandari *et al*. 2001).

Globally, the snack food industry is fetching up bigger and more imperative every day. In the last ten years, revolution in way of living and eating habits have escort to an ongoing enhance in demand for snack foods. Snacks can supply a better dietary intake of essential amino acids and other food nutrients for developing countries. Extrusion cooking is preferable over other food-processing methods due to of constant process with high efficiency and important nutrient preservation, due to the high temperature and short cooking time required (Guy, 2001).

There is a need to make use of locally-grown crops to produce of suitable local recipes in the under developed countries has been tense by international agencies as the most efficient channel for addressing depending world food harms (Iwe *et al.,* 2001). Maize is the cereal of major importance in the developing world and has the maximum genetic production potential of all the cereal crops. Global grain production of maize is about 600 million tons a year (Pingali, 2001). In the year 2002, maize was the most important cereal crop with 29.7% of the world cereal production after rice and wheat (FAOSTAT, 2003). .Maize processors have long described that flint type of maize cultivar show more expansion during extrusion cooking. It has also been found that endosperm protein composition is highly related with maize grain flintiness (Eyherabide *et al.,* 1996).

More to the point being a key basis of food for human beings, maize also utilized as feed for livestock and as raw materials for industries for the manufacturing of many food and non-food products. Designing extruded snack foods today can be a difficult process to meet up varying consumer’s tastes and demands. The consumer’s requirement for “good for your health” and “distinctive flavor” extruded snacks leads to the indefinable exploration for something exceptional that also demand to a extensive range of peoples. Food extrusion is an energy-efficient process for the reason that a considerable quantity of mechanical energy from the drive motor and thermal energy system is degenerate as the extruder screw is in motion the gelatinous material within the barrel. Energy necessary to revolve the extruder screw can be expressed in terms of torque such that products involving greater demand of energy are more costly to process (Titus and Maduebibisi, 2007).

Advantages of extrusion are adaptability, product shapes, high product quality, energy competence, production of new foods, and no effluent or waste material. Many ordinary snack foods are fried, making them high in fats while extruded snack foods are mostly not fried. Due to this an extruded snacks also well for health (Riaz, 2000). filled products, extrusion give the snack-food producer a flexibility and variety of processing technologies.

Consequently the current study has been designed to determine the extrusion cooking behavior of maize cultivars through physical characteristics and sensory evaluation

Materials and Methods

The current research was performed to determine the suitability of maize cultivars for extrusion cooking and effect of different extrusion parameters on quality of product. The study proposed in this manuscript was conducted at the "Extrusion Center", National Institute of Food Science and Technology, University of Agriculture, Faisalabad-Pakistan. Two commercial maize cultivars namely hybrid R-2303 No matter what the future convey, it's simple to see that, from simple corn puffed snacks and balls to complex yellow dent corn and R-2207 White flint corn were milled to obtain maize grits according to a milling diagram proposed by Robutti *et al.* (2002).

Extrusion process

The maize cultivars were extruded through a single-screw, short barrel (90 mm) snack food extruder (Extru-Tech, Inc.Model # KN, Sabetha, Ks 66534). The extruder was fixed with a 2 start screw and a 2-hole die with 4mm orifice. The prepared raw material, maize grits were fed into the extruder at the rate of 20 Kg /h using a mass flow feeding device. The extruder was run at different barrel temperatures ranges between 110 and 150 °C. Energy consumption during extrusion differs among the grits extruded in the research. The extruder variables applied in this study are given in Table1

Table 1: Detail of different treatments (temperature, screw speed and moisture content) during extrusion for two maize cultivars (R-2303 and R-2207)

Different treatments	Temperature ^{o}C	Screw speed (R.p.m)	Moisture content %
T0	105	110	18
T1	130	120	20
T2	135	120	17
T3	135	140	20
T4	150	170	19
T5	150	150	20
T6	150	170	18

Physical analysis

The method described by Rayas *et al.*, (1998) with small modification was used to find out the expansion ratio of the maize extrudates. The procedure described by Singh and Heldman (1993) was followed to determine the bulk density of maize extrudates. Color characteristics of the extrudates were instrumentally calculated according to the procedure followed by Rhee *et al.*, (2004) with a Color Tech, lab colorimeter (model PCM/PSM, U. S. Patent 5.137, 364 +5.838, 451. S. # 300/330

Sensory Evaluation

To assess the quality and acceptability of extruded corn snacks were presented for sensory evaluations performed by a team of judges from the staff and postgraduate students of NIFSAT. A 9-point hedonic scale (from 1 = extremely dislike to 9 = extremely like) was used to assess the liking in color, flavor, taste, texture and overall satisfactoriness according to the procedure expressed by Stone and Sidel (1998).

Statistical Analysis

Statistical analysis was carried out using two factor factorial, completely randomized design (CRD). Duncan's Multiple Range Test (DMR) was applied to evaluate objective, sensory data, and for pair wise comparison of treatment means. Statistics were reported at a significance level of 0.05.

Results and discussion

The present study was performed to determine the suitability of maize cultivars for extrusion cooking and effect of different extrusion parameters on quality of product. Extrusion parameters considered comprise extrusion cooking temperatures, speed of screw and moisture level of raw material. These parameters are the most important factors recognized to influence extrusion process performance, density of extruded product, expansion ratio of product, color characteristics, textural properties and sensory characteristics of extruded product.

Physical analysis of corn extrudates

Extrudates from two maize cultivars R-2303 and R-2207 were assessed for their physical characteristics like expansion ratio of extrudates (ER), bulk density of snacks (BD) and color characteristics.

Expansion ratio of corn extrudates

.It is evident from results that maize varieties significantly affected the expansion ratio of the maize extrudates. The treatments also significantly affected the expansion ratio of maize extrudates. The interactive affect of maize variety and extrusion temperature was also found significant with respect to expansion ratio. The mean values of expansion ratio of maize extrudates are given in table no.2. It is evident from results that expansion ratio significantly with treatments as a function extruder temperature, screw speed, and moisture content. judges for the reason that it has suitable cell uniformity due to high temperature and screw speed. Whereas, T_1 was least acceptable because there was low degree of expansion.

Maize grits did not expand completely during extrusion at temperatures less than 140 °C and several grits stay intact in the extruded product. It is known that the expansion process that takes place as element of extrusion cooking process as expansion ratio increase as a result there is a decrease in bulk density of extruded product.

Gujska and Khan (1991) reported that as the temperature of extrusion cooking increased, starchy material completely cooked and consequently show improved expansion. Gonzalez *et al.* (2004) reported that moisture level and feed rate have a significant effect on the expansion ratio of extrudates. Increase in feed rate results in higher expansion and higher level of moisture reduced the expansion of extrudates. Statistical study prove that there was a considerable linear relationship, at 5 % level, between barrel temperature, moisture content and screw speed on expansion ratio of extrudates. Generally expansion increased directly with increase in cooking temperature and screw speed up to 150 °C and 170 r. p. m. On other side, at lesser screw speed, as the temperature increased the radial expansion increased up to a temperature of about 150 °C and afar that the radial expansion reduced. When screw speed was higher than 170 r. p. m. the raise in radial expansion showed a decreasing tendency with temperature. The maximum radial expansion was observed to be at 150 °C and 170 r.

Bulk density of maize extrudates

It is evident from the results that maize varieties and treatments significantly affected the bulk density of the maize extrudates. The interactive affect of maize variety and treatment were not found significant with respect to bulk density. The mean values of the bulk density of maize extrudates are given in table no. 3. It is evident from the results that the bulk density significantly affected with treatments as a function extruder temperature, screw speed, and moisture content. The bulk density observed in maize extrudates are T_0 R-2303 obtain maximum worth of bulk density 0.925 g/cc, whereas T_6 of R-2207 obtain the lowly value of 0.580 g/cc. T_6 of R-2303 and R-2207 corn was favored by the judges for the reason that it has suitable expansion and least bulk density. Whereas, T_0 was least suitable for the

,

1994), an increase in gelatinization results in increase of expansion ratio and significant decrease in bulk density.

The expansion ratio observed in maize extrudates is T_6 of R-2207 find maximum degree of expansion 4.060 mm and T_6 of R-2303 got premier degree of expansion 4.010 mm. T_0 of R-2303 get a hold the lowest level of expansion of 3.110 mm and T_1 of R-2207 got the lowest value of 3.170 mm. T_6 of R-2207 was favored by the p. m. screw speed at 18 % moisture content of T_6 of R-2207.

Choudhury and Gautam (1999) reported that speed of the screw also effect the expansion of extrudates There is increase in screw speed resulted in improvement of the expansion ratio of extrudates. During the study it is observed that by increasing moisture level up to 18 % result in a decrease of expansion ratio for corn starch. Same kinds of observations were also reported by Owusuansah *et al.* (1984). The maximum expansion ratio for corn grits was between the moisture levels 18-19 %. Corn grits extruded at 18 % moisture give a higher expansion ratio than at 19 % and 21 % moisture.

Phillips and Falcone (1988) also found that increasing moisture content from 13 to 18 % increased expansion of sorghum extrudates but further increase caused a decrease in expansion. The results of this study are in accordance with the findings of Liu *et al.,* (2000) who found that the increase in moisture would reduce the product temperature resulting in a lower extrudates expansion. Extrudates from R-2207 corn had greater expansion than extrudates from R-2303 corn. Lower expansion of extrudates from R-2303 corn may have resulted from non-homogeneous dough because of presence of greater amounts of opaque and finer particles which act as capillaries; hence less water was available for hydration of vitreous particles. The grits from R-2207 corn had a lower percent of finer particles which resulted in a more homogeneous mass which uniformly plasticized and resulted in a more expanded product. The results are in accordance with the Gujral *et al.* (2001).

reason is that there was less expansion and elevated bulk density of extrudates.

During extrusion bulk density of extrudates (BD) were affected by a number of extrusion processing variables like screw speed, moisture contents and cooking temperature. Mostly it is seen that as expansion ratio increased and the bulk density decreased under similar extrusion processing condition. At a level of 22% moisture when temperature increased from 160 to 180 °C and starch degradation resulting in less expansion Kokini *et al.* (1992). There is a strong proof in the literature that raw material having high-fibre, high-protein contents are added to starch-based extruded products, Bulk density of extrudates is likely to increase (Onwulata *et al.,* 2001). Bulk density and expansion ratio are also associated to starch gelatinization (Bhattacharya and Choudhury, 1994). According to (Bhattacharya and Choudhury

Process variables significantly affect the bulk density of extrudates. Extrudates bulk density and hardness of R-

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2303 and R-2207 reduced as expansion ratio increased with rising extrusion cooking temperature. Low extrusion temperatures (110-125 °C) formed extrudates with hard texture and comparatively great bulk densities. The Bulk density was established to be high at small extrusion temperatures, declining progressively as the temperature was increased. Extrudates from R-2303 and R-2207 low in bulk density was observed for high extrusion temperature and screw speed and reduce in moisture content. The lowest amount bulk density was observed to be at 150 °C and 170 r. p. m. screw speed at 18 % moisture content of T_6 of R-2303 and R-2207. At a temperature of 105 °C for T_0 resulted product is uneven formed at the die. Bulk density of extrudates reduced with increase in temperature. At a very low temperature extrudates produced with a rough surface possibly the reason is a small degree of starch gelatinization. The results are also reported by Chinnaswamy and Hanna (2002).

Table 2: Effect of extrusion variables on expansion ratio of extrudates of two maize cultivars

Treatments	R-2303	R-2207	Mean
T_0	3.110g	3.390fg	3.25
T_1	3.170f	3.823g	3.456
T_2	3.565f	3.572f	3.566
T_3	3.865ef	3.878e	3.871
T_4	3.860ef	3.867e	3.863
T_5	3.990cd	4.005c	3.99
T_6	4.010b	4.060a	4.05
Mean	3.143b	3.799a	

(T_0 105ºC, 110 r.p.m, 18% m.c), (T_1 130 ºC,120 r.p.m, 20% m.c.) (T_2 135 ºC,120 r.p.m, 17% m.c.) (T_3 135 ºC, 140r.p.m, 20% m.c.) (T_4 150 ºC, 170 r.p.m, 19% m.c.) (T_5 150 ºC, 150 r.p.m 20% m.c.) ($T_6$150 ºC, 170 r.p.m, 18% m.c.)

Table 3: Effect of extrusion variables on bulk density of extrudates of two maize cultivars.

Treatments	R-2303	R-2207	Mean
T_0	0.925a	0.950a	0.937
T_1	0.818cd	0.809cd	0.811
T_2	0.764b	0.720bc	0.744
T_3	0.634ed	0.624ed	0.631
T_4	0.664d	0.630d	0.645
T_5	0.640ef	0.625ef	0.633
T_6	0.615fg	0.580g	0.597
Mean	0.722fg	0.706g	

(T_0 105ºC, 110 r.p.m, 18% m.c), (T_1 130 ºC,120 r.p.m, 20% m.c.) (T_2 135 ºC,120 r.p.m, 17% m.c.) (T_3 135 ºC, 140r.p.m, 20% m.c.) (T_4 150 ºC, 170 r.p.m, 19% m.c.) (T_5 150 ºC, 150 r.p.m 20% m.c.) ($T_6$150 ºC, 170 r.p.m, 18% m.c.)

Color of corn extrudates

The L*, A* and B* reading technique were recorded for this study. "L*" describe the lightness by means of its value ranging from 0 (darkness) to 100 (lightness), "A*" express for redness when interpretation are positive and greenness when values are negative, and "B*" stands for yellowness at positive value and blueness at negative readings. For every treatment, three extrudates were randomly chosen and tested. It is evident from results that maize varieties significantly affected the color of the maize extrudates. The treatments also significantly affect the color of maize extrudates. The interactive affect of maize variety and treatment were found significant with respect to color. It is evident from results that color significantly affected with treatments as a function extruder temperature, screw speed, and moisture content. The color observed in maize extrudates (L*, A* and B*) readings of the maize extrudates are shown in Table 4, Table 5 and Table 6. With respect to L* values, for R-2303 and R-2207 corn extrudates, T_6 got highest value of L*= 63.12, while T_0 got the lowest value of L* = 48.52. T_6 of R-2207 corn extrudates was favored by the judges for the reason is that it has proper golden yellow color. While, T_0 of R-2303 maize grits was least satisfactory because it has tedious yellowish color.

With respect to A* (red-green) assessment, results showed a considerable variation (P<0.01) among treatments and non significant relations of cultivars and treatments. Results showed an important difference among A* values of extrudates. For R-2303 and R-2207 corn extrudates, T_0 got highest value of A= 356.00, while T_6 got the lowest value of A*= 203. T_6 of R-2207 corn extrudates was preferred by the judges because it has attractable yellow color. While, T_0 of R-2303 corn extrudates which has highest A* value was least acceptable because it has reddish yellow color.

With respect to B* (yellow-blue) values, the results showed large differences (P<0.01) among behavior and significant relations of cultivars and treatments.. For R-2303 and R-2207 corn extrudates, T_0 got highest value of B*= 510.00, while T_6 got the lowest value of B*= 365.675. T_6 of R-2303 and R-2207 maize extrudates was most liked by the judges for the reason that they have excellent yellow color. Whereas, T_0 of R-2303 and R-2207 corn extrudates which has highest B value was slightest suitable because it has dark yellow color.

So the low values for A* and B* like in T_6 for R-2207 provide the good extrudates color and repeal is factual for L* values. Extrudates lightness, redness and yellowness were influence most extensively by moisture level and screw speed and temperature. The raw material moisture level for attractive extrusion and extrudates color character was set at 16-18 %. Previous research on extrusion of yams show that feed moisture content between 8 and 16 % was the ideal for the preferred extrudates characteristics. (Kpodo and Plahar, 1992).Temperature affects the color of maize extrudates by varying the grain structure and stir up browning reactions.

In the terms of product color, visual judgment of the products point to ongoing lightening with rising temperature but to definite level. In this study the preferred golden brown product color, which also show sufficient cooking, was achieved in T_6 of R-2207 extrudates with an extrusion temperature of 150 °C, screw speed of 170 r. p. m. and feed moisture contents of either 18 %. Conversely the extrusion temperature away from 160 °C produced a darker color and a browning smell that made the extrudates less suitable than the extruded non-roasted sample. The enhance in cooking temperature and cooking time usually results in reduced lightness of extrudates. Elevated cooking temperatures did not extensively influence the yellowness and redness of extrudates but vaguely bigger the redness of the extrudates. Conversely, the redness and yellowness of most of the extrudates showed an increasing trend when cooked.

Table 4: Effect of extrusion variables on color (L*) value of extrudates of two maize cultivars.

Treatments	R-2303	R-2207	Mean
T_0	48.52g	49.82fg	49.15
T_1	49.58g	50.72f	50.30
T_2	50.74f	51.59ef	51.23
T_3	51.95ef	52.93e	52.80
T_4	53.53de	56.66d	54.86
T_5	58.23cd	59.15b	59.08
T_6	63.12ab	62.02a	62.63
Mean	53.66b	54.69a	

($T_0$105ºC, 110 r.p.m, 18% m.c), (T_1 130 ºC,120 r.p.m, 20% m.c.) (T_2 135 ºC,120 r.p.m, 17% m.c.) (T_3 135 ºC, 140r.p.m, 20% m.c.) (T_4 150 ºC, 170 r.p.m, 19% m.c.) (T_5 150 ºC, 150 r.p.m 20% m.c.) ($T_6$150 ºC, 170 r.p.m, 18% m.c.)

Table 5: Effect of extrusion variables on color (A*) value of extrudates of two maize cultivars.

Treatments	R-2303	R-2207	Mean
T_0	356ab	368a	362
T_1	345.77b	358.66ab	351.95
T_2	346.34b	343.33b	344.58
T_3	327c	313.66cd	320.66
T_4	311cd	294.66d	303.54
T_5	296.d	235.3ef	265.85
T_6	265ef	203g	229
Mean	319.58f	292.17g	

(T_0 105ºC, 110 r.p.m, 18% m.c), (T_1 130 ºC,120 r.p.m, 20% m.c.) (T_2 135 ºC,120 r.p.m, 17% m.c.) (T_3 135 ºC, 140r.p.m, 20% m.c.) (T_4 150 ºC, 170 r.p.m, 19% m.c.) (T_5 150 ºC, 150 r.p.m 20% m.c.) ($T_6$150 ºC, 170 r.p.m, 18% m.c.)

Table 6: Effect of extrusion variables on color (B *) value of extrudates of two maize cultivars.

Treatments	R-2303	R-2207	Mean
T_0	510.22a	498.39ab	504.61
T_1	488.45bc	478.20c	480.61
T_2	463.15cd	452.12cd	458.11
T_3	449.25cd	438.42d	442.45
T_4	440.15d	418.17ed	429.55
T_5	397.25ef	399.44ef	398.45
T_6	365.67g	375.67g	377.24
Mean	444.87g	437.20g	

($T_0$105ºC, 110 r.p.m, 18% m.c), (T_1 130 ºC,120 r.p.m, 20% m.c.) (T_2 135 ºC,120 r.p.m, 17% m.c.) (T_3 135 ºC, 140r.p.m, 20% m.c.) (T_4 150 ºC, 170 r.p.m, 19% m.c.) (T_5 150 ºC, 150 r.p.m 20% m.c.) ($T_6$150 ºC, 170 r.p.m, 18% m.c.)

Sensory evaluation of extrudates

Sensory assessment is a very vital feature condition in food industry, so the sensory assessment for the color, taste, flavor, texture and overall acceptability for R-2303 and R-2207 maize cultivars. The results obtained are argued as below. Sensory scheme are used for the reason that apparatus can only detect a part of the overall flavor and texture characteristic in a specified food product.

Color of maize extrudates

It is evident from results that maize varieties significantly affected the color of the maize extrudates. The treatments also had a significant affect on the color of maize extrudates. The interactive affect of maize variety and treatment were found non significant with respect to color. The mean values of color of maize extrudates are given in table no.7. The results showed a greatly major difference among the color of extrudates, due to alteration of processing condition. For two maize cultivars R-2303 and R-2207, T_6 got the highest value 7.66, at the same time as T_0 get the lowly value of 4.7000.The T_6 of R-2207 was favored by the judges as it present golden brown color which eminent it from the other.

Darkening of color is due to high moisture level up to 20 % and low cooking temperature that resulted in lowest score of T_0 for color. As temperature increased there is a significant improvement in color of extrudates was seen. The highest score 7.66 was attain for R-2207 at 18 % moisture content, screw speed of 170 r. p. m. and temperature of 150 °C. The outcome are in harmony with the conclusion of Chen *et al.,* (1991) who observed that color alteration during the extrusion process can offer significant information about the scale of heat treatment. In the terms of product color, visual judgment of the products point to ongoing lightening with rising temperature but to definite level. In this study the preferred golden brown product color, which also show sufficient cooking, was achieved in T_6 of R-2207 extrudates with an extrusion temperature of 150 °C, screw speed of 170 r. p. m. and feed moisture contents of either 18 %. Conversely the extrusion temperature away from 160 °C produced a darker color and a browning smell that made the extrudates less suitable than the extruded non-roasted sample. The enhance in cooking temperature and cooking time usually results in reduced lightness of extrudates. Elevated cooking temperatures did not extensively influence the yellowness and redness of extrudates but vaguely bigger the redness of the extrudates. Conversely, the redness and yellowness of most of the extrudates showed an increasing trend when cooked.

According to Lin *et al.* (2006) the disintegration of corn color and extrudates expansion during the extrusion procedure also extensively influences the color of extrudates. Screw speed has no important effect on the color of the extrudates. In the terms of product color, visual judgment of the products point to ongoing lightening with rising temperature but to definite level. In this study the preferred golden brown product color, which also show sufficient cooking, was achieved in T_6 of R-2207 extrudates with an extrusion temperature of 150 °C, screw speed of 170 r. p. m. and feed moisture contents of either 18 %. Conversely the extrusion temperature away from 160 °C produced a darker color and a browning smell that made the extrudates less suitable than the extruded non-roasted sample. The increase in cooking temperature and cooking time usually results in reduced lightness of extrudates. Elevated cooking temperatures did not extensively influence the yellowness and redness of extrudates but vaguely bigger the redness of the extrudates. Conversely, the redness and yellowness of most of the extrudates showed an increasing trend when cooked.

Flavor of maize extrudates

Flavor is an essential attribute in consumer's opinion of food and purchasing assessment. It is evident from results that maize variety significantly affected the flavor of the maize extrudates. The treatments also significantly affect the flavor of maize extrudates. The interactive affect of maize variety and treatment were found non significant with respect to flavor. Mean values of different treatments are given in table no. 8.

T_6 got highest score of 7.8, while T_o got the lowest score of 5.112. There was satisfying flavor in T_6 of R-2207 as compared to R-2303. Chen *et al.,* (1991) initiate that boiled maize odor in the corn meal extrudates was superior in the arrangement of lower moisture and advanced screw speed. At elevated screw speed and high cooking temperature, as in T_6 (18 % moisture content, 170 r. p. m. screw speed and 150 °C temperature) for R-2207 maize-related flavors were more possible to produced.

The results are in harmony with the conclusion of Rhee *et al.,* (2004) who originate that improvement of flavor was due to the secondary compounds that contribute in non enzymatic browning reactions, causative to development of new flavors complex molecules of protein that could moderately be ruined by high temperature.

Taste of maize extrudates

Savor is the mainly significant feature that patrons judge when buying for food. Taste feelings are created when salty, sweet, sour, or bitter elements liquefy in solution are sense by the taste buds. It is evident from results that maize variety significantly affected the taste of the maize extrudates. The treatments also significantly affect the taste of maize extrudates. The interactive affect of maize variety and treatment were found non significant with respect to taste.

Study of variation present a large variation ($P<0.01$) among treatments and non significant difference among the relations of cultivar and treatment. Mean values are given in table no. 9. DMR test was used to determined variations among taste of extrudates. T_6 find maximum score of 7.90, while T_0 got the lowest score of 5.15.

Maximum score 7.90 was got by the R-2207 which was progressively reduced to 5.15 for R-2303. It is obvious from the results that judges grade T_6 of R-2207 at the peak and T_0 of R-2303 at the lower level, T_2, T_4 and T_5 were also privileged by the judges.

Extrusion processing variables like Screw speed, cooking temperature and moisture level have large effect on the taste of extrudates. High moisture have negative impact on extrudates quality while screw speed and cooking temperature have a positive effect on extrudates quality. Liu *et al.* (2000) study that the taste of extrudates reduces as the moisture content increases. This might be due to the reduced expansion and increase in solidity caused by the raise in moisture level. According Kokini (2002) the harsh situation (high temperature and screw speed) come across during food extrusion cause different degrees of granular and molecular changes in the corn starch that may affect on the taste of extrudates.

Table 7: Effect of extrusion variables on the color of extrudates of two maize cultivars.

Treatments	R-2303	R-2207	Mean
T_0	5.000d	4.70e	4.85
T_1	6.2cd	5.90c	6.05
T_2	5.000d	5.60c	5.30
T_3	6.40bc	6.50bc	6.45
T_4	6.40bc	6.30b	6.35
T_5	6.7ab	7.000ab	6.85
T_6	7.4a	7.66a	7.55
Mean	6.15a	6.22a	

(T_0 105ºC, 110 r.p.m, 18% m.c), (T_1 130 ºC,120 r.p.m, 20% m.c.) (T_2 135 ºC,120 r.p.m, 17% m.c.) (T_3 135 ºC, 140r.p.m, 20% m.c.) (T_4 150 ºC, 170 r.p.m, 19% m.c.) (T_5 150 ºC, 150 r.p.m 20% m.c.) ($T_6$150 ºC, 170 r.p.m, 18% m.c.

Table 8: Effect of extrusion variables on the flavor of extrudates of two maize cultivars.

Treatments	R-2303	R-2207	Mean
T_0	5.112e	5.40ef	5.25
T_1	6.17bc	6.67cd	6.37
T_2	5.000de	5.45f	5.225
T_3	5.50cd	6.20de	5.85
T_4	5.75de	6.10e	5.93
T_5	6.55bc	7.10b	6.83
T_6	7.75ab	7.8ab	7.78
Mean	5.97b	6.38a	

(T_0 105ºC, 110 r.p.m, 18% m.c), (T_1 130 ºC,120 r.p.m, 20% m.c.) (T_2 135 ºC,120 r.p.m, 17% m.c.) (T_3 135 ºC, 140r.p.m, 20% m.c.) (T_4 150 ºC, 170 r.p.m, 19% m.c.) (T_5 150 ºC, 150 r.p.m 20% m.c.) ($T_6$150 ºC, 170 r.p.m, 18% m.c.).

Texture of corn extrudates

Texture is an imperative attribute in consumer's observation of food and buying assessment. Texture defines as the "sensory expression for the structure of products in terms of their Reaction to stress by the kinesthetic sense.It is evident from results that maize variety significantly affected the texture of the maize extrudates. The treatments also significantly affect the texture of maize extrudates. The interactive affect of maize variety and treatment were found non significant with respect to texture. Mean values are given in table no. 10. It is obvious from the information that judges positioned T_6 at the top and T_0 at the bottom,. All the left over samples achieved unstable scores for texture. All treatment found to be significant with their interaction effect. T_6 of R-2207 find the highest score of 7.6, T_6 of R-2303 got 7.2 score whereas T_0 was at bottom with a score of 5.25.

The raise moisture level creates a plasticizing of the starch–protein matrix and as a result an increase in hardiness of the product (Biliaderis, 2003). Textural factor were extensively affected by the extrusion processing variables. Chew ability was the only exemption; it was not affected by the screw speed. Consumers distinguish a sample with higher numbers of air cells as crisper. Textural properties were radically abridged at higher screw speed the stickiness decreased at higher screw speed .Fracturability and solidity of the extrudates increased as the moisture content increased. Screw speed effects on the fracturability and hardness of extrudates were converse to the moisture content.

Badrie and Mellowes (2001) reported that the hardness and fracturability of the extrudates increased at a higher moisture level. A higher screw speed may also reduce the hardness and fracturability by increasing the cooking temperature that generally leads to a higher expansion ratio of extruded product. Rokey (2000) found that a soft texture product resulted from a fine granulation and a coarse meal led to a hard product.

Overall acceptability of maize extrudates

It is evident from results that maize variety significantly affected the general acceptability of the maize extrudates. The treatments also significantly affect the general acceptability of maize extrudates. The interactive affect of maize variety and treatment were found non significant with respect to general acceptability Mean values are given in table no. 11 .DMR test was used to determined variations among taste of extrudates It is apparent from the results that judges positioned T_6 at the first and T_0 ranked at the last position. All the other samples obtained different scores for overall acceptability. For R-2303 and R-2207 maize extrudates, T_6 obtain the highest score of 7.50, whereas T_0 was at bottom obtaining 3.87 scores. As a entire highest score was obtained by T_6 due to low moisture (18 %), high temperature (150 °C) and high screw speed (170 r. p. m.) which was slowly reduced with increase in moisture level and decrease in screw speed.

Table 9: Effect of extrusion variables on the taste of extrudates of two maize cultivars.

Treatments	R-2303	R-2207	Mean
T_0	5.15e	6.15de	5.65
T_1	6.50bc	6.50bc	6.50
T_2	5.40e	6.20cd	5.60
T_3	5.70de	6.10cd	5.50
T_4	5.20e	5.80de	5.50
T_5	7.000bc	7.20b	7.10
T_6	7.80a	7.90a	7.85
Mean	6.10b	6.55a	

(T_0 105ºC, 110 r.p.m, 18% m.c), (T_1 130 ºC,120 r.p.m, 20% m.c.) (T_2 135 ºC,120 r.p.m, 17% m.c.) (T_3 135 ºC, 140r.p.m, 20% m.c.) (T_4 150 ºC, 170 r.p.m, 19% m.c.) (T_5 150 ºC, 150 r.p.m 20% m.c.) ($T_6$150 ºC, 170 r.p.m, 18% m.c.)

Table 10 Effect of extrusion variables on the texture of extrudates of two maize cultivars.

Treatments	R-2303	R-2207	Mean
T_0	5.250f	5.38e	5.27
T_1	6.17bc	6.47bc	6.27
T_2	5.85ef	5.85ef	5.85
T_3	5.45de	5.78cd	5.63
T_4	5.85cd	6.15c	6.00
T_5	6.25bc	6.58b	6.27
T_6	7.20ab	7.60a	7.40
Mean	6.00b	6.25a	

(T_0 105ºC, 110 r.p.m, 18% m.c), (T_1 130 ºC,120 r.p.m, 20% m.c.) (T_2 135 ºC,120 r.p.m, 17% m.c.) (T_3 135 ºC, 140r.p.m, 20% m.c.) (T_4 150 ºC, 170 r.p.m, 19% m.c.) (T_5 150 ºC, 150 r.p.m 20% m.c.) ($T_6$150 ºC, 170 r.p.m, 18% m.c.)

Table 11: Effect of extrusion variables on the overall acceptability of extrudates of two maize cultivars.

Treatments	R-2303	R-2207	Mean
T_0	3.87f	4.10e	3.99
T_1	5.25cd	5.95cd	5.60
T_2	4.15ef	5.15d	4.65
T_3	5.15de	5.98d	5.57
T_4	6.50bc	6.70bc	6.60
T_5	6.80b	7.50ab	7.15
T_6	7.10ab	7.50ab	7.20
Mean	5.60b	6.25a	

(T_0 105ºC, 110 r.p.m, 18% m.c), (T_1 130 ºC,120 r.p.m, 20% m.c.) (T_2 135 ºC,120 r.p.m, 17% m.c.) (T_3 135 ºC, 140r.p.m, 20% m.c.) (T_4 150 ºC, 170 r.p.m, 19% m.c.) (T_5 150 ºC, 150 r.p.m 20% m.c.) ($T_6$150 ºC, 170 r.p.m, 18% m.c.)

The mean value of physical and color result from instrumental measurement and sensory expressive panel for T_0-T_6 were pooled. Color hue, which specify the color character (pale or yellow) of the extrudates, was harmonized well with the yellowness (B*) measured by the lab. Colorimeter. Mutually lightness estimated by visual examination and collected from lab. Colorimeter (L*) were to be found near each other and come together with the specific length and moisture adsorption. Redness (B*), and open cell recommend that extrudate with high specific length also allow the characteristics of high lightness, several open cell on the surface, high lightness and redness from lab. Colorimeter, as well as high moisture adsorption inside the mouth.

Hardness and fracturability for R-2303 and R-2207 at three extrusion variables were extremely associated with each other and match up well with the hardness assessed by human mouthful. Extrudates with a high bulk density as T_0, T_1 and T_o of R-2303 were generally come with by some negative sensory characteristic, such as coarseness, solid curing, and uneven profile, as well as desiccated surface. Extrudates with low bulk density as T_3, T_4, T_5 and T_6 of R-2207 were typically come with by some positive sensory characteristic like good expansion, color and standard profile

In addition, expansion ratio was extremely associated with the cohesiveness and springiness and associated with the crunchy texture and glossy surface. Statistical study shows that the same instrumental variables were greatly connected with the same sensory variables. During extrusion cooking, the moist cereal flours are changed into viscoelastic dough, whose rheological properties depend on the extrusion variables and chemical composition Dhanasekharan and Kokini (2003).

Conclusion

It was distinguished that high temperature, high screw speed and low moisture content as in T_6 of R-2207, improved the sensory and physical characteristics of extrudates. While T_0 (high moisture, low temperature and low screw speed) was slightest suitable to the judges. Physical properties and expansion characteristics of extruded snacks are important especially for the acceptability by the consumers. Property indicator such as expansion ratio, density and porosity can be used to enumerate this structure. Despite the fact that extensive work been done in the area of extrusion in general, and extrusion expansion in particular, this complex field carry on to some degree to dexterous art rather than a apparent science. There are many areas that require further research regarding extrusion and nutrition. Very little has been published on the effects of extrusion on photochemical and other healthful food components. Prospect study may be focused on the association between compositional changes on product worth together with dietary and sensory characteristic.

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Application of nanotechnology in food and dairy processing: An overview

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Abstract

Over the past few decades, the evaluation of a number of science disciplines and technologies have revolutionized food and dairy processing sector. Most notable among these are biotechnology, information technology etc. Recently "Nanotechnology", an essentially modern scientific field that is constantly evolving as a broad area of research, with respect to dairy and food processing, preservation, packaging and development of functional foods. Food and dairy manufacturers, agricultural producers, and consumers could gain a more competitive position through nanotechnology. Furthermore, the delivery of bioactive compounds for nutritional as well as development of functional food are possible through this technology. Nanotechnology will replace many fields with tremendous application potential in the area of dairy and food sectors. Several critical challenges, including discovering of beneficial compounds, establishing optimal intake levels, developing adequate food delivering matrix and product formulation including the safety of the products need to be addressed. And also the potential negative effects of nanotechnology- based delivery systems on human health need to be considered.

Keywords: Nanotechnology, Nanocapsules, Nanolaminates, Food and Dairy Processing, Nanotubes, Nanoceuticals, Nanosensors

Introduction

In today's competitive market new frontier technology is essential to keep leadership in the food and food processing industry. Consumers demand fresh, authentic, convenient and flavourful food products. The future belongs to new products and new processes, with the goal of enhancing the performance of the product, prolonging the shelf life, freshness, improving the safety and quality of food product. Nanotechnology has the potential to revolutionize the food and dairy processing sectors days to come.

Nanotechnology is based on the prefix "nano", a Greek word meaning "dwarf". According to Pehanich (2006), nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers. To be more specific, nanotechnology is defined as the design, production and application of structures, devices, and systems through control of the size and shape of the material at the nanometer (10^{-9} of a meter) scale where unique phenomenon enable novel applications (Ravichandran, 2006; National Nanotechnology Initiative, 2006). This technology has already revolutionized the health care, textile, information technology, and energy sectors etc. and has been well publicized (Kumar and Rai, 2009). Several products enabled by nanotechnology are already in the market, such as antibacterial dressings, transparent sunscreen lotions, light-diffracting cosmetics, penetration enhanced moisturizers, stain and odour repellent fabrics, scratch free paints for cars, and self cleaning windows, dirt repellent coatings, long lasting paints and furniture varnishes, and even some food products (Miller, 2008).

Nanotechnology has been described as the new industrial revolution and both developed and developing countries are investing more in this technology. Recently the Helmuth Kaiser Consultancy predicted that the nanofood market will surge from 2.6 billion USD to 20.4 billion USD by 2010 and is extended to grow to $30.4 billion in 2015. The government of India established the Nanoscience and Technology Initiative in the later part of the 2001 through Department of Science and Technology (DST), New Delhi and invested about Rs. 350 Crores (2002-06) and granted approval for the Nanomission worth Rs. 1000 crores for next five years (Patra *et al.*, 2009).

Nanotechnology can be applied by two different approaches either "bottom up" or "top down." in food and dairy processing (Ravichandran, 2010). The top-down approach involves a physical processing of the food materials, such as dry-milling of wheat into fine flour that has a high water-binding capacity. The antioxidant activity in green tea powder is improved by when the size of the powder is reduced to 1000 nm, the digestion and absorption resulted in an increase in the activity of an oxygen-eliminating enzyme (Shibata, 2002). By contrast, self-assembly and self-organization are concepts derived from biology that have inspired a bottom-up food nanotechnology. For example, self-assembly structures through organization of casein micelles or starch and the folding of globular proteins and protein aggregates which create stable entities to form nanometer scale via self-organization (Dickinson and Van Vliet , 2003).

In food and dairy industries, the applications of nanotechnology include Nanoparticulate Delivery Systems (nanodispersions and nanocapsules), Packaging (nanolaminates, nanocomposites bottles, bins with silver nanoparticles), Food Safety and Biosecurity (nanosensors) etc. (Chen *et al.* 2006). The nanotechnology will play an vital role in the food and dairy processing in near future and would involve two forms of nano food applications viz, food additives (nano inside) and food packaging (nano outside). The nanoscale food additives may be used to influence texture, flavour, nutritious improvement, provide functionally and even detect pathogens and food packaging involves extend food shelf life, edible, nano wrapper which will envelope foods, preventing gas and moisture exchange, 'smart' packaging (containing nano-sensors and anti-microbial activators) for detecting food spoilage and releasing nano-anti-microbes to extend food shelf life (Richardson and Piehowski, 2008; Miller, 2008).

Nanotechnology in Food and Dairy Processing

Cell membranes, harmones, DNA etc. that exist in nature are example of nano structures and the food molecules, proteins, fats, carbohydrates etc. are not exceptional and the results of nanoscale level murges between sugars, fatty acids and amino acids (Powell and Colin, 2008).

'Nanofoods' from the Helmut Kaiser Consultancy (2009) estimates an increasing growth in the development of food and dairy related nanoproducts and patent applications. Nanotechnology can be applied to develop nanoscale materials, controlled delivery systems, contaminant detection and to create nano devices for molecular and cellular biology from how food is grown to how it is packaged. The application of nanotechnology with respect to food and dairy industry will be covered under two major heads viz. food additives (nano inside) and food and dairy packaging (nano outside).

Food Additives (Nano Inside)

Nanodispersions and Nanocapsules

Functional ingredients (for example, drugs, vitamins, antimicrobials, antioxidants, flavorings, colorants, and preservatives etc.) and comes in different molecular and physical forms such as polarities (polar, nonpolar, amphiphilic), molecular weights (low to high), and physical states (solid, liquid, gas). These ingredients are rarely utilized directly in their pure form; instead, they are often incorporated into some form of delivery system.

Weiss *et al.* (2006) examined that a delivery system must perform a number of different roles. First, it serves as a vehicle for carrying the functional ingredient to the desired site of action. Second, it may have to protect the functional ingredient from chemical or biological degradation (for example, oxidation) during processing, storage, and utilization; this maintains the functional ingredient in its active state. Third, it may have to be capable of controlling the release of the functional ingredient, such as the release rate or the specific environmental conditions that trigger release (for example, pH, ionic strength, or temperature). Fourth, the delivery system has to be compatible with the other components in the system, as well as being compatible with the physicochemical and qualitative attributes (appearance, texture, taste, and shelf-life) of the final product. In order to achieve above said objectives, a number of potential delivery systems based on nanotechnology could be used as under:

- association colloids,
- biopolymeric nanoparticles,
- nanoemulsion

Association colloids

A colloid is a stable system of a substance containing small particles dispersed throughout. An association colloid is a colloid whose particles are made up of even smaller molecules. Surfactant micelles, vesicles, bilayers, reverse micelles, and liquid crystals are some examples of association colloids which have been used to encapsulate and deliver polar, nonpolar, and amphiphilic functional ingredients (Flanagan and Singh, 2006; Golding and Sein, 2004). The dimensions of many association colloids are in the range of 5 to 100 nm, and these structures are therefore considered to be nanoparticles.

Biopolymeric nanoparticles

Gupta and Gupta, (2005) reported that nanometer range particles can be produced using food-grade biopolymers such as proteins or polysaccharides through self-association or aggregation or by inducing phase separation in mixed biopolymer systems. Polylactic acid (PLA) a commen biodegradable nanoparticle is often used to encapsulate and deliver drugs and micronutrients like iron, vitamin, protein etc. It has shown that the PLA need an associative compound such as polyethylene glycol for successful results and the functional ingredients can be encapsulated in nanoparticles and released in response to specific environmental triggers (Riley *et al.* 1999).

Nano-emulsions

Emulsions are often referred to as “nano-emulsions.”, when the use of high-pressure valve homogenizers or microfluidizers often causes emulsions with droplet diameters of less than 100 to 500 nm and functional food components can be incorporated within the droplets, the interfacial region, or the continuous phase (McClements, 2004). According to McClements and Dekker (2000), the different types of nanoemulsions with more complex properties—such as nanostructured multiple emulsions or nanostructured multilayer emulsions—offer multiple encapsulating abilities from a single delivery system that can carry several functional components and these components could be released in response to a specific environmental trigger.

It is possible to develop smart delivery systems by engineering the properties of the nanostructured shell around the droplets. This interfacial engineering technology would utilize food-grade ingredients (such as proteins, polysaccharides, and phospholipids) and processing operations (such as homogenization and mixing) that are already widely used in the manufacture of food emulsions (Weiss *et al.* 2006). Nanosize emulsion-based ice cream with a lower fat content has been developed by Nestle and Unilever (Renton, 2006).

Nanofibers

Nanofibres with diameters from 10 to 1000 nm, makes them ideal for serving as a platform for bacterial cultures as well as structural matrix for artificial foods. Since nanofiberes are usually not composed of food-grade substances, they have only a few potential applications in the food industry (Weiss *et al.*, 2006). Electrospinning is a manufacturing technology capable of producing thin, solid polymer strands (nanofiberes) from solution by applying a strong electric field to a spinneret with a small capillary orifice. The food industry can use electrospun microfibers in several ways as under:

- as a building/reinforcement element of composite green (that is, environmentally friendly) food packaging material,
- as building elements of the food matrix for imitation/artificial foods, and
- as nanostructured and microstructured scaffolding for bacterial cultures.

Though the electrospun fibers application is increasing, its use in food and dairy processing are relatively few and are made primarily from synthetic polymers. As progress in the production of nanofibers from food biopolymers is made, the use of biopolymeric nanofibers in the food industry will increase (Ravichandran, 2010).

Nanotubes

Carbon nanotubes have been used nonfood application. The structures have been used as low-resistance conductors or catalytic reaction vessels among other uses. Graveland-Bikker and Kruif (2006), have reported that certain globular proteins from milk (such as hydrolyzed α-lactalbumin) can be made to self assemble to form nanotubes under appropriate conditions. This technique is applicable to other proteins as well and has been explored to assist in the immobilization of enzymes or to build analogues to muscle-fiber structures. Nanotubes made of the milk protein α -lactalbumin are formed by self-assembly of the partially hydrolysed molecule (Graveland-Bikker *et al.* 2006). Otte et al. (2005) examined that at neutral pH and in presence of an appropriate cation, these building blocks self-assemble to form micrometre-long tubes with a diameter of only 20 nm. The minimum concentration to form nanotubes of α-lactalbumin is 20 g/l. The α-lactalbumin nanotubes could withstand conditions similar to a pasteurisation step (72ºC/40s). According to Gouin (2004), the features of the α-lactalbumin nanotube makes it an interesting potential encapsulating agent. Because α-lactalbumin is a milk protein it will be fairly easy to apply the nanotubes in foods or pharmaceutics. These nanostructures promise various applications in food, nanomedicine etc. (Rajagopal and Schneider, 2004).

In general protein hydrolysis increases the digestibility of protein. Furthermore α -lactalbumin has important nutritional value. A nanotube made by food / dairy proteins or their derivatives have so far only been reported for α-lactalbumin.

Nanocapsules

A number of new processes and materials derived from nanotechnology have the potential to provide new solutions to dairy and food processing fronts. In recent years, there has been considerable interest in exploring the potential of nanotechnology in encapsulation and delivery of biologically active substances into targeted tissues, enhance the flavour and other sensory characteristics of food and dairy products. Casein micelle (CM) plays a role as natural nano-capsular vehicle for nutraceuticals. The CM is important due to their biological activity, good digestibility. The micelles are very stable to processing and retain their basic structural identity through most of these processes (Gouin, 2004).

Uricanu *et al.* (2004) reported that casein micelles (CM) are in effect nano-capsules created by nature to deliver nutrients such as calcium phosphate and protein to the neonate. A novel approach is to harness CM for nano-encapsulation and stabilization of hydrophobic nutraceutical substances for enrichment of non-fat or low-fat food products. Such nano-capsules may be incorporated in dairy products without modifying their sensory properties.

The general approach is to develop nanosized carriers or nanosized materials, in order to improve the absorption and, hence, potentially the bioavailability of added materials such as vitamins, phytochemicals, nutrients, or minerals. The materials can be incorporated into solid foods, delivered as liquids in drinks, or even sprayed directly on to mucosal surfaces.

Food 'fortification' through Nanotechnology

Nanotech companies are trying to fortify processed dairy and food products with nano-encapsulated nutrients, their appearance and taste boosted by nano-developed colours, their fat and sugar content removed or disabled by nano-modification, and 'mouth feel' improved. Food 'fortification' will be used to increase the nutritional claims for example the inclusion of 'medically beneficial' nano-capsules will soon enable chocolate chip cookies or hot chips to be marketed as health promoting or artery cleansing. Nanotechnology will also enable junk foods like ice cream and chocolate to be modified to reduce the amount of fats and sugars that the body can absorb. This is possible by using nanoparticles to prevent the body from digesting or absorbing these components of the food. In this way, the nano industry could market vitamin and fibre-fortified, fat and sugar-blocked junk food as health promoting and weight reducing (Miller, 2008).

Nanostructures and Nanoparticals in Food

Most polysaccharides and lipids are linear polymers with thicknesses less than nanometers, while food proteins are often globular structures (1-10 nm) in size. The functionality of many raw materials and the processing of foods arise from the presence, modification, and generation of forms of self-assembled nanostructures (Chen *et al.* 2006). The crystalline structures in starch, and processed starch-based foods that determine gelatinization and influence the nutritional benefits during digestion, the fibrous structures that control the melting, setting, and texture of gels, and the two-dimensional (2D) nanostructure formed at oil-water and air-water interfaces that control the stability of food /dairy foams and emulsions (Rudolph, 2004).

For example, the creation of foams (e.g., the head on a glass of beer) or emulsions (e.g., sauces, creams, yoghurts, butter, and margarine) involves generating gas bubbles, or droplets of fat or oil, in a liquid medium. This requires the production of an air-water or oil-water interface and the molecules present at this interface determine its stability. These structures are one molecule thick and are examples of two dimensional nanostructures. A source of instability in most foods is the presence of mixtures of proteins and other small molecules such as surfactants (soap-like molecules or lipids) at the interface (Morris, 2005). Atomic Force Microscopy has allowed to visualized and understand these interactions and to improve the stability of the protein networks that can be simultaneously applied widely in the dairy, baking and brewing industries.

The knowledge gained in the nanotechnology in the field of medicine , electronics etc. could be adapted in the field of food and dairy processing, more specifically in food safety (e.g., detecting pesticides and microorganisms), in environmental protection (e.g., water purification), and in delivery of nutrients (Roco, 2003; Chau, 2007) The area that has led to most debate on nanotechnology and food is the incidental or deliberate introduction of manufactured nanoparticles into food materials.

Nanoceuticals

The concept of "nanoceuticals" is gaining popularity and commercial dairy/food and food supplements containing nanoparticles are available (Chen *et al.* 2006; Mozafari *et al.* 2006).

The examples of food-related nanoproducts are:

- carotenoids nanoparticles can be dispersed in water, and can be added to fruit drinks for improved bioavailability;
- canola oil based nanosized micellar system is claimed to provide delivery of materials such as vitamins, minerals, or phytochemicals;
- patented "nanodrop" delivery systems, in the form of encapsulated materials, such as vitamins, transmucosally, rather than through conventional delivery systems such as pills, liquids, or capsules; and
- Chinese nanotea (nano-based mineral supplements) claimed to improve selenium uptake.
- a wide range of nanoceutical products containing nanocages or nanoclusters that act as delivery vehicles, e.g., a chocolate drink claimed to be sufficiently sweet without added sugar or sweeteners;
- nanosilver or nanogold are available as mineral supplements
- to prevent the accumulation of cholesterol some of the nutraceuticals incorporated in the carriers include lycopene, beta-carotenes and phytosterols
- a synthetic lycopene has been affirmed GRAS ("generally recognized as safe") under US FDA procedures

Food Packaging (Nano Outside)

Customers today demand a lot more from packaging in terms of protecting the quality, freshness and safety of foods and the nanotechnology, which uses microscopic particles, is effective and affordable and will bring out suitable food and dairy packaging in the near future (El Amin, 2006).

Food packaging is considered to be one of the earliest commercial applications of nanotechnology in the food sector. Reynolds (2007) reported that about 400-500 nano-packaging products are estimated to be in commercial use, while nanotechnology is predicted to be used in the manufacture of 25% of all food packaging within the next decade.

The significant purpose of nano-packaging is to set longer shelf life by improving the barrier properties of food packaging to reduce gas and moisture exchange and UV light exposure (Sorrentino *et al.* 2007). For example, Du Pont has announced the release of a nano-titanium dioxide plastic additive namely "DuPont light stabilizer210", which could reduce UV damage of foods in transparent packaging (El Amin, 2007).

By 2003, over 90% of nano-packaging was based on nanocomposites, in which nanomaterials were used to improve the barrier properties of plastic wrapping for foods and dairy products. Nano-packaging can also be designed to release antimicrobials, antioxidants, enzymes, flavours and nutraceuticals to extend shelf life (Cha and Chinnan, 2004). El Amin (2005) reported that exciting new nanotechnology products for food packaging are in the pipeline and some anti-microbial films, have already entered the market to improve the shelf life of food and dairy products. Further more, nanomaterials are being developed with enhanced mechanical and thermal properties to ensure better protection of foods from external mechanical, thermal, chemical or microbiological effects with an addition level of safety and functionality.

A scientific group at the Norwegian Institute of Technology is using nanotechnology to create tiny particles in the film, to improve the transportation of some gases through the plastic films to pump out unwanted carbon dioxide that would shorten the shelf life of the foods. They are also looking at whether the film could also provide barrier protection and prevent gases such as oxygen and ethylene from deteriorating foods (SINTEF, 2004).

Nano-Coatings

Waxy coating is used widely for some foods such as apples and cheeses. Recently, nanotechnology has enabled the development of nanoscale edible coatings as thin as 5 nm wide, which are invisible to the human eye. Edible coatings and films are currently used on a wide variety of foods, including fruits, vegetables, meats, chocolate, cheese, candies, bakery products, and French fries (Morillon *et al.* 2002; Cagri *et al.* 2004; Rhim 2004). These coatings or films could serve as moisture, lipid, and gas barriers. Alternatively, they could improve the textural properties of foods or serve as carriers of functional agents such as colors, flavors, antioxidants, nutrients, and antimicrobials and could also increase the shelf life of manufactured foods, even after the packaging is opened. The U.S. Company Sono-Tec Corporation announced in early 2007 that it has developed an edible antibacterial nano-coating, which can be applied directly to bakery goods (El Amin, 2007).

Nanolaminates

Nanotechnology provides food scientists with a number of ways to create novel laminate films suitable for use in the food and dairy industry. A nanolaminate consists of 2 or more layers of materials with nanometer dimensions that are physically or chemically bonded to each other. According to Decher and Schlenoff (2003), one of the most powerful methods is based on the LbL deposition technique, in which the charged surfaces are coated with interfacial films consisting of multiple nanolayers of different materials.

Weiss *et al.* (2006) reported that nanolaminates offer some advantages for the preparation of edible coatings and films over conventional technologies and may thus have a number of important applications within the food and dairy industry. A variety of different adsorbing substances could be used to create the different layers, including natural polyelectrolytes (proteins, polysaccharides), charged lipids (phospholipids, surfactants), and colloidal particles (micelles, vesicles, droplets). It would be possible to incorporate active functional agents such as antimicrobials, antibrowning agents, antioxidants, enzymes, flavors, and colors into the films. These functional agents would increase the shelf life and quality of coated foods. These nanolaminated coatings could be created entirely from food-grade ingredients (proteins, polysaccharides, lipids) by using simple processing operations such as dipping and washing.

Clay nanoparticles and nano crystals

The barrier properties of dairy and food packaging materials are improved by incorporating as well as embedding nanoclays and nanocrystals. The plastic films and bottles containing these nanoparticles are able to block oxygen, carbon dioxide and moisture from reaching food products (meat, beer etc.). The advantage of clay nanocomposite in the packaging material offers improved shelf life, shutter proof, light in weight and heat resistant (Ravichandran, 2010).

Nanosensors

Packaging equipped with nano-sensors is also designed to track either the internal or external conditions of food products, pellets and containers, throughout the supply chain. For example, such packaging can monitor temperature or humidity over time and then provide relevant information of these conditions, for example by changing colour. Some of these nano-sensors are under development and the Georgia Tech in the United State used modified carbon nanotube as biosensor to detect microorganisms, toxic substances and spoilage of foods or beverages (Nachay, 2007). Another example, Opal, which makes Opal film incorporating 50nm carbon black nanoparticles was used as biosensor that can change colour in response to food spoilage (Gander, 2007).

Nanosensors in plastic packaging can detect gases given off by food when it spoils and the packaging itself changes color to alert you. These films are packed with “silicate nanoparticles” to reduce the flow of oxygen into the package and the leaking of moisture out of the package to stay food fresh. Nanosensors are being developed that can detect bacteria and other contaminates such as salmonella on the surface of food at a packaging plant. There are also nanosensors being developed to detect pesticides on fruit and vegetables (http://www.nanoforum.org).

Industrial nanotech (OTC: INTK), a company that specializes in nanotechnology innovation and product development, has announced recently the successful application of the company, s8217, sNansulate protective coatings, to dairy processing equipment. The Nansulates were used to coat dairy processing tanks and pipes in order to protect them against corrosion and insulate against heat loss and to increase the efficiency of the manufacturing process by reducing both energy and corrosion-related expenses (Pehnich, 2006).

Nanotechnology is also enabling sensor packaging to incorporate cheap Radio Frequency Identification (RFID) tags. The nano-enabled RFID tags are much smaller, flexible and can be printed on thin labels. This increases the tags versatility and thus enables much cheaper production (http://www.thefreelibrary.com/).

Roberts (2007) reported that, a United States company Oxonica Inc, has developed nano-barcodes to be used for individual items or pellets, which must be read with a modified microscope for anti- counterfeiting purposes. Another trend in the application of nano-packaging is the nano-biodegradable packaging. The use of nanomaterials to strengthen bioplastics (plant-based plastics) may enable bioplastics to be used instead of fossil-fuel based plastics for food packaging and carry bags (Nanowerk, 2007).

The Scientists at Kraft, Rutgers University and the University of Connecticut, are trying to exploit the "electronic tongue" to detect pathogens and other substances in parts per trillion with the help of embedded nanosensors in the packaging materials using nanotechnology. The sensors trigger colour changes in the package when the dairy and food products began to spoil (Ravichandran, 2010).

The present technologies, to detect microbes especially pathogens in food products take 2 to 7 days. Researchers in the United States are developing biosensors that can detect pathogens quickly and easily called "super sensors" would play a crucial role in the event of a terrorist attack on the food supply. With US Department of Agriculture (USDA) and National Science Foundation funding, researchers at Purdue University are working to produce a hand-held sensor capable of detecting a specific bacteria instantaneously from any sample. They've created a start-up company called BioVitesse (Kokini, 2002).

Nanotechnology for antimicrobial, active and bioswitch for food Packaging

Kodak is using nanotechology to develop antimicrobial packaging as well as active packaging, that absorbs oxygen, to keep food fresh that will be commercially available in near future (Clark, 2006). The Netherlands Researchers are developing intelligent packaging that will release a preservative if the food within begins to spoil. This "release on command" preservative packaging is operated by means of a bioswitch developed through nanotechnology (Ravichandran, 2010).

Nanotechnology and food safety

Food safety means that all food products must be protected from chemical, biological, physical and radiation contamination through processing, handling and distribution. So far the present review has focused on the application of nanotechnology in the dairy and food processing including packaging. The nanotechnology has brought revolution in the non-food sectors; however, it is slowly gaining popularity in the dairy and food processing. Although consumers are thrilled at the exciting food and dairy products emerging through the application of nanotechnology, there is a serious question about safety and will requiring attention by the industry as well as the policy makers. It is important to note that nanomaterials (increased contact surface area), might have toxic effects in the body that are not apparent in the bulk materials (Dowling, 2004). Despite the lack of regulation and risk knowledge, a wide variety of food and nutrition products containing nanoscale additives are already in the market (e.g. iron in nutritional drink mixes, micelles that carry vitamins, minerals, and phytochemicals in oil, and zinc oxide in breakfast cereals etc.) and nanoclays incorporated in plastic beer bottles.

The additives universally accepted as GRAS will have to be reexamined when used at nanoscale level. The nanoparticles are more reactive, more mobile, and likely to be more toxic. This toxicity is one of the important issues must be addressed. There is strong possibility that nanoparticles in the body can result in increased oxidative stress that, in turn, can generate free radicals, leading to DNA mutation, cancer, and possible fatality. It is also not fully understood whether enhancing the bioavailability of certain nutrients or food additives might negatively affect human health (Moraru *etal.*, 2003). The ingredients in these nanoparticles must undergo a full safety assessment by the relevant scientific advisory association before these are permitted to be used in the dairy and food products including packaging (U.K.RS/RAE, 2004).

Regulation of nanotechnologies to ensure food safety

The health implications of food processing techniques that produce nanoparticles and nanoscale emulsions also warrant the attention of food regulations. The potential for such foods to pose new health risks must be investigated in order to determine whether or not related new food safety standards are required (Bowman and Hodge, 2007). The European Union regulations for food and food packaging have recommended that for the introduction of new nanotechnology, specific safety standards and testing procedures are required (Halliday, 2007). In the United States, nanofoods and most of the food packaging are regulated by the United States Food and Drug Administration (US FDA) (Badgley *et al.* 2007), while in Australia, nanofood additives and ingredients are regulated by Food Standards Australia and New Zealand (FSANZ), under the Food Standards Code (Bowman and Hodge, 2006).

There is an urgent need for a common regulatory system capable of managing any risks associated with nanofoods and the use of nanotechnologies in dairy and food industry. Governments must also respond to nanotechnology's broader social, economic, civil liberties and ethical challenges. To ensure democratic control of these new technologies in the important area of food and dairy, public involvement in nanotechnology decision making is essential (U.K.RS/RAE, 2004).

Conclusion

The prediction is that nanotechnology will transform the entire food and dairy industry near future. Nanotechnology has already entered into food and dairy industries, research facilities are established, potential applications are under study. Although only a handful of nano food products are now available in the market, the tremendous potential will attract more and more competitors in this field. However, there are few issues, particularly regarding the accidental or deliberate use of nanoparticles in food, or food-contact materials, that consumers are concerned about the potential negative effects of nanotechnology-based delivery systems on human health and also regulatory stands. Several critical challenges, including discovering of beneficial compounds, establishing optimal intake levels, developing adequate food delivering matrix, product formulations and safety of the products need to be addressed. Irradiation technology took more than 5 decades of research and safety assessment for its acceptance in food and dairy processing. Nanotechnology also will have to wait till all safety issues are resolved. There is an urgent need for regulation of nanomaterials before their incorporation into food and dairy processing including packaging. Nanomaterials must not cause any health risks for consumers or to the environment. More research studies are required to investigate the hazards of nanomaterials, taking the size as a main factor even though some of the chemical materials in the form of large particles are safer than when they are in the nano state.

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Nutritional aspects and acceptability of Water Melon juice syrup

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Abstract

Highly stable and nutritious watermelon juice syrup was evaluated for its chemical/ nutritional and sensory attributes. Carbohydrates and protein contents of the water melon juice syrup averaged from 69.90 to 70.17% and 0.92 to 0.98 % respectively. Fat content ranged from 0.25% to 0.26%, whereas crude and dietary fiber varied from 0.62 to 0.68 % and 1.32 to 1.37%. Energy content ranged from 285.17 to 286.87 kcal /100g. The main constituents of the syrup lycopene and vitamin C content varied from 138 -140 mg/100g and 9-10 mg/100g. Among other vitamins, riboflavin , niacin, thiamin and vitamin A ranged from 9-10mg/100g, 0.20 -0.23 mg/100g, 0.03-0.032 mg/100g and 560 -591 IU respectively.

Key words: Nutritients, lycopene, vitamins, acceptability, watermelon

Introduction

Water melons (*Citrullus lanatus*) are one of the leading worldwide and popular staple summer fruit in the world and consumed frequently as a dessert ,snack, fruit salad, break fast food, picnic food edible plate garnish in drinks and also used in many creative ways. It is a natural source of nature's most powerful antioxidants. American heart association identified watermelon as a constitute of a sensible low sodium, low saturated fat and low cholesterol diet and a rich source of nutrients. This property makes it a best choice for the diet conscious people. The health benefits of watermelon have been known about for a long time. It belongs to *cucurbitceae* family. It has its origin in Africa and is said that Egyptians had cultivated it 5000 years ago. China is the single largest producer of watermelon in the world (Pastor *et al* 2009; Britton, 1995).

Watermelon fruit is one of the few excellent natural sources, richest and abundant in an antoxidant, lycopene and β-carotene. The amount of lycopene in watermelon ranges from 35 to 125 mg per kg of the edible red fleshed portion and it ranks 5^{th} among the major contributors of lycopene in the US diet. Lycopene in fresh watermelon is as much as 40 % more bioavailable than the fresh tomatoes (Maria *et al* 2008; Perkins *et al* 2008; Salman *et al* 2007). Lycopene and vitamin C present in watermelon due to their antoxidant activity has shown very important role in human nutrition and preventing various cancers particularly prostrate, lung, colon , breast ,oral cavity, pancreas and oesophageal cancers and control scurvy illness due to formation of collagen as well (Tang *et al* 2009; Giovannucci, 1999; Rao & Agarwal, 1999).

In addition many other recent epidemiological studies have linked reduction in risks of cardiovascular disease, oxidative damage and cholesterol with diets rich in lycopene containing foods (Rissanen *et al* 2003; Chopra *et al* 2000; Rao and Shen, 2000). Due to these precious nutritional facts present study was aimed to develop acceptable quality lycopene rich watermelon syrup of 75 brix° and was subjected to sensory, nutritional and microbial studies as well.

Materials and Methods

Collection of Raw Material

Raw material was collected from local market of the Lahore city.

Preparation of watermelon syrup

After the pealing and removal of seed, it was mashed. The liquid obtained and sugar was added to make the syrup with slow heating. Brix° of the syrup was maintained at 75. Sodium benzoate was added at the rate of 0.074% as precautionary measures to increase its shelf life. To observe any change its nutritional values were estimated after three weeks intervals.

Storage of syrup

Watermelon syrup has been stored for a period of twelve month and analyzed after three weeks interval i.e. 0, 21,.35, 70 days.

Chemical analysis

Protein, fat, ash, total carbohydrate, fiber, dietary fiber, energy, lycopene, riboflavin, niacin, vitamin A, vitamin C, were determined by methods of the AOAC (AOAC 2005).

Over all acceptability and sensory evaluation of water melon syrup

The syrup was evaluated for the following attributes such as taste, flavor, color and texture by the scoring methods as described by Land and Shephered (1998).

Determination of lycopene

The lycopene content of the watermelon syrup were estimated spectrophotometrically at 502 nm against petroleum ether used as blank (Rangana 1986).

Statistical analysis

The data obtained by the said research was statistically analyzed and assessed by using the analysis techniques as described by Steel and Torrie (1997)

Results and discussions

The results for fat, fiber, dietary fiber, protein and total carbohydrates of watermelon syrup was reported in Table 1, along with the inter day precision values. It is clear from the Table-1 that fat ranged from 0 .25% to 0.26% where as fiber varied from 0.62 to 0.68. Dietary fiber ranged from 1.32 to 1.37, while protein and total carbohydrates varied from 0.92 to 0.98 % and 69.90 to 70.17% respectively. In this way energy content in the water melon syrup varied from 285.17 to 286.87 kcal /100g.

Over all acceptability of any food product is one of the very important and basic criteria for the acceptance or rejection of a food products (Sharma *et al* 2006). It was clear from the table 2. That watermelon syrup prepared was highly accepted by the Judges and experts after each storage of intervals. Statistical data regarding overall acceptability showed no significant differences.

Table 3 summarizes the lycopene and vitamin contents of the watermelon syrup. The main constituents of the watermelon syrup lycopene and ascorbic acid were ranged from 138 -140 mg/100g and 9-10mg/100g respectively. Similarly riboflavin, niacin, thiamine and vitamin A varied from 0.026- 0.28 mg/100g, 0.20-0.23 mg/100g, 0.03-0.032 mg/100g and 560-591 I.U. respectively. These results were similar as given in literature (Perkins *et al* 2001). Lycopene and other carotenoids in some fruits and vegetables especially water melon due to their antioxidant activity has an etiological association with prostrate cancer and has an important role in reducing risks of many diseases including breast cancer and heart diseases. (Fuhrman *et al* 2000; Gioannucci *et al* 1995; Helzlsouer *et al* 1989).

Table 1. Nutritional facts of water melon juice syrup

Days	Moisture	Ash	Fat	Fiber	Dietary Fiber	Protein	Carbohydrate	Energy Kcal/100g
0 day	37.04a	0.24a	0.25a	0.65a	1.35a	0.94a	69.90a	285.61a
21 day	37.05a	0.24a	0.25a	0.62a	1.35a	0.98a	70.08a	286.49a
42day	37.09a	0.26a	0.25a	0.61a	1.32a	0.92a	70.00a	285.93a
63day	37.14a	0.26a	0.25a	0.68a	1.34a	0.96a	70.05a	286.29a
84day	37.20a	0.22a	0.25a	0.66a	1.35a	0.93a	69.80a	285.17a
105day	37.15a	0.28a	0.25a	0.66a	1.35a	0.96a	70.15a	286.69a
126day	37.10a	0.29a	0.25a	0.64a	1.35a	0.94a	70.10a	286.41a
147day	37.08a	0.25a	0.26a	0.65a	1.32a	0.98a	69.95a	286.06a
168day	37.16a	0.24a	0.25a	0.62a	1.37a	0.96a	70.11a	286.53a
189day	37.20a	0.26a	0.25a	0.68a	1.35a	0.96a	70.16a	286.73a
210day	37.15aa	0.22a	0.26a	0.66a	1.33a	0.96a	70.14a	286.65a
231day	37.13a	0.26a	0.25a	0.63a	1.34a	0.97a	69.98a	286.05a
252day	37.07a	0.29a	0.25a	0.64a	1.36a	0.93a	70.16a	286.61a
273day	37.09a	0.22a	0.25a	0.68a	1.33a	0.94	70.13a	286.57a
294day	37.12a	0.28a	0.26a	0.66a	1.34a	0.92a	69.93a	285.63a
315day	37.16a	0.26a	0.25a	0.64a	1.36a	0.96a	69.90a	285.69a
336day	37.07a	0.25	0.25a	0.66a	1.32a	0.94a	70.17a	286.69a
357day	37.19a	0.27a	0.25a	0.63a	1.32a	0.98a	70.14a	286.87a

Results are given as means of three observations

Values with same letters are non significant with each other

Table 2. Over all acceptability of water melon syrup

Sr. No	Days	Poor	Acceptable	Good	Very good
1	0 day				√
2	21 day				√
3	42day				√
4	63day				√
5	84day			√	
6	105day			√	
7	126day			√	
8	147day			√	
9	168day			√	
10	189day			√	
11	210day			√	
12	231day			√	
13	252day		√		
14	273day		√		
15	294day		√		
16	315day		√		
17	336day		√		
18	357day		√		

Table 3. Lycopene and vitamins content of watermelon juice syrup

Days	Lycopene mg/100g	Vitamin-C mg/100g	Riboflavin mg/100g	Niacin mg/100g	Thiamine mg/100g	Vitamin A IU/100g
0 day	138 a	09 a	0.028 a	0.21 a	0.030 a	560 a
21 day	139 a	09 a	0.026 a	0.20 a	0.023 a	575 a
42day	140 a	10 a	0.028 a	0.23 a	0.031 a	590 a
63day	138 a	09 a	0.028 a	0.21 a	0.032 a	565 a
84day	139 a	08 a	0.026 a	0.20 a	0.030 a	590 a
105day	140 a	09 a	0.028 a	0.20 a	0.031 a	570 a
126day	139 a	10 a	0.03 a	0.22 a	0.032 a	590 a
147day	138 a	10 a	0.03 a	0.21 a	0.032 a	591 a
168day	140a	09 a	0.029a	0.21 a	0.030 a	575 a
189day	139 a	09 a	0.029 a	0.21 a	0.030a	580 a
210day	138 a	08 a	0.028 a	0.20 a	0.030a	570a
231day	139a	08a	0.029a	0.20a	0.030a	570a
252day	140a	0.8 a	0.028a	0.21a	0.031a	572a
273day	139a	09a	0.03a	0.21a	0.031a	585a
294day	140a	09a	0.029a	0.20a	0.031a	590a
315day	138a	10a	0.03a	0.22a	0.031a	580a
336day	140a	08a	0.26a	0.22a	0.031a	575a
357day	139a	08a	0.028a	0.20a	0.030a	575a

Results are given as means of three observations

Values with same letters are non significant with each other

Conclusion

From this brief study we concluded that watermelon is a rich source of lycopene and vitamins which are very important in reducing the risks of many diseases, making collagen and protective against oxidative damage. So due to such exceptional qualities people should keep watermelon and its products in their daily use.

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Effectiveness of extension education methods used by Rafhan Maize Products for information dissemination to maize growers of Central Punjab, Pakistan

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Abstract

The fundamental objective underlying extension service of Rafhan Maize Products Company is to disseminate information among maize growers, so that they can improve the quantity and quality of maize crop. In this research project the effectiveness of extension education methods used by Extension Field Staff (E. F. S.) to transfer information to maize growers, was studied. The study was administered in Central Punjab. The data were collected from 120 growers through personal interviews. The findings manifest that Group discussion was found to be the most effective extension teaching methodology followed by Lecture and Demonstration. Telephone call was ranked at 4th position. Literature, Farm and home visit and Farmer's day were ranked at 5th, 6th, and7th spot, respectively. Sign boards/ Slogans, Campaign and Electronic media (Radio and TV) were not found to be used by any farmer.

Keywords: Extension education methods, Dissemination of information, Maize growers, Rafhan Maize Products Company

Introduction

Rafhan Maize Products Co. Ltd. Faisalabad started its operation in 1953 as a pioneer corn refining industry in Pakistan. From relatively modest start, the operation of the company has grown into one of the largest agro-based industry in Pakistan over the last 59 years. Initially, one crop of maize was sown in Pakistan during winter season only and per hectare yield was merely 948-1482 kg per hectare. To share government's agricultural development programme, Rafhan took initiative in 1970 to grow a crop in spring season as well. Through consistent efforts, Rafhan was successful in developing spring crop (March to June) of maize as second crop. The development of hybrid spring maize crop, as a second crop through Contract Maize Farming Programme is a great contribution in agricultural growth. The per hectare yield of hybrid maize has been increased upto 5928-9880 kg per hectare. The Extension Field Staff (EFS) of Rafhan are working in maize growing areas of Faisalabad, Multan, Okara and Sahiwal. EFS mostly aim at practical training and technical skill development of farmers. Farmers are encouraged to manage their affairs themselves regarding research, problem analysis and solution to stimulate the sense of responsibility and ownership. For dissemination of information EFS of the company use variety of extension education methods.Extension education methodologies occupy great importance as far as the technology transfer and farmer's education are concerned (Houghton *et al.*, 1994). Certainly, the standard of efficiency and persuasiveness of an extension programme improves many folds, if best education method to communicate with farmers is utilized (Aphunu and Otoikhian, 2008). These methods can be categorized into three groups (Garforth, 1993 and Okunde, 2007) (a) Individual contact methods (b) Group contact method (c) Mass contact methods. Individual contact methods include farm and home visits, office calls, telephone calls and personal letters.These methods are concerned with face to face interaction of teacher and learner. Group contact methods are comprised of demonstrations,general meeting, lectures, group discussion, exhibitions, farmer's day, field day brainstorming and buzz group. Group tactics involve group learning with the essential participation of farmer in the learning process. Mass contact methods encompass bulletins, newspaper, literature, internet, radio, television and cinema. These methods cover maximum number of people in the shortest span of time. Different extension teaching strategies have different potential in varying circumstances and at different stages in adoption process (Sim and Hilmi, 1987).

Keeping in view all the above mentioned facts, the present study was planned to find out the effectiveness of various extension methods used by EFS of Rafhan Maize Products Co. Ltd. Faisalabad to provide information to maize growers of Central Punjab.

Materials and Methods

Pakistan is comprised of four provinces namely Punjab,Sindh, Baluchistan and N.W.F.P. (which is now renamed as Khyber Pakhtoonkhwa) (Sharif, 2004).The main operational area of EFS of Rafhan Maize Products is the Punjab province, particularly the Central Punjab, which is comprised of districts of Faisalabad, Toba Tek Singh, Jhang and Okara. Through simple random sampling technique, District Okara was selected as study area. Okara District is comprised of three tehsils i.e. Okara, Renalakhurd and Debalpur. Randomly 40 maize growers were selected from each tehsil to make total sample of 120 respondents. The data were collected with the help of a well structured and validated interview schedule (Wingenbach *et al.,* 2003). A five point Likert type scale was utilized to record the perceptions of the farmers regarding the effectiveness of various extension education methodologies (Linder *et al*., 2003). The collected data were analyzed by using Statistical Package for Social Sciences (SPSS) (Davis *et al.,* 2004). Descriptive statistics were used for analysis of collected data (Bonne *et al.,* 2002).

Results and Discussion

The data presented in table 1 manifest that extension field staff of Rafhan Maize Products is employing variety of extension education methods for information dissemination and technology transfer among farming community.

Results (Table 1)indicate that considering the effectiveness of various extension education methodologies, majority of the respondents used to extension methods such as Group discussion to very good extent (43.4%) followed by Lecture (42.6%). These findings are in complete accordance with those of (Bajwa, 2008).Demonstration was rated as good by (44.0%) of the farmers. More or less similar findings were recorded by (Abbas *et al*., 2008) who found that more than half of the respondents rated Demonstration as good method. Whereas, Telephone call was rated as good by (35.1%) of the respondents. While, Literature, Farm and home visit and Farmer's day were not reported by farmers to be used on large scale by EFS, as 36.1% of the farmers reported Literature as averagely effective, 40.0% of the respondents regarded Farm and home visit as very poorly effective and 37.5% of the growers rated Farmer's day as poorly effective . Sign boards/ slogans, Campaign and Electronic media (Radio and TV) were not found to be used by any farmer.

The weighted score of the effectiveness of extension methods were calculated by multiplying the relative score values allotted to each category of scale with its frequency count. Then mean values and standard deviations were calculated by using SPSS (Table 2).

Table (2) categorically reveals that Group discussion with the weighted scored 482, mean value 4.38 and standard deviation 0.69 ranked first in the ranking of effectiveness of extension methods, followed by Lecture and Demonstration at 2nd and 3rd position, respectively. These findings are in complete agreement with those reported by Bajwa, 2010).

Table 1: Ranking of extent of use of various extension methods/ media used by Rafhan Maize Products Co. Ltd.

Extension methods	Response									
	Very poor		Poor		Average		Good		Very Good	
	No.	%	No.	%	No.	%	No.	%	No.	%
Group discussion	9	7.5	8	6.7	7	5.8	44	36.6	52	43.3
Lecture	6	5.2	5	4.3	14	12.2	41	35.7	49	42.6
Demonstration	2	1.8	2	1.8	12	10.9	48	44.0	45	40.9
Telephone call	14	14.4	11	711.3	24	24.7	34	35.1	14	12.7
Literature	9	25.0	13	36.1	5	13.9	7	19.4	2	5.5
Farm and home visit	14	40.0	5	14.0	10	28.7	6	17.1	-	-
Farmer's day	10	31.2	12	37.5	7	18.8	3	12.5	-	-
Sign board/Slogan	-	-	-	-	-	-	-	-	-	-
Campaign	-	-	-	-	-	-	-	-	-	-
Radio	-	-	-	-	-	-	-	-	-	-
Television	-	-	-	-	-	-	-	-	-	-

(Source: Field data) Very poor=1, Poor=2, Average=3, Good=4, Very Good=5

Table 2: Ranking of the effectiveness of various extension methods/ media

Extension methods/media	Weighted score	Mean	Standard Deviation	Rank order
1- Group discussion	482	4.38	0.69	1
2- Lecture	467	4.28	1.03	2
3- Demonstration	459	4.21	0.85	3
4- Telephone call	314	3.24	1.26	4
5- Literature	88	2.51	1.22	5
6- Farm and home visit	78	2.23	1.17	6
7- Farmer's day	67	2.13	1.01	7
8- Sign boards/Slogans	0	-	-	8
8- Campaign	0	-	-	9
8- Radio	0	-	-	10
8- Television	0	-	-	10

(Source: Field data)

Telephone call got 4th ranking and Literature was rated at 5th place in the ranking order. Farm and home visit and Farmer's day, were ranked at 6th, and7th, respectively. Sign boards/Slogans, Campaign and Electronic media (Radio and TV) were not found to be used by any farmer.

Farmer's inclination towards Group discussion implies that they learn best when they are made participants of learning process in a democratic and friendly atmosphere. The results also show that group contact methods and individual contact methods were ranked highest in the effectiveness of transmission of information to maize growers. This may be attributed to specific characteristics of these methods. It was also revealed that skill is better acquired through group contact methods. Group methods are generally practical-oriented and motivate farmers to take initiative by bringing a desirable change in his attitude. The main function of these methods is to make farmers aware of specific practices and make him realize that practice will result into better outcome. The principle focus of the individual method is to improve co. ordination and interaction with farming community to simulate the adoption of technology by enhancing better understanding. Literature is the only mass media channel which ranked highest in the extent of use and ranked 5th in the effectiveness. The poor outcome of mass media in its effectiveness regarding information dissemination is due to low literacy rate in Pakistan and miserable economic plight of masses to get benefit from mass media. Moreover, Rafhan Maize Products has paid no attention to use Radio and T.V. to disseminate information to farmers.

Conclusions

Based on the study, following conclusions are drawn.
1- Group discussion was found to be the most effective information dissemination extension education method.
2- Lecture got 2nd position in order of effectiveness followed by Demonstration, Telephone call, Literature, Farm and home vist and Farmer's day were rated 3rd to 7th position, respectively.
3- Group contact and Individual contact methods were ranked higest in the ranking.
3-Literature was the only mass media medium used by the EFS and was included in the rank order of effectiveness.
4- Electronic media(Radio, TV and Internet) was not found to be used by Rafhan Maize Products.

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Volatile flavor components of orange juice obtained from major citrus producing cities of Punjab

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Abstract

Orange juice is the most popular fruit beverage worldwide due to its nutritional and sensory properties. Fresh and unique delicate flavor of orange juice is due to the presence of complex combination of several organic components. The following study was aimed to evaluate volatile components of oranges obtained from three major citrus producing cities of Punjab (Faisalabad, Sargodha and Bhalwal). Orange juice was extracted by using rose head machine and different physiochemical tests (pH, Acidity, Brix, Ash, Ascorbic Acid) were performed to evaluate the orange juice. Volatile flavor components were extracted from orange juice by liquid-liquid extraction is the multiple-batch extraction using a separating funnel. Then the quality and quantity of these components was be determined by using GC-FID. There were four major compounds were determine in orange juices that were Carvone, γ–Terpinene, Citronellol, Limonene of different concentration in orange juices.

Keywords: Orange, juice, volatile, flavor, GC

Introduction

Citrus is a common term and genus of flowering plants in the family Rutaceae, originating in tropical and subtropical southeast Asia, it refers to all edible and rootstock species of genus citrus and a few closely related genera of the family rutaceae. Commonly sweet oranges, mandarins, grape fruit, lemon/limes, tangerines, pummelos, kumquats etc. are included in this group.

Citrus is a leading tree fruit crop of world with a production of 105 million tonnes. As in the world, citrus also hold number one position with respect to area and production in Pakistan. Citrus covers an area of 640 thousands hectares with 6.3 million tonnes production in the country. Today Pakistan among the 14 citrus growing countries of the world, producing 167 thousands tonnes citrus on an area of 185 thousands hectares (Anonymous, 2005). Citrus fruit is grown in all four provinces of Pakistan but Punjab produces over 95% of the crop because of its greater population, favorable growing conditions and adequate water. Pakistan contributes 2% share in the total production of citrus in the world (Anonymous, 2007).

The citrus flavor is among the most popular fruit flavors for beverages. The flavor of orange juice has been studied more than that of any other type of citrus fruit. This is partly because the orange juice is the most popular fruit beverage worldwide, and its great demand is a result of its nutritional and sensory properties. Its fresh and uniquely delicate flavor is due to complex combinations of several odour components that have interdependent quantitative relationships (Shaw, 1991; Maccarone *et al*., 1998). Volatile flavor components are the compounds, which are biosynthesized during the normal metabolic process in plants (Orav and Kann, 2001). The major volatile components that impart flavor to orange juices are: Esters, Aldehydes, Alcohols, Terpenes, Terpenols and Ketones (Selli *et al*., 2004).

Volatile components are important contributors to natural orange flavor and aroma (Moshonas and Shaw, 1987). Essential oils from orange peel are the most important and most widely used flavoring ingredients in many foods, beverages, cosmetics and toothpastes (Orav and Kann, 2001). Volatile flavor components are also a component for the pharmaceutical industry for the preparation of medicines and soaps, perfumes and other cosmetics. Volatile flavor components impart different functions in foods: like they make the food tasty, provide pleasure and satisfaction to the consumer, serve as an indicator of stability or shelf life of the food. Antimicrobial activity, anticancer, antitumor and antioxidant effects are also exhibited by volatile flavor compounds (Goff and Klee, 2006). The species of oranges is very diverse and consists of a considerable number of cultivars. Up to now, numerous investigations have been performed aimed at identifying the volatile flavor components of orange juices. One of the reasons for this is the high quality of its flavor (Moshonas & Shaw, 1994). Limonene is the most abundant component of this fraction for all the aromas examined; its contents vary from 63% in the blood orange aroma to about 90% while the remaing compounds found in varying amount (Moufida *et al*., 2003). There has been relatively little information published on location wise determination of volatile flavor components.

Materials and Methods

Procurement of Oranges from three different places (Faisalabad, Sargodha and Bhalwal) of same variety.

Processing of Orange Juice

Fruit was washed in tap water and then was peeled and divided into halves. Fruit juice was extracted using a citrus hand juice extractor. After juice extraction, raw juice was filtered through 8-folded cheese cloth to eliminate particulates.

Physiochemical Analysis

pH measurement

pH was determined by pH meter (AOAC, 2000)

Acidity

Acidity was determined by titration method (AOAC, 2000)

Brix

Brix was determined by hand refractometer (Rangana, 1991)

Density

Density was determined by Pycnometer Measurement (AOAC, 2000)

Ascorbic Acid determination

Ascorbic Acid was determined by titration method (AOAC, 2000)

Estimation of volatile flavor components

Volatile flavor components were determined by GC-FID (Selli *et al.*, 2004)

Volatile flavor components

Extraction Technique

Different extraction methods can be utilized in flavor isolation. The simplest, but quite tedious method for liquid-liquid extraction is the multiple-batch extraction using a separating funnel (Stevenson, *et al.*, 1996) but more specialized equipment may be required depending on the solvents used. Extraction can be done using for example organic solvents. Solvent extraction using for example pentane, diethyl ether or dichloromethane can be best applied to isolate volatiles from some nonfat foods (Stephan, *et al.*, 2000). After that anhydrous sodium sulphate was added to remove the water from the samples, about 5 % of sample. Then keep the sample for 1 hr, so anhydrous sodium sulphate absorbed the whole moisture from the sample. After 1 hr sample was filter through No. 4 Whatman filter paper. The remaining samples were concentrated through rotary evaporator at a temperature of 40°C. That sample was again concentrated by passing nitrogen from it.

Gas Chromatographic method

By far the most used actual analysis method in flavor research is gas chromatography with a variety of detectors. Different kinds of capillary columns are utilized, and often whole column cryogenics, cryogenic traps, or on-column injections are used in conjunction with further enhancement of resolution, especially for lower boiling point volatiles (Stevenson *et al.*, 1996). The most common instrumental detectors for GC analyses are Mass Spectrometry (MS) Flame Ionization Detection (FID).

The flavor components were identified by GC-FID. Agilent Technologies 6890N was used with the DB-Wax column specified as above. The flow rate of helium carrier gas was 1.5 mL/min. The same oven temperature programming as explained above was applied with an injection volume of 1 mL. The on-column injector temperature was programmed to increase from 20°C to 250°C at 180°C/min. Then, it was held at 250°C for 80 min (Schneider *et al.*, 1998).

Statistical Analysis

The data obtained was subjected to statistical analysis by using Completely Randomized Design (one factor factorial) and comparison of means was done by Duncan's Multiple Range Test (Steel *et al.*, 1997).

Results & Discussion

Chemical Composition

The chemical composition of the orange juice is given in Table 1. The data obtained from chemical analysis showed different reading of orange juice taken from different locations. Statistical analysis revealed that the results were highly significant of ash, ascorbic acid, acidity, taste and overall acceptability while the other tests like density, brix, pH, flavor and colour show non-significant results.

Volatile Flavor Compounds

Volatile flavor compounds of orange juices from three different locations were determined through Gas chromatography-Flame Ionization Detector. Four standards were run on Gas Chromatography Flame Ionization Detector that give different chromatograph's retention time of different concentration. After the running of standards juice samples (Sargodha, Bhalwal and Faisalabad) were run on Gas Chromatography Flame Ionization Detector that give different chromatograph's retention time. The concentration was determined through retention time and peak area.

Concentration of standards were observed in different samples like Sargodha, Bhalwal and Faisalabad orange juices showed the concentration of Limonene respectively was 13262.57, 11631.98 and 15520.505.where as γ–Terpinene concentration was 45.116, 61.99 and 44.64 respectively. Citronellol concentration was 0, 55.60 and 37.55 respectively. Carvone concentration was 169.68, 179.82 and 115.31 respectively. These results are in close confirmatory with findings of (Selli *et al*., 2004).

Table 1. Mean values of Physicochemical analysis in T1, T2 and T3

Physiochemical Test	T1	T2	T3
Acidity	1.351	1.354	1.304
pH	3.730	3.713	3.720
Brix	12.500	12.333	13.000
Density	1.054	1.054	1.055
Ascorbic Acid	33.83	32.44	38.36

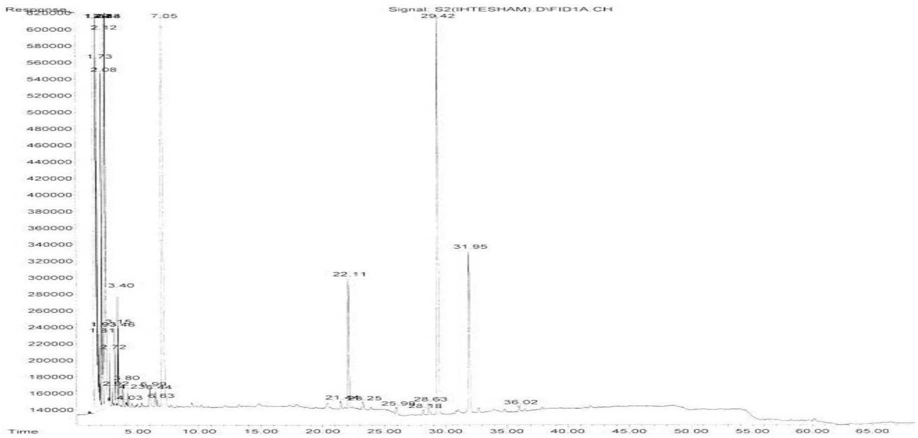
T1= Sargodha, T2= Bhalwal, T3=Faisalabad

Table 2 Retention time (R.T) of standards used in Gas-Chromatography

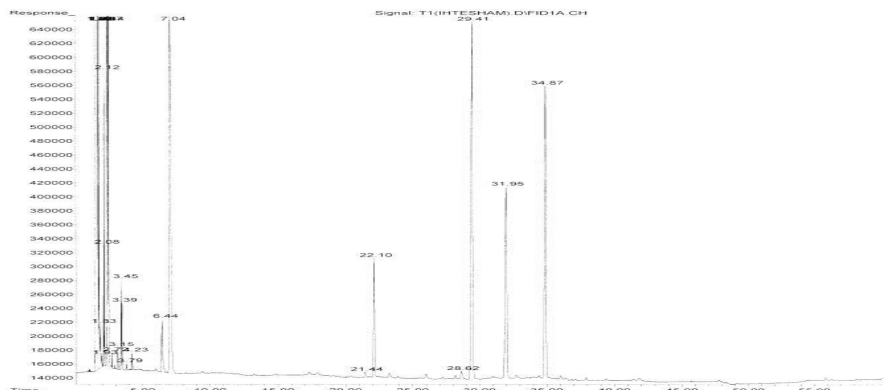
Volatile Flavor compounds	R.T (Minutes)
Limonene	6.93
γ -Terpinene	6.39
Citronellol	35
Carvone	32.08

Table 3 Concentration of standards that are present in orange juice samples.

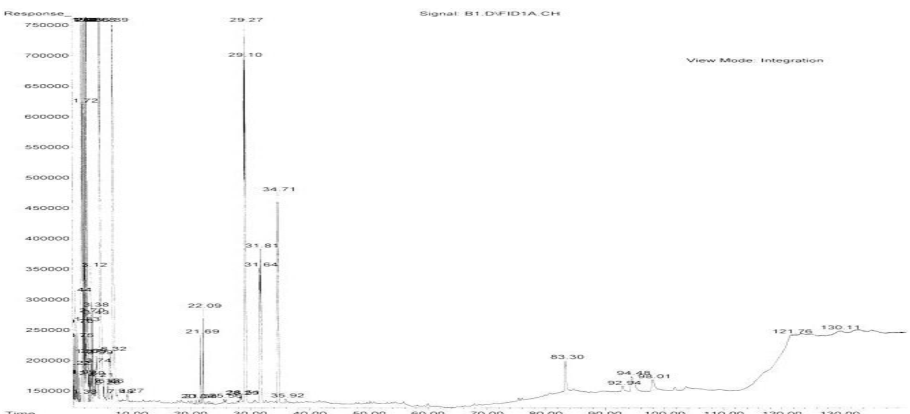
Volatile Flavor compounds	Sarghoda (µg/L)	Bhalwal (µg/L)	Faisalabad (µg/L)
Limonene	13262.57	11631.98	15520.50
γ -Terpinene	45.116	61.99	44.64
Citronellol	ND	55.60	37.55
Carvone	169.68	179.824	115.31



Chromatograph of orange juice sample obtained from Sargodha.



Chromatograph of orange juice sample obtained from Faisalabad.



Chromatograph of orange juice sample obtained from Bhalwal.

Conclusion

The data obtained from chemical analysis showed different reading of orange juice taken from different locations of Punjab. Statistical analysis revealed that the results were highly significant of ash, ascorbic acid, acidity, taste and overall acceptability while the other tests like density, brix, pH, flavor and colour showed non-significant results. Volatile flavor compounds of orange juices from three different locations show minute difference in concentration.

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Exploring the extrusion cooking behavior of Maize-A Review

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Abstract

Maize has significant importance in the countries, where rapidly increasing population has already outstripped the available food supplies. Extrusion technology has been around for a long period of time in one form or another in many food industries Extrusion cooking is a quite latest form of food processing. Extrusion is exploited for the manufacture of ready to-eat cereals, snacks, and food additives with diverse swelling properties. The majority of the research on the thermo mechanical behavior of these materials concerned the variation of starch. Extrusion cooking is progressively more being used for production of a wide range of snack foods and breakfast cereals. Extrusion is an ultimate technique for producing a variety of extruded products such as snacks and breakfast cereals. Extrusion processing conditions (moisture content, low residence time and low temperature) help advanced preservation of amino acids, high protein and starch digestibility, and reduce lipid oxidation, higher retention of vitamins and higher absorption of minerals. Extrusion processing parameter Screw speed, temperature and moisture content has considerable effect on the physical properties of extudates and sensory properties of maize extrudates. No matter what the future convey, it's simple to see that, from simple corn puffed snacks and balls to complex filled products, extrusion give the snack-food producer a flexibility and variety of processing technologies.

Keywords: Extrusion, Maize, consumers, emerging technologies, food processing

Introduction

Maize (*Zea mays.* L) or corn instigate in middle Mexico about 7000 years back, starting from teosinte (*Zea mays* parviglumis) that will be cultivated. Maize is the member of the subfamily Panicoideae in the family Gramineae. The maize utilized around the world differs, range from cooked immature grain to processed kernels. A number of million people, mostly in the developing countries, meet up their protein and calorie necessities from maize. The maize grain accounts for about 15 to 56% of the total daily calories in diets of people in about 25 developing countries where animal protein is scarce and expensive and consequently, unavailable to a vast sector of population (Prasanna *et al.*, 2001). The major uses of corn are: as food and as raw material for industry.

The maize utilized around the world ranging from cooked unripe grain to processed maize products (Bressani, 1991). In its diverse development forms maize is a vital food for great numbers of people in the developing world, providing considerable amounts of energy and protein. Maize is used in a large range of products around the world such as tortillas, tortilla chips, corn snacks, and others. Tortillas are flat breads made from either corn or wheat (Tia, 2003).Maize is a main cereal grain which is cultivated worldwide and position second only to wheat in overall production area and stand second to rice in total production (Fuhrmeister *et al*,. 2003). Maize is of great significance in the human food and animal feed in various parts of the world (Pereira *et al.*, 2008). The maize grain, like other cereal grains, comprise pericarp (6%), endosperm (82%) and germ (12%) (Prasanna *et al.*, 2001). The amount of protein of various maize cultivars is reported as 6–12% (Chanvrier *et al.*, 2005).Protein quality of maize is similar to wheat or sorghum (Boyer and Hannah, 2001) Maize proteins, like other seed proteins, may be categorized with respect to solubility of protein as described by Osborne into the albumins, globulins, prolamins and glutelins (Taylor and Belton, 2002). The proteins of the grains are usually ranked based on their solubility in number of solvents. The albumins and globulins both build up about 19% of total protein in maize flour. But, the percentage of these proteins is greatly lesser in the endosperm, about 3.5% in maize grain (Yau *et al.*, 1999).

The most important chemical constituent of the maize grain is starch that gives up to 72 to 73% of the kernel weight. The chemical properties of maize starch have been deeply investigated due to its extensive utilization in food. Most of 80% of the entire global production of starch come up to from maize (Boyer and Hannah, 2003). In maize with high amylose contents can range from 50 to 80%. A variety of types of modified starches produced from maize that comprises distinctive properties which dissimilar from native starch. The characteristics of these starches differ extensively, and may demonstrate valuable in some example for the production of gluten-free foods. Various types of corn posses' various extent of horny and floury endosperm. The floury endosperm is softer and easier to break than the horny endosperm (Sandhu *et al.*, 2007). Different types of maize can be differentiating on the base of endosperm and grain composition (Dhanasekharan *et al.*, 2003).

Hard endosperm contains compact, polygonal starch granules, with abundant, directly associated protein matrices. In soft endosperm, starch granules are larger and less aggregated. Good qualities of expanded products are achieved like snacks foods, and many breakfast cereals by the use of greater-shear force extruders. The physical properties of the corn extrudates are a sign of the efficiency of the extrusion cooking process and suitability of raw material constituent. However, food extrusion study was being performed more than 50 years; there are a number of deviations in the way of assessment of the characteristics as well as difference in sample size for determining them.

Extrusion an emerging Technology for Maize processing

Extrusion technology has been around for a long period of time in one form or another in many food industries Extrusion cooking is a quite latest form of food processing. Forcing material in the course of a hole is the process of extrusion. During the 1930s heat was provided to the barrel include the screw; puffed corn curl snacks resulted product. The pressure produced as the ingredient moved beside the screw; this, collectively with the heating under pressure caused the corn to expand on exiting the dies. Since extrusion cooking processed more types of food, extruders became more particular for food use.

Extrusion cooking can formulate customary product to be more suitable in the swift changing society. Starch is generally the key food ingredient in extruded foods such as breakfast cereals, snacks and weaning foods. Humans do not readily digest native starch. Distinct several thermal processes, extrusion cooking gelatinizes starch fairly low (12-22%) moisture level. Increased temperature of barrel, shear force and pressure in extrusion raise the level of gelatinization of starch, but lipids, sucrose, dietry fiber and salts can impede gelatinization (Jin *et al.,* 1994). While full gelatinization may not occur through extrusion, digestibility is frequently enhanced (Wang *et al*., 1993). Extrusion may progress protein digestibility by denaturing proteins, revealing enzyme-accessible sites. Enzymes and enzyme inhibitors mostly lose action due to denaturation (Della Valle et al, 1994).

There is a need to make use of locally-grown crops to produce of suitable local recipes in the under developed countries has been tense by international agencies as the most efficient channel for addressing depending world food harms (Iwe *et al.,* 2001). Maize is the cereal of major importance in the developing world and has the maximum genetic production potential of all the cereal crops. Global grain production of maize is about 600 million tons a year (Pingali, 2001). In the year 2002, maize was the most important cereal crop with 29.7% of the world cereal production after rice and wheat (FAOSTAT, 2003).).Maize processors have long described that flint type of maize cultivar show more expansion during extrusion cooking. It has also been found that endosperm protein composition is highly related with maize grain flintiness (Eyherabide *et al.,* 1996).

More to the point being a key basis of food for human beings, maize also utilized as feed for livestock and as raw materials for industries for the manufacturing of many food and non-food products. Designing extruded snack foods today can be a difficult process to meet up varying consumer's tastes and demands. The consumer's requirement for "good for your health" and "distinctive flavor" extruded snacks leads to the indefinable exploration for something exceptional that also demand to a extensive range of peoples. Food extrusion is an energy-efficient process for the reason that a considerable quantity of mechanical energy from the drive motor and thermal energy system is degenerate as the extruder screw is in motion the gelatinous material within the barrel. Energy necessary to revolve the extruder screw can be expressed in terms of torque such that products involving greater demand of energy are more costly to process (Titus and Maduebibisi, 2007).

Advantages of extrusion are adaptability, product shapes, high product quality, energy competence, production of new foods, and no effluent or waste material. Many ordinary snack foods are fried, making them high in fats while extruded snack foods are mostly not fried. Due to this an extruded snacks also well for health (Riaz, 2000).

Extruded foods are composed mostly of cereals, starches. The most important role of these constituents is to provide structure, texture, mouth feel, bulk density and different properties desired for specific finished products.

Consumer demand

Consumer acceptance of extruded foods is largely due to the ease, value, eye-catching look and texture found to be exacting for these foods, particularly when it concern snack products (Anton et al 2008).While corn starch provides all the features for manufacture of greatly suitable extruded snack foods, its nutritional worth is far from pleasing the needs of health-conscious customers. Extrusions study continually focal point four different variables, while selection study performed to categorize important factors. These factors such as screw speed feed moisture contents and barrel temperature as principal factors which determine a secondary factors: specific mechanical energy (SME), product temperature (PT) and pressure (Meuser and Van Lengerich, 2003). These factors affect the viscosity of food in the extruder barrel, the residence time of the raw material in the extruder, and the shear force used for the food. Deviation caused by composition of feed material and preceding processing of the feed materials is vital base for experimental variation. Mostly in the snack food industry, extrusion was explained as a multifaceted technique which is different from straight processing technique with elevated shear rates and high temperatures (> 150°C) for very short time (seconds). A large variety of mechanical and thermo-chemical reaction were concerned, with shear, maillard reactions, protein denaturation and hydrolysis. These processes end result in the physical, chemical and nutritional modification of food ingredient during extrusion (Jowitt, 2002).

Low moisture extrusion is frequently used to make breakfast cereals and snack foods. Many variable process parameters affect the extrudates of both twin screw and single screw extruders. Variables which can be modified by using a single screw extruder and controlling the parameters like speed of screw, feeding rate, moisture contents and temperature of extrusion (Nelson, 2003) Both the expansion and structure of food ingredients depend on starch gelatinization that was affected by extrusion processing conditions (i.e., moisture content, screw speed, temperature) and composition of raw material (Chinnaswamy and Hanna, 1991). Different high-temperature-short-time extrusion techniques had been used to get the optimum expansion of raw material like starches and cereals. But, all cereals and starches do not expand equally, due to the variability in raw material quality and composition and extrusion process variations (Rangan, 1993).

Maize Extrusion

The maize grain is changed into vital foods and industrial products by dry milling and wet milling process. The dry milling produce grits, meal and flours as major products. The wet milling process produces starch and other vital resulting products Maize by means of less test weight frequently has an inferior percentage of hard endosperm; therefore it give a lower yield of principal, large grits when milled. Robutti *et al.,* (2002) studied that the maize endosperm hardness related to the maize grain chemical composition. Hardness of endosperm cause compacted, polygonal starch granules, with rich protein material. In softness of endosperm cause the starch granules to be larger and show less aggregation. Maize grits were the core raw material for the manufacturing of expanded corn snacks. Grits from harder maize are preferred to use by Processors, because of the improved texture of the product obtained as compared to softer maize grits (Robutti *et al.* 2002). Maize grain contain different ratio of hard and soft endosperm. Cultivars of maize with almost all hard endosperm are called "flint" maize, and those with soft endosperm are called "Dent" maize. "Dent" maize cultivars differ in ratio of hard and soft endosperm. The percentage of hard-to-soft endosperm can also differ due to genotype difference, or environment (Pomeranz *et al.,* 1984).Sandhu *et al.,* (2007) reported that yellow corn consist on a horny endosperm, and extra carotenoids contents (74–86%), that impart yellow color in corn, while the floury endosperm (9–23%). Hardness and breakage propensity are allied properties which affect the use of corn. changes solubility of protein. Grits from harder maize and extrudates from harder Quality characteristics of maize cultivars which may help breeders to develop cultivars best adapted to diversified extrusion conditions. Extrusion cooking changes protein hydrophobicity and level of aggregation, conversely variation between the maize cultivars. The maize kernel hardness is an important economic trait. Enough hardness is essential to keep kernel integrity all through mechanical harvesting, while being handled during marketing and in storage (Anderson et al 1991).

Maize cultivars that have large proportion of hard endosperm are best suited for dry milling process as they give better production of excellent flaking grits.

Grain hardness is a vital grain quality feature which had a great role in the processing of maize grains and in the final-use quality of maize grain based products like snack foods (Bettge and Morris, 2000).Under the processing circumstances of their study, maize grits of harder texture show more expansion, use a lesser amount of energy during extrusion, and cook more quickly than the maize grits of softer texture. The variation in product quality characteristics is related to conflicting protein contents and textures of endosperm of maize cultivars (Robutti *et al.*, 2002). Sandhu *et al.,* (2007) studied that the protein was the major factor in grain hardness as it comprises a matrix contiguous and embedding of the granules of starch. Hardness of grains reason of the deposition of prolamins and antifungal proteins in larger quantity than softer maize grains. Sandhu *et al.,* (2007) found that the area of hard endosperm in the corn grain have a larger alpha and gamma zein protein. Pratt *et al.,* (1995) reported that the hardness of endosperm in maize and sorghum are strongly associated mutually with protein composition and protein content. The most rich endosperm proteins of maize and sorghum are the prolamins that are further divided into subclasses based on solubility, structure, and amino acid order. Pratt *et al.,* (1995) studied the interaction among the prolamin subclasses and hardness of grain and also described that the vitreous endosperm of maize grains is greater in total protein and total prolamin, whereas the floury endosperm is more affluent in γ-prolamins in contrast to vitreous endosperm. Two maize-grits samples were obtained from a yellow dent and a white flint type of maize at different temperatures, 150 and 180°C and at different moisture content. These grits samples were extruded using a Brabender 10 DN extruder. The end result of extruded product showed that more expansion and higher cooking degrees for white flint maize samples. Flint type of maize had the harder texture as compared to dent type of maize. The grits from flint type of maize, shows better expansion values with higher level of extrusion cooking and minimized the mechanical resistance, that result in improved product texture, hence sustaining the first choice of the snack industry for flinty maize grits, It was valuable to note that the diversity in texture hardness of two maize grits shown under study were generally originate between commercial maize cultivars (Rolando et al. 2004). Maize grain hardness and extruded characteristics of puffed snacks were significantly associated. Physical properties of maize grains were associated with total amount proteins in maize grain and zein protein subclasses. The extrusion cooking extensively maize show higher level of amylose content, less extent of starch damage, and disintegration at deviating screw speeds than grits from softer maize and its extrudates (Lee *et al.,* 2006).

Liquefy expansion was seen by extrusion cooking when maize grits were extruded. During extrusion it was observed that the expansion process was strongly reliant on the geometrical properties of the inserted die, and principally on the diameter of the inserted die. During extrusion, starch molecules can be physically broken into smaller, more digestible fragments. For example, amylopectin branches can be sheared off the main molecule, with larger molecules experiencing the greatest effect (Politz et al 1994b). Screw configuration using more reverse and high shear elements favor starch breakdown (Gautam and Choudhoury, 1999).Lower molecular weight starches fragmentation may be sticky, thus raising the possibility of dental caries, since bacteria in the mouth rapidly ferment this dextrin. Toothpick, the amount of material hold on to on teeth, has been used as a sign of the harshness of extrusion processing. By combining the both, shearing and heat treatment in extrusion was result in the gelatinization of granular starch, disintegration of protein structure and the development of complex among starch, lipids and proteins. Food extrusion is an energy proficient method because a significant amount of the mechanical energy drive from motor is degenerate in the gelatinous flow within the channel of the extruder screw (Lai and Kokini, *1991)*. Longer cellulose fiber added to corn starch reduces starch solubility (Chinnaswamy and Hanna, 1991).

The density, porosity and expansion of extruded products were found to be reliant on raw material moisture content, residence time during extrusion and temperature of cooking Water is an vital reaction associate in gelatinization and plays one of the key roles in scheming extrudates expansion (Thymi, et al, 2005) Effect of different moisture level on expansion of extruded snacks heavily investigated and They reported that elevated moisture level during extrusion cooking reduce the radial expansion of product and also cut volumetric expansion (Singh *et al.,*2007).High level of feed moisture raise bulk density of the extrudates Foods that have less moisture contents be liable to be extra gummy, consequently, the pressure degree of difference would be minor for higher moisture extruded foods, primary to a lesser amount of expanded product. The raise in moisture level at the similar extrusion temperature, decrease the degree of starch transformation and improved the visible density significance At little moisture levels a considerable structural breakdown of the starch granules occur indicative of a significant alteration in the molecular structure of the starch (Lin *et al.,* 2000). Speed of screw had no considerable influence on the bulk density, specific length, and expanded ratio of product. Increased product temperature was due to decrease in moisture content of raw material and by increasing screw speed that was greatly associated with quality of an expanded product. By an elevated screw speed and a high product temperature, specific corn allied flavors were developed. Extrusion processing conditions and ingredient characteristics affect the extrudates physical and chemical properties. These influences were significantly studied (Singh *et al.,* 2007). Studied effects comprises that the extrusion cause the destruction of anti nutritional components of food, gelatinization of starch, increased soluble dietary fibers and decrease the lipid oxidation. On the other hand, maillard reactions during extrusion, among protein and sugars lessen the nutritional significance of the protein. High moisture content, small residence time and low temperature enhance the nutritional value, while increase extrusion temperatures (200°C) low moisture contents (<15%) and variable composition of raw material can damage nutritional value.

Moisture content in the range (21-23%) and adding of soybean flour (0-40%) prove important influence on the texture of the extrudates. Addition of soybean flour in the range from 0 to 40% improved the expansion ratio, reduces the hardness and changes the specific volume and chew ability of the extrudates. Higher the moisture content from 21 to 23%, result in decreased specific volume, and increased the hardness of the extrudates (Siquan *et al.,* 2005). Plahar *et al.,* (2003) make a standardized extrusion cooking process for manufacture of a good protein contents weaning food found on peanuts, maize and soybeans. Consequences described that bulk density and hardness improved at the same time as expansion reduce with raise in feed moisture level. At a set series of moisture level, bulk density of extruded food product and firmness reduce whereas expansion improved by means of escalating extrusion temperature. For most excellent product quality extrusion processing conditions established were mix together formulation of 75 % maize, 10 % peanut and 15 % soybean: mesh size of 300-400 μ, speed of screw 500 r. p. m., feed rate of 4.6 kg/min, moisture level of 16–18 % and extrusion cooking temperature of 100°C-105°C.

Diverse extrusion processing conditions such as screw speed, moisture contents, and temperature alter the physical properties of extrudates like expansion ratio, bulk density and level of betaglucan. Reducing sugars like glucose and lactose take part in Maillard reactions. The shear forces in extrusion can also produce reducing sugars from complex carbohydrates as well as from sucrose and other sugars (Noguchi and Cheftel, 2002).Whereas sucrose contents loss may affect color of the product and flavor, there is an chance to decrease the amount of indigestible oligosaccharides that result in flatulence. Sucrose, raffinose and stachyose reduce extensively in extruded product. (Borejszo and khan, 1992). Corn soy snacks have inferior degree of both stachyose and raffinose compared to unextruded soy grits and flour, but value were not accurate for the 50-60% corn present. Starch and stachyose were lesser in quantity in extruded peas compared to raw peas (Alonso *et al.*, 2000), but an enhance in total free sugars did not fully account for these sufferers. Addition of sucrose in different concentration levels 0 and 12.5% by weight to corn grits prior to extrusion largely affect the textural properties of corn extrudates. The effects of sucrose on texture of the end products were;

1. The internal structure and cell size of extrudates reduced by adding sucrose.
2. The crispness of products evaluated by puncturing increased with the sucrose content until an optimum whatever the flour.
3. The addition of sucrose in corn reduced overall product expansion
4. Increasing the amount of sucrose in the mix induced greater molecular degradation of corn starch (Mezreb *et al.*, 2006).

Food extrusion has advantages such as versatility, high productivity, flexible, multifunctional, low cost, product shapes, high product quality, high nutritional value, energy efficiency, production of new foods, shelf stability and no effluents or waste (Zasypkin *et al.*, 1998). Cooking of ingredients during extrusion leads towards gelatinization of starch, denaturation of protein, inactivation of raw food enzymes, destruction of naturally occurring toxic substances and diminishing of microbial counts in the final product elevated barrel temperature, small moisture and high shear increased the Maillard reactions. Browning can take place yet when reducing sugars are excluded from recipe for the reason that new reducing sugars may be produced from breakdown of sucrose, starch and other polysaccharides. (Bates *et al.*, 1994). Lysine can be conserved, yet, if extruder processing conditions and recipe are cautiously balanced. Corn-soy blends extruded for reconstitutions as porridge lysine preservation (Konstance *et al*., 1998).

Extrusion cooking also develops the nutritional value of foods by demolish various natural contaminant and anti nutrients. A problem present as to whether it is necessary to eliminate these compounds. Enzymes inhibitors, and other compounds like, saponins and other compounds may possibly mess up growth in children, but these similar compounds may propose protection against chronic diseases in adults.alergens and mycotoxins are extremely challenging to thermal processing, but extrusion with chemical treatment via reactive extrusion may successfully lower these compounds to secure levels.Microwave cooking in contrast with other processes their effect on anti nutritional factors like phytic acid, tannins, trypsin inhibitors was studied (Habiba, 2002).Extrusion Cooking decreased phytic acid and tannin contents. Regular cooking, that receive much time, was most valuable in reduction of phytic acid contents upto (47.9%), whereas microwaving heating provide the maximum reduction (25.7%) in pea tannins.It has been demonstrated that various anti-nutritional factors can be destroyed during extrusion. Nawab (2006) studies that the extrusion cooking of maize for the manufacture of a variety of conversational products cause in the reduction of phytic acid contents. Fresh mature maize grains have a smaller amount of phytic acid. The reduction of phytic acid contents differs from 18.1 to 46 percent for fresh maize and from 11 to 52% for dry maize correspondingly for the duration of extrusion cooking. Abd El-Hady and Habiba (2003) proposed that extrusion process has been an effective solution to improve the digestibility and remove the anti-nutrients at the same time. Mukhopadhyay *et al.* (2007) optimized the values of the extrusion process variables like barrel temperature (82°C), extruder speed (90 rpm) and oilseed moisture content (41.22%) for linseed tannin detoxification founded to be 61.25%. Wu *et al.* (2008) investigated the optimized results, including the temperature (146.0 ºC), the feeding rate (60 kg/h) and the screw speed (152.5 rpm) for the removal of HCN (84.38%) in flaxseed. Killeit (1994) study that vitamin preservation in extruded foods. Further study on the bioavailability of added and endogenous vitamins is required, principally in light of strengthening programs for folate and new vitamins Lasekan *et al.*, (1996) investigated the effect of extrusion process on the nutritional worth, storage stability and sensory characteristics of an native maize-based snack food. Product was evaluated for existing lysine loss, protein dispersibility index, variation in total carbonyls (lipid oxidation) and sensory characteristics during storage (at 25, 30 and 40 °C). Extruded product suffered little loss (10%) in available lysine but had an significant decline in protein dispersibility. In addition, high storage temperature (40 °C) extensively decreases the sensory acceptance of the maize-based puffed snacks.. Concern of abridged vitamin levels exclusive of impediment some producer to use vitamins before extrusion. Current study has focused on vitamin stability during extrusion (Marchetti *et al.*, 1999). Vitamins like D and K are quite stable during extrusion processing conditions, but are not used in several extruded human food products. Vitamin E and related tocopherol act as mutually vitamin and antioxidant during extrusion. Gamma and delta tocopherols lost upto (40%) while alpha and beta forms of tocopherols lost (23-28%) (Suknark *et al.*, 2001). Tocopherol present in rice bran gets lower at higher extrusion temperature (Shin *et al.*, 1997)

The preservation vitamins of B Group throughout extrusion cooking were compared with the other cereal and under diversified extrusion conditions in a single screw extruder).By Using single screw extruders, Lorenz and Jansen (2007) study that preservation of over 90% for thiamine, riboflavin, vitamin B_6 and folic acid in corn snack that are processed at higher temperature. The results prove that short barrel extruders employ for snack production preserve the B group vitamins between 44% and 62%. This is significantly higher than the 20% preservation for maize described formerly for long barrel extruders. Only the Thiamin was lost during extrusion cooking (Athar *et al.* 2006). Phytic acid contents were in the form of phosphorus in various cereals. It is an anti nutritional factor, because it makes unavailable other nutritionally important cations. Consequently, there are evident reasons for lowering the level of phytic acid in the snacks (Feil, 2001) Mineral and their bioavailability are usually maintained during extrusion cooking.while corn meal, that has small dietary fiber content, had no vary in total, component, (Camire and Dougherty, 1998). Extrusion somewhat higher the iron accessibility in corn snacks (Hazell and Jhonson, 1998). . Snacks prepared from maize on a single screw extruder had adequate textural characteristics with additional calcium hydroxide levels of 0.02-0.078% (Zazueta-Morales et al, 2001). The equipment must be replaced and refurbished periodically due to this wear, as the metal accumulates in the extruded food. Extrusion cooking performance and product properties of flint type of maize and sweet corn grits was seriously effected by moisture contents temperature of extrusion and screw speed. Moisture contents demonstrate the most prominent effect on die pressure, expansion ratio and Water Solubility Index. Die pressure of the extruder was extensively greater for sweet corn than flint type of maize grits. The grits from both types vary greatly with respect to extrusion response and final product quality under same extrusion conditions. High screw speed and temperature produce extrudates with better expansion and less degree of bulk density (Gujral *et al.* 2001).Extruded product density and expansion ratio reliant on moisture content, screw speed and temperature. More distinctively, the obvious bulk density of extrudates had an increasing development with moisture content and residence time, whereas it reduces with temperature of product. Porosity and expansion ratio of extrudates reduced a lot with feed moisture level and residence time, (Thymi *et al*., 2004). Gujska and Khan (1991) study the effect of moisture in raw material on functional properties and trypsin inhibitor behavior of extruded bean high starch fractions. For all beans, water solubility index reduced with increasing moisture level. Color of extrudated product was also affected by moisture level of material. The extrusion cooking decreased trypsin inhibitions activity about 70%. The reduced level of this anti nutritional factor was accessed by moisture content of raw material and temperature during extrusion cooking.

Bhatnagar and Hanna (1994) performed extrusion of the normal corn starch having 25 % amylose with and exclusive of stearic acid and at different combination of barrel temperatures, screw speeds, and moisture levels. The existence and quantity of starch-stearic acid complexing was measured using iodine binding capacity. Utmost complexing was reported at 110-140 °C barrel temperatures, 140 r. p. m. screw speed, and 19 % moisture. Physical properties (expansion ratio, bulk density) of extruded starches were also estimated. Gujska (1991) deliberate the mechanical properties of cereal extrudates which were professed by the absolute consumer as criteria of quality. They scrutinize one of the significant characteristics of extrudates, mechanical hardness, which is one of the foremost texture properties. Textural properties has a control on taste sensory evaluation, and thus on the suitability of the product. Characteristics which have enormous effect on acceptability are crispness, flexibility, hardness and softness. These characteristic are only just associated to, and affected by, the process variables. Factorial experimental design was applied to study the effect of temperature of expansion, screw speed, moisture content and feeding rate, and their relations, on the mechanical hardness of extrudates. Moisture content, screw speed and temperature are to initiate manipulate, while feed rate does not have considerable effect on extrudates hardness.

Conclusion

Despite the fact that extensive work been done in the area of extrusion in general, and extrusion expansion in particular, this complex field carry on to some degree to dexterous art rather than a apparent science. There are many areas that require further research regarding extrusion and nutrition. Very little has been published on the effects of extrusion on photochemical and other healthful food components. Prospect study may be focused on the association between compositional changes on product worth together with dietary and sensory characteristic. High moisture extrusion and utilize of with a reduction of reactive sugars may developed an innovative contour of research objectives.

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