

Optimization of process temperature and brine concentration for canning of Desi and Kabuli type chickpea

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CERTIFICATE – II

*This is to certify that the thesis entitled “**Optimization of Process Temperature and Brine Concentration for Canning of Desi and Kabuli Type Chickpea**”. Submitted by **Mr. Milind Madhavrao Patil** to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, in partial fulfillment towards the requirements for the degree of “**MASTER OF SCIENCE**” in **Agriculture (Food Technology)** JNKVV, Jabalpur has been, after evaluation, approved by the External Examiner and by the Student’s Advisory Committee after an oral examination on the same.*

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LIST OF ABBREVIATIONS

%	-	Percent
i.e.	-	that is
ha	-	hectare
viz.	-	which is/ are
mm	-	millimeter
cm	-	Centimeter
ml	-	Mililiter
g	-	gram
S	-	Satisfactory
N	-	Normal
No.	-	Number
<i>et al.</i>	-	co-workers
w/v	-	weight/volume
°C	-	degree centigrade
hr.	-	Hour
min	-	Minute
X ₁	-	Holding time
X ₂	-	Brine concentration
X ₃	-	Blanching time
YD	-	Response for Desi chickpea
YD ₁	-	Length desi type chickpea
YD ₂	-	Thickness
YD ₃	-	Weight
YD ₄	-	Moisture
YD ₅	-	Fat
YD ₆	-	Carbohydrate
YD ₇	-	Ash
YD ₈	-	Acidity
YD ₉	-	Total sugar
YD ₁₀	-	Total phenol
YD ₁₁	-	Colour
YD ₁₂	-	Taste
YD ₁₃	-	Texture
YD ₁₄	-	Drain weight
YD ₁₅	-	pH content
YD ₁₆	-	Head space
YD ₁₇	-	Vacuum
YD ₁₈	-	CFU Per ml
YK	-	Response for Kabuli chickpea
YK ₁	-	Length kabuli type chickpea
YK ₂	-	Thickness
YK ₃	-	Weight
YK ₄	-	Moisture
YK ₅	-	Fat
YK ₆	-	Carbohydrate
YK ₇	-	Ash

YK ₈	-	Acidity
YK ₉	-	Total sugar
YK ₁₀	-	Total phenol
YK ₁₁	-	Colour
YK ₁₂	-	Taste
YK ₁₃	-	Texture
YK ₁₄	-	Drain weight
YK ₁₅	-	pH content
YK ₁₆	-	Head space
YK ₁₇	-	Vacuum
YK ₁₈	-	CFU Per ml

INTRODUCTION

Chickpea (*Cicer arietinum* L.) commonly known as Bengal gram belongs to family, leguminosae and sub family papilionaceae. Chickpea is believed to have originated in south-eastern Turkey and the adjoining northern region of Syria and spread to other parts of world. Chickpea has been recognized as a valuable source of protein, vitamins and minerals in human diet and occupy a very important place in human nutrition in many developing countries. On an average, Chickpea seed contains 23% protein, 64% total carbohydrate, 47% starch, 5% fat, 6% crude fibre, 6% soluble sugar & 3 % Ash (www.newcrops.uq.edu). The chickpea is also rich source of probiotics substances. The desi chickpeas have markedly higher fiber content than Kabuli and hence had a very low glycemic index which makes this pulse suitable for the people with blood sugar problem (David 2008). Chickpea protein is rich in lysine and arginine but most deficient in the sulphur containing amino acids, such as methionine and cystine. In addition to carbohydrates and vitamins, chickpea is also a good source of micro and macro mineral such as phosphorus, potassium, magnesium, iron and zinc.

In India two major types of chickpea are cultivated i.e. Desi and Kabuli chickpea. Dried, Desi chickpea is used in the form of whole seeds, dehulled splits (Dhal) and refined flour (Basen) made from chickpea dhal, while Kabuli chickpea (white to cream seed coat) is generally used as whole grain in India. At green stage of crop, the grains of desi and Kabuli chickpea are also consumed as a fresh green seed (Boots) or green roasted/baked grain.

In the last couple of years it has been observed that nutritional awareness of consumer towards the consumption of green chickpea (Boots or Hara chana) has been increased. In accordance with the consumer demand crop breeder have evolved new high yielding variety a chickpea cultivar named as hara chana. This cultivar has unique

feature of persistence of green seed coat colour after harvest, high protein and carbohydrate content.

The harvest and post-harvest losses in cereals, pulses and oilseeds crops are too many. According to an estimate every year 10-12 percent of food grains are lost for want of processing. Every year huge stock of green chickpea and kabuli chana remains unutilized and untraded. Under extreme circumstances farmers sale out there green produce at a very low cost. In order to minimize losses, value addition and provide good remunerative prize to farmers, the canning of green chick pea (Hara chana) raw material is one of the most affective processes to extend the shelf life of product. This process offers the advantage of long term preservation, convenience in handling, storage, marketing consumption of food product. Apart from above Freeze-drying, Control Atmospheric Storage, IQF freezing technologies are also available. However, these are costlier technique than any other conventional method. Looking for the cost factor and quality of product the entrepreneurs prefers canning technology for production of food products.

Global demand for high quality canned food made from indigenous material like hara chana have been increased in last few years, as a result of which of food processing industries have come up. These food-processing industries use conventional raw material and methods to produce canned products, which are of not high quality in terms of their physical, chemical and sensory attributes. To standardize them, the information on canning technology of green chickpea for optimum conditions of processing time, brine concentration, blanching time and their effect on physical properties, chemical composition and sensory quality attributes of canned products are meager. Therefore, the present investigation entitled "Optimization of process temperature and brine concentration for canning of Desi & Kabuli type Green Chickpea" has been planned with following objectives.

Objectives

1. To study the physical properties and chemical composition of Desi and Kabuli type chickpea at green stage.
2. To standardize the levels of processing temperature for canning of hara chana (Desi) and Kabuli type chickpea at green stage.
3. To standardize the level of concentration of brine solution for canning of hara chana (Desi) and Kabuli type chickpea at green stage.
4. To evaluate the physical properties, chemical composition, microbiological, sensory quality during storage of canned desi and Kabuli type chickpea.

REVIEW OF LITERATURE

The past experience is essential to have an introspective view in the research. Keeping this idea forth, an attempt has been made in this chapter to present the available review of literature related to present status of chickpea production, physical properties, proximate composition of chickpea, canning technology and effect of processing parameters of canning on quality of canned product. The available literature has been summarized and presented as under.

2.1 Present status of chickpea production in India

Grain legumes, interchangeably referred as pulses in the Indian sub-continent, occupy an important place in human nutrition. They are the variable sources of proteins, minerals and vitamins in the daily diets of the people, particularly of the low income group. In India, it is the major pulse crop from the production and consumption point of view. It is processed and used in many forms and is popular with all sections of the population in the Indian sub-continent, because of its taste and flavour. It is processed by boiling, roasting, canning and used in many forms. The pulses varied within all sections of the population in India because of its taste and flavour. Dhal and other food items are prepared from besan (dhal flour) that are major dietary items in India, Pakistan and Bangladesh. The kabuli type chickpea is most popular for canning purpose.

Jambunathan and Singh (1990), Khattak *et al.*, (2008) reported that Chickpea is the most important food legume of dryland agriculture. Singh (1995) reported that, India alone contributes nearly 75% of the world production of chickpea. Chickpea is currently grown on about 10.1 m ha area worldwide, with production 7.8 m tonne (www.icarda.cgiar.org). Chickpea accounts for 12% of the World pulses production. In India chickpea is being grown in 7.10 m ha area, with production 5.65 m tonne and productivity 795 kg/ha

(www.ipgri.cgiar.org). In India Madhya Pradesh, Uttar Pradesh, Maharashtra and Rajasthan are the major chickpea growing states, sharing 85% area. The maximum area (2.9 m ha) and production (2.98 m tonne) of chickpea is recorded in central zone (www.ipgri.cgiar.org). Madhya Pradesh covers 2.9 m ha area with production 2.98 mt and productivity 931 kg/ha. Madhya Pradesh is contributing 37% of India's total chickpea production.

2.2 Physical properties of chickpea

Waldia *et al.*, (1995) reported that the genotypes showed variation in seed mass. It ranges from 16.4 to 42.2 g per 100 seeds. Sing and Lyer (1988) also recorded wide range of variability for 100 seed weight ranging from 12 to 22 g in chickpea.

Suryawanshi *et al.*, (1998) studied 5 varieties of chickpea cultivars for physical characteristics and observed that the 100 seed weight ranged from 15.5 to 33.9 g.

Suryawanshi *et al.*, (1999) evaluated ten chickpea (*Cicer arietinum* L.) varieties for seed quality in relation to seed size and reported that brown seeded cultivars PG-5 recorded the highest seed weight (33.04 g/100 seeds), followed by yellow seeded 'vishal'.

Singh *et al.*, (1999) evaluated 4 chickpea varieties (*cicer arietinum* L.) for seed quality in relation to grain weight reported in 'semsen' (15.3±0.32) 'amethyst' (24.6±0.40) 'T-1315' (29.8±0.28) and 'T- 1414 (24.3±0.68) reported in g/100 seed weight.

Yadav *et al.*, (1999) reported that substantial variation existed for 100-seed weight (25-59 g) in the accessions and the differences between small, medium and large seed size groups were highly significant.

Nimbalkar (2000) reported the highest variation for 100 grain weight ranging from 13.00 to 25.00 g/100 seed. How were Singh *et al.*,

(2003) evaluated three chickpea cultivars namely HC-1, HK 89-131 and HC-3 for physico-chemical characters and observed that the 100 seed weight were 17.2, 19.7 and 28.9 g/100 seed weight.

Agrawal and Singh (2003) evaluated eight indigenous desi chickpea cultivars for physico-chemical characters and observed that the 100 grain weight ranged from 11.4 to 26.4 g.

Singh and Yadava (2003) observed wide range of variability among chickpea genotype for 100 seed weight ranging from 12.83 to 29.78 g.

Gupta *et al.*, (2005) observed physical and nutritional quality traits in fifty genotypes including recommended varieties of desi and kabuli type and promising breeding lines and reported that the seed weight ranged from 11.79 to 42.73 g /100 g.

Erge *et al.*, (2008) studied that the loss of visual green color, as represented by the change of the -a, the ratio -a/b and h (hue) values measured by tristimulus colorimeter, also followed a first-order reaction.

2.3 Chemical composition of chickpea

Hulse (1991) reported that pulses are suitable source of protein supplements to cereals. They are generally 2-3 times richer in protein than cereals; they are beneficial for people whose diet is either cereal based or tuber based, particularly in Asia Pacific region.

Khan *et al.*, (1995) investigated the physico-chemical and nutritional quality of 5 improved CVS of desi and kabuli chickpeas. The kabuli chickpea (25g/100 seeds) had larger seed than desi type (21g/100 seeds). Desi and kabuli chickpeas chickpea contains protein (25.4, 24.4%), fat (3.7, 5.1%), carbohydrates (47.4, 55%), crude fibre (11.2, 3.9%) and ash (3.2, 2.8%) respectively.

Singh (1997) and, Kharakwal (1999) reported that the grain legumes, interchangeably referred as pulses in the Indian sub-continent, occupy an important place in human nutrition. They are the variable sources of proteins (20 to 25 %), minerals and vitamins in the daily diets of the people, particularly of the low income group.

Gulati and Sood (1998) analyzed chickpea seeds for proximate composition and mineral content. They reported that the desi type of cultivars exhibited significant variation for proximate composition to be: moisture 6.13-12.95%, protein 17.4-21.2%, fat 5.28-6.83%, ash 3.19-3.60%, crude fiber 3.86-4.40% and carbohydrates (by difference) 56.08-60.46%.

Saxena *et al.*, (2002) reported that the *Cicer arietinum* cultivars possess highest nutritive value. Among 6 cultivars under investigation, GL 92162, GL 93011 and GL 94008 showed a high protein content and concluded that cultivar GG 1111 is nutritionally better than other cultivars.

Yadav *et al.*, (2002) observed that the chickpea genotypes exhibited significant variation in biochemical constituents such as moisture, protein, ether extracts, ash and carbohydrates from 7.59 to 8.23 %, 19.19 to 22.86%, 4.85 to 6.37%, 2.22 to 2.77% and 69.40 to 73.34% respectively. The cultivar Avrodhi and KWR 1036 were identified as superior, excelling in most of the biochemical constituents and nutritive value parameters.

Agrawal and Singh (2003) reported that the cultivars contain moisture from 6.13-12.95%, protein 17.4-21.2%, fat 5.28-6.83%, ash 3.19-3.60%, crude fibre 3.86-4.40% and carbohydrates (by difference) 56.08- 60.46%.

Koca *et al.*, (2008) studied that the effect of pH on the chlorophyll degradation and visual green colour loss in blanched green peas. They observed that degradation of chlorophylls *a* and *b* followed

a first-order reaction The activation energies ranged from 4.80 ± 0.91 to 14.0 ± 0.71 kcal mol⁻¹ for chlorophyll *a* and from 6.84 ± 0.29 to 11.0 ± 1.06 for chlorophyll *b* with varying pH values. The visual green colour degradation, as represented by the change of the —*a* (greenness), the ratio — *a/b* and hue (*h*) values measured by tristimulus colorimeter, also followed a first-order reaction. Activation energies for —*a* values ranged from 8.13 ± 0.71 to 12.0 ± 1.07 kcal mol⁻¹, and for —*a/b* values ranged from 8.77 ± 1.34 to 12.0 ± 1.07 kcal mol⁻¹ with varying pH values at 70, 80, 90 and 100 °C.

Vasishtha *et al.*, (2009) studied that the total insoluble fibre was higher in desi and green seeded type than kabuli type chickpeas, whereas soluble fibre was much higher in green seeded and kabuli types than desi type.

Sharma *et al.*, (2013) reported that the crude protein content varied from 18 to 31% in chickpea. It was higher in kabuli chickpea cultivars than desi type.

2.4 Canning Technology

The technology of canning of fruits and vegetables was discovered by Nicolas appertz during the stress of war conditions towards the close of the 18th century. In this process of food preservation, food is processed and packed in hermetically sealed airtight container. During canning process the high heat destroys microorganism and inactive enzymes, to preserve the safety and quality of food. Canning is done to make chickpea available and edible long after the process time. Canned unripe chickpea in brine or baked desi green chickpea canned in tomato sauce could also serve as ready-to-eat breakfast foods Siddhappa (1986), Nistor *et al.* (2010). Ranganna (1991) reported the methodology for evaluation of canned products.

Nleya *et al.*, (2002) reported that, chickpea has become an important pulse crop in Saskatchewan where both the large-seeded

(Kabuli) and small-seeded (Desi) market classes are grown. In North America, Kabuli chickpea is mainly used for canning and in salad bars. Both the genotype and the environment contribute significant effect in the canning quality of chickpea. Their finding reveals that, three cultivars of chickpea grown in 17 environments in Saskatchewan and Alberta during 1996, 1997, 1998 shows the significant genotype, environment and genotype environment interactions for most canning quality traits. Significant genotypes x environment interactions suggest that chickpea cultivars did not perform consistently relative to each other in different environments.

Malecki *et al.*, (1976) reported the process for treating peas or other green vegetables, such that they may be canned in a manner to retain their green colour. The process is characterized by the steps of maintaining the vegetable in a fresh state and in an aerobic environment such that it does not wilt and continues to respire aerobically up to the sterilization step, sterilizing the vegetable at a temperature between 250° F preferably 275° F and the scorching temperature of the vegetable for a sufficient amount of time to yield a commercially sterile vegetable and sealing the vegetable in a container.

Laborde *et al.*, (1994) reported method for improving the colour of containerized green vegetables, comprising the steps of: (a) blanching the vegetables for an extended period of time; (b) packing the blanched vegetables into a container along with an aqueous packing solution containing zinc or copper ions; (c) sealing the container and (d) subjecting the containerized vegetables and packing solution to a sterilization process.

Saikia *et al.*, (1999) studied the thermal process schedules for canned gourds and recommended the actual processing time for commercial processing (canning) of bitter gourd and ivy gourd were 27.0 min, 19.0 min and 16.0 min respectively with corresponding F_0 .

values of 4.3 min, 4.5 min and 3.7 min, respectively at 115.6 °C (240°F).

Revilla *et al.*, (2008) evaluated the effects of canning process on texture of faba beans and reported the different sterilization treatment affected skin texture of beans.

2.5 Effect of processing parameters of canning on quality of canned product

Nordstrom *et al.*, (1977) reported no significant difference in hydration ratios after blanching of beans, except in those that were not soaked. Beans canned in tomato sauce were much firmer and were higher in riboflavin content. Strong interactions was observed between the main effects of, type of canning media, soak time and storage time, influenced the decision for recommending any one soak time or canning media for all types of beans unless other processing conditions are altered.

Islam *et al.*, (1979) reported the, nutrient content and canning quality of a newly developed green-seeded soybean and reported the sensory evaluation and nutrient content of soybeans of 95-day maturity found to be most desirable.

Davis *et al.*, (1980) reported that, storage times did not affect drained weights in non blanched and non cooled samples. They were significantly higher in drained weights than the samples cooled after blanching. However they also observed that samples those are blanch method and post-blanch treatment had significant effects, which varied between bean types, on drained weight, shear values and percent split beans, but not on moisture content.

Segner *et al.*, (1982) reported that the natural colour of canned green vegetables is retained by blanching the vegetables, prior to packing.

Paredes *et al.*, (1988) reported the effect of canning on physical, chemical and sensory changes during thermal processing.

Sharma *et al.*, (1992) reported that drained weight in canned apricot increased with storage and had an inverse relationship with cut-out syrup.

Ros *et al.*, (1993) reported changes in crude protein (CP), non protein nitrogen (NPN), total sulphur (TS) contents, carbon/nitrogen (C/N) and nitrogen/sulphur (N/S) ratios and albumin protein (AP) in four sizes of peas at various stages of the commercial canning process and investigated that among all the parameters, considered, NPN, AP and TS showed the most regular trend to decrease during the commercial canning process.

Kotzekidoo (1996), Kilara *et al.*, (2007), Prevost *et al.*, (2010), Ranganna (1991) investigated the microbiological quality of canned food and reported that thermophilic bacteria constitute an important group of spoilage bacteria of low-acid canned food. Kotzekidoo (1996) reported the method of simplified identification scheme of *Bacillus* spp. in canned foods

Kebede *et al.*, (1998) reported ascorbic acid retention in a model food packed in barrier plastic trays and in cans. After sterilization and during storage the plastic trays showed on overall better ascorbic acid retention. However the rate constants for ascorbic acid degradation were higher in the trays than in the cans.

Walter *et al.*, (1998) evaluated alkali-neutralization process maintains the firmness and sensory quality of canned sweet potato pieces and were found treated samples significantly firmer than control. Overall sensory acceptance at 10 months was greatest for phosphate-treated samples in 30⁰Brix syrup. Thus the alkali-neutralization process retains firmness, wholeness and sensory quality of sweet potato canned after long term storage.

Aggarwal *et al.*, (1999) reported that total chlorophyll content decreased in brassica greens during 6 month storage to 80% of its initial value after cooking while in canning 40-50%.

Patwardhan (1999) determined the boiling point of canned drinking water and were found the no significant disagreement in two measurements of vacuum.

Tyler *et al.*, (2000) investigated the effects of calcium level in the soak water; blanch water and brine, blanching temperature and total seed solids on dry bean canning quality. The finding shows a linear increase in the calcium level of soak water, blanch water however brine resulted in a linear decrease in hydration coefficient.

Lav *et al.*, (2000) determined the textural and green colour degradation of asparagus, after heat treatments at temperature between 70°C and 98°C for selected time intervals. Thermal softening of asparagus followed a first order kinetic reaction. Green colour changes of asparagus spear surface a first order reaction. The activation energies for green colour degradation of asparagus were 13.1 minus 0.2 kcal/mol and kinetic reaction rates at 84°C were 0.0066 plus or minus 0.0002 min⁻¹.

Tripathi *et al.*, (2003) studied the thermal process schedules for baked soybean canned in 2.5% brine (pH=5.66) and in tomato sauce (pH=4.98) and reported that cold point of plain A 2^{1/2} cans filled with brine and tomato sauce were found to be on central axis 2.0cm and 4.0 cm above the base of the cans. The corrected process time (Pt) to achieve sterilization value (F₀) corresponding to 6.0 min for A 2^{1/2} can size at 121.1°C in still vertical retorts calculated by improved general and lethal rate paper methods were found to be 35.6 min and 36.8 min, respectively for baked beans canned in brine and 40.8min and 40.4 min, respectively for baked beans canned in tomato sauce.

Shi *et al.*, (2004) reported the effect of thermal processing on the characteristics and stability of phytates in canned bean products. Phytates are less thermal sensitive. During soaking and blanching, portions of phytates were dissolved in water and lost in soaking, washing and blanching liquors. An optimum thermal process can increase the stability and maintain the phytates in canned bean products, which is useful for food industry to improve thermal processing technology and enhance bean product quality.

Tarley *et al.*, (2004) analyzed the proximate composition, cholesterol content and fatty acids composition of different brands of sardines canned in soybean oil and tomato sauce. Highest levels were observed in sardines canned in tomato sauce.

Tripathi *et al.*, (2004) reported that little changes were observed in the proximate composition of baked soybean canned in brine or tomato sauce during storage at $37\pm^0$ C for 90 days. The organoleptic evaluation showed greater preference for baked soybean in tomato sauce over product canned in brine.

Lathrop *et al.*, (2006) investigated thermal degradation rates of ascorbic acid in peas during a simulated retort operation at various temperatures and reported that fresh peas were blanched and vacuum sealed in thermal death time cans with brine. The canned peas were processed at $110-132^0$ C for different time intervals. The ascorbic acid degradation reaction was found to be first order with activation energy of 41kcal/mole.

Kilara *et al.*, (2007) reported that application of the citric acid vacuum hydration process to 227 kg quantities of fresh mushrooms tissue in commercial cannery resulted in no loss in canned product yield, significantly improved product color, greatly minimized thermophilic spoilage and did not significantly influence flavour and texture.

Rafique *et al.*, (2009) analyzed the variation in concentration of essential and non essential elements in canned and fresh food. The result showed that concentration of element in canned food samples was greater than fresh food and it increases with increasing time and temperature but decreases with increasing pH.

Chukwumah *et al.*, (2012) evaluated the effect of canning and storage on the phenolic composition of peanuts and reported that canning has been shown to be detrimental to certain nutrients. However canned peanuts still retained some bioactive polyphenols with antioxidant activity.

Jaworska *et al.*, (2012) reported that effects of pretreatment on canning and 12-month storage on the amino acid content in bisporus and *Boletus edulis* mushrooms. After storage of canned mushrooms, significant decreases in alanine, asparagines, glutamine, methionine, valine were observed.

After doing the critical appraisal towards literature, it reveals that the information is still quite meagre on optimization of process parameters i.e. Holding time, Brine concentration and Blanching time for canning of green chickpea. With the changing demand towards the nutritional consciousness and new technology requirements, optimum processing parameters of canning are required to be evaluated for development of canned green chickpea (Desi and kabuli type). Therefore, the present investigation has been undertaken and the findings are given in next chapters.

MATERIALS AND METHODS

This chapter deals with the various experimental technique material and methodologies used for preparation of canned green chickpea. The present investigation was carried out in the Department of Food Science and Technology, College of Agriculture, JNKVV, Jabalpur (M.P.) during the year 2012-2013.

3.1 Experimental materials

Green chickpea pods of variety JG 14 and JGK 2 of Desi and Kabuli type respectively were procured from Department of Plant Breeding and Genetics, College of Agriculture, Jabalpur. Tin cans were purchased from Umesh trading corporation, Indore (M.P.). All the chemicals used in present investigation were of standard analytical grades from BDH (India), E-Merck Sarabhai, M. (Guaranteed) and glassware's used in the present investigation were of Qualigens and Borosil respectively.

3.2 Canning of green chickpea

The canning of green chickpea was done by following the standard procedure as described by Ranganna (1991).The unit operations of canning technology are presented in plate1-3.

3.2.1 Processing of raw material for canning

Green pods of Desi and Kabuli chickpea were cleaned and subjected to green chick pea pod splitting cum shelling machine to obtain chick pea seeds. The seeds were thoroughly cleaned and washed in running tap water to remove adhering dust, mud and soil particles. The representative samples of green chickpea were blanched at predetermined (Table 3.2) time, following the procedure as described by Ranganna (1991).

3.2.2 Brine solution for canning

Sodium chloride solution (brine) was selected as medium for canning of chickpea. The brine solution was prepared at 20°C at their predetermined levels (Table 3.2) of concentration, following the procedure as described by Ranganna (1991).

3.2.3 Can filling

A No1 Tall (capacity 100g) olio resign lacquered, semi finished cans (Reformed, Flanged and fixed with lower lid) were selected for canning of chickpea. The cans were washed with water to remove any adhering dust or foreign matter. Cans were sterilized in Can sterilizer and filled with desired quantity of hot brine solution (60°C) of varying concentration as per experimental plan and 100g fresh green chickpea. The cans after being filled were covered loosely with the lid and passed through the exhaust box.

3.2.4 Exhausting and Sealing of Cans

Before sealing i.e. double seaming operation of cans, it is necessary to remove all air from the contents inside the cans. The exhausting of cans was done in 15 ft long can exhausting box at 79°C to 82°C for 5 to 25 min. Immediately after exhausting operation the cans were sealed by semi automatic double seamer machine, Ranganna (1991).

3.2.5 Sterilization of Cans

The sealed cans under hot condition were processed in boiling water for complete distraction of micro organism. The Sterilization of cans was done in boiling water at 121°C at pre determined holding time. After sterilization the cans were further dipped in cold water. The excess water adhering on surface of cans was wiped off to avoid rusting.

3.2.6 Storage of Cans

Cans were stored at $37\pm 2^{\circ}\text{C}$ in thermostatically controlled incubator for 60 days. They were observed periodically for quality attributes and any external signs of spoilage.

3.3 Analytical methods

The following methods were used for various determinations.

3.3.1 Physical properties

3.3.1.1 Weight (100 seed)

The weight of 100 chickpea seeds was determined using electronic scale. The averages of three determinations are reported in grams.

3.3.1.2 Length

Length of chickpea was measured by vernier calipers. The average value of three determination are reported in centimeters (AACC, 1967)

3.3.1.3 Thickness

Thickness of chickpea was measured by vernier calipers. The average value of three determination are reported in centimeters (AACC, 1967)

3.3.1.4 Colour

Colour of fresh and stored canned green chickpea was measured using Hunter colour lab analyzer where L, a and b values were recorded for the different canned product combinations. The opponent color scale give measurement of color in units of approximate visual infirmity throughout the color solid thus in the Hunter scale "L" measure

lightness and varies from 100 for perfect white to 0 for black, approximately as the eyes would evaluate it.

The chromaticity dimension (a & b) gives understandable designations of color as follows:

“a” measures redness when positive, grey when 0 and green when negative.

“b” measures yellowness when positive, grey when 0 and blue when negative.

3.3.2 Chemical composition

3.3.2.1 Moisture

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

$$\text{Moisture (\%)} = \frac{\text{Difference in the weight}}{\text{Weight of the sample}} \times 100$$

3.3.2.2 Protein

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

Reagents

1. Catalyst mixture- A mixture of 100 g K₂SO₄, 20g of CuSO₄ and 2.5 g of SiO₂.
2. Sodium hydroxide 40%(w/v)

3. Boric acid 2 %(w/v).
4. Concentrated sulphuric acid AR (sp. gr. 1.81)
5. Mixed indicator: 2 parts of 0.2 %(w/v) methyl red and 1 parts 0.2% (w/v) methyl blue in absolute alcohol.
6. Standard sulphuric acid (0.1N)

Procedure

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

Distillation

The content in the flask were allowed to cool and the digested material was transferred quantitatively to a vacuum jacketed flask of micro Kjeldahl distillation apparatus and the ammonia liberated by the addition of 10 ml of 40% NaOH on heating was absorbed in 20 ml of boric acid containing 2-3 drops of mixed indicator in 100ml conical flask. The distilled off ammonia was titrated against 0.1N sulphuric acid. The blank was also run in a similar way.

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

$$\text{Crude protein} (\%) = N \% \times 6.25$$

3.3.2.3 Fat

The fat content of the sample was determined by the procedure as described in AOAC (1984). The sample (5g) was weighed

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

$$\text{Crude fat (\%)} = \frac{\text{Weight of flask (B)} - \text{Weight of flask (A)}}{\text{Weight of sample}} \times 100$$

3.3.2.4 Carbohydrates

Total carbohydrates in the samples were estimated by hydrolysis method as described in AOAC (1984).

Reagents

1. Conc. HCl (AR sp. gr. 1.25)
2. Fehling's solution

Fehling's solution A: 34.64 g of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ was dissolved in 500ml of distilled water.

Fehling's solution B: 173 g of sodium potassium tartarate and 50 g of sodium hydroxide were dissolved in 500 ml of distilled water. The Fehling's solution was prepared by mixing the equal volume of solution A and solution B. It was prepared fresh daily.

3. Sodium hydroxide 40 % (w/v).
4. Methyl blue indicator 0.1 % (w/v) in 95% alcohol.
5. 3N HCl – 68.18 ml concentrated HCl was made up to 250 ml with distilled water.

6. Dextrose 1%- 1 g of dextrose was dissolved in 100 ml distilled water.

Procedure

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

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

$$\text{Dextrose \%} = \frac{\text{Factor} \times 250}{\text{Titrated value} \times \text{Weight of sample}} \times 100$$

$$\text{Total carbohydrates (\%)} = \text{Dextrose \%} \times 0.9$$

3.3.2.5 Ash

The ash content in the sample was determined by procedure as describe in AOAC (1984). The sample (5g) was placed in pre weighed crucible. It was burned on gas flame until it was completely charred. The samples were then placed in muffle furnace for combustion at 520°C for 5hr their after samples were cooled in desiccators and weighed. The heating in muffle furnace was repeated until constant weight was obtained. The ash content was calculated as under

Calculation

$$\text{Ash (\%)} = \frac{\text{Initial weight of empty crucible and sample} - \text{Final weight of crucible with ash}}{\text{Weight of sample}} \times 100$$

3.3.2.6 Crude fiber

The crude fibre was determined by the method as described in AOAC (1984).

Reagents

1. Sulphuric acid 0.255 N
2. Sodium hydroxide 0.313N

Procedure

Dry defatted sample (2g) was transferred in to 500ml conical flask to which 200ml of 0.255 N boiling sulphuric acid was added, then it was boiled for 30 min., kept the volume constant by the addition of water at frequent intervals. The mixture was cooled and filtered through a muslin cloth and the residue was washed with hot water till it was free from acid. The material was then transferred to the same beaker and 200ml of boiling 0.313 N NaOH was added. After boiling for 30 min. the mixture was cooled and again filtered through muslin cloth. The residue was washed with water till it get free from alkali, followed by washing with absolute alcohol and ether to remove the moisture and residue fat. It was then transferred to a weighed crucible and kept in oven at 100 °C for 4-6 hr. The crucible was cooled and weighed. The difference in weight represents the crude fibre content in samples.

$$\text{Crude Fibre (\%)} = \frac{\text{Difference in weight of crucible}}{\text{Weight of sample}} \times 100$$

3.3.2.7 Acidity

Titrate acidity content of samples was determined by simple acid-alkaline titration method as described in A.O.A.C. (1984). The samples were homogenized with 100 ml distilled water. Now 25 ml of diluted sample was transferred into a 250ml beaker. Three drops of

phenolphthalein indicator was added to the solution. N/10 NaOH solution was taken in burette and titrated with alkali solution drop by drop with constant stirring till the pink end point is reached. End point readings were recorded and the percentage acidity was calculated in terms of citric acid by the following formula.

$$\text{T.A. \%} = \frac{\text{Reading} \times \text{Normality of NaOH} \times \text{Citric acid eq. wt.}}{\text{Volume of sample taken} \times 1000} \times 100$$

3.3.2.8 Total sugar

The sugars content of the sample was determined by the procedure as described by Ranganna (1991).

Reagents

1. Fehling's solution A
2. Fehling's solution B
3. Methylene blue indicator
4. 45% Neutral Lead Acetate solution
5. 22% Potassium Oxalate solution

Standard invert sugar solution

Weighed 9.5gm of AR grade sucrose into 1litre volumetric flask. Then added 100ml water and 5ml concentrated HCl. Allowed it to stand for 3 days at 20-25°C for inversion to take place and then make up volume up to mark with distilled water. The solution is stable for several days. Pipetted out 25ml of standard invert sugar solution into 100ml volumetric flask and added 50ml water. Added few drops of phenolphthalein indicator and neutralized it with 20% NaOH until pink colour appears. Then it was acidified with 1N HCl by adding it drop wise until 1 drop causes the pink colour to disappear. Now make volume up to mark with water. A 1ml of given solution is equal to 2.5mg of invert sugar.

Standardization of Fehling's solution

50ml each of Fehling solution A and Fehling B were mixed. Now 10ml of mixed solution was pipette out into 250ml conical flask and added with 25 ml water. Take invert sugar solution prepared by inversion of sucrose in 50ml burette. Added this to the mixed Fehling solution almost the whole of the standard invert sugar solution (18-19ml) required to effect the reduction of copper, so that not more than 1ml will required to complete titration. The flask was heated over a hot plate covered with asbestos filled wire guaze. When liquid began to boil, keep in moderate ebullition for 2min. On flame, added three drop of methylene blue and completed titration in 1min, over all in 3 min without interruption. End point were noted which was indicated by the discoloration of blue colour of indicator. The colour was turned to brick red

Procedure

50ml of the clarified solution of sample was pipetted into 250ml flask and added with 5g of citric acid and 50ml of water. It was boiled gently for 10 min to complete inversion of sucrose, and then cooled. Transferred it to 250ml flask and neutralized with 1N NaOH using phenolphthalein and make up volume and was titrated with Fehling solution.

Calculation

$$\text{Total sugar\%} = \frac{\text{Factor x Dilution}}{\text{Titre Value x Weight of sample}} \times 100$$

3.3.2.9 Total phenol

The total phenol content of samples was determined by procedure as described by **Sadasivam and Manickam (1990)**.

Reagents

1. 80% ethanol (80ml + 20 ml Distilled water)
2. Folin - ciocalteau reagent
3. 20% sodium carbonate (Na_2CO_3)
4. Standard – (100mg catechol in 100 ml distilled water) dilute 10 times for working standard 0.1 g.
5. Blank - (3ml distill water + 0.5 ml folin reagent + 2 ml Na_2CO_3).

Procedure

The sample (0.5 to 1.0 g) was grind in pestle and mortar in 10 time volume of 80% ethanol. The aliquot was centrifuge and homogenized at 10000 RPM for 20 min. The supernatant collected and residue was re-extract five times with 80% ethanol. The supernatant was pooled and evaporated to dryness. The dried residue was further dissolved in a known volume of distilled water (5 to 10 ml). Form the above solution pipette out aliquots, 0.2 ml into 20ml test tube. Now make up the volume in each test tube up 3 ml with distilled water (add 2.8 ml distilled water). 3ml of folin reagent was taken and its volume was makeup to 9 ml. From this solution add 0.5 ml of folin reagent in to the test tube. After a period of 3 min, add 2 ml of 20% Na_2CO_3 solution to each tube. Mix it thoroughly and place the tubes in boiling water for exactly 1 min. Cool it and measure the absorbance at 650 nm against a reagent blank. Also prepare a standard curve simultaneously using different concentration of catechol.

Calculation

The phenol content was calculated from the standard curve prepared by catechol and express as mg of phenol/100 g sample.

3.3.3 Sensory evaluation of canned chickpea

A semi trained panel of 10 members was given samples of chickpea to evaluate the sensory quality attributes viz., colour, flavour, taste, and texture. A 9 point hedonic scale (Appendix-I) has been adopted. The data were statistically analyzed by standard procedure as described by Ranganna (1991)

3.3.4 Cut out examination of canned green chick pea

Cut out examination of canned green chickpea was done for evaluation of external appearance, weight, gross weight, net weight, drain weight, inspection of contents of cans, internal condition of can, pH, and vacuum in cans by following standard procedure described as under, Ranganna (1991)

3.3.4.1 External appearance of cans

Cans were evaluated for body dents or scratches leakage around seams. The condition of Can ends is described using the following terms:

Flat: A can where both ends are concave. The vacuum is high enough to maintain the ends in concave condition.

Flipper: A can in which the vacuum is so low that mechanical shock will produce distortion of one or both ends. For example, if a sharp blow is given against a massive object, close to the top of the can, one or both ends may spring out. The can should not be dented while striking.

Springer: A can in which one end is distorted and other one end is flat, and the pressure on the convex end will cause the flat end to spring out when pressed.

Swell: A can in which both ends are convex, i.e., in which there is sufficient pressure to cause permanent distortion of both ends.

3.3.4.2 Weight

3.3.4.2.1 Gross weight

The cans were weighed as such and recorded as gross weight.

3.3.4.2.2 Net weight of content

The net weight of contents in can was calculated by subtracting weight of clean and dry empty can.

3.3.4.2.3 Drain weight

The drain weight was determined by emptying the contents of the can in such a manner as to distribute the product evenly upon a circular sieve which should be so inclined as to facilitate drainage of syrup or brine and allow the product to drain for 5 min. The drained weight was recorded as the weight of the sieve and the contents minus the weight of the dry sieve.

3.3.4.3 Inspection of contents of cans

As soon as the can is opened, appearance and surface of can was seen and recorded for under filling or overfilling, cloudiness of brine for colour, clarity and flavour. The cloudiness in canned food liquid often indicates spoilage. It often accompanies flat sour spoilage and can be detected by bad odour.

3.3.4.4 Internal condition of cans

The internal condition of can surface were determined when they were emptied and washed. The cans were examined for evidence of corrosion, blistering or defects of lacquer, pitting, scratching, solder globules, discoloration, leaks, evidence of scorching along seams.

3.3.4.5 pH

The pH of canned chickpea was measured using Elico make pH meter equipped with glass electrode.

3.3.4.6 Vacuum

The vacuum or pressure of canned chickpea was measured using Bajaj Process Pack make vacuum gauge. The gauge was used by piercing the hollow pointed end of the gauge through the lid of the can so that the rubber gasket makes a gas-tight seals and prevents the loss of vacuum. Moisten the rubber before applying the gauge and pierce the can with the gauge towards the one side edge. Do not press to hard (so as not to alter the head space). The vacuum or pressure is indicated by the needle on the dial of the gauge. The vacuum was recorded in Kg/cm² of mercury, and pressure in lbs.

3.3.4.7 Total bacterial plate count

The total bacterial plate count of the sample was determined by the procedure as described by Dubey and Maheshwari (2005). The microscopic appearance of bacterial cells appeared in Petri dish were recorded and reported as Number of CFUs per ml of sample.

3.3.5 Experimental plan and design

A central composite rotatable design was used to plan the experiment. Based on the information available in the literature and preliminary trials, three independent variables viz, brine concentration, blanching time and holding time were selected for standardization of technology of canning of green chickpea. The range of variables was selected taking into consideration the maximum and minimum values used as reported by many workers in the past. Five levels of each independent variables were chosen. Response surface methodology was used to reduce the number of experiments, without affecting the accuracy of results. The details of levels of variables with experimental plan are given in Table 3.1. The experimental plan was consisted of 20 experiments (Table 3.2) where the first 8 experiments were of first order part, 6 experiments were in second order part and next 6 experiments were at centre point.

Table 3.1. Experimental variables their coded and uncoded (actual) values for canning of green chickpea (Desi and Kabuli type)

S.No.	Variables	Code	Coded level				
			-1.68	-1	0	+1	+1.68
1.	Holding time(min)	X ₁	28.18	35	45	55	61.82
2.	Brine conc. (%)	X ₂	0.64	2	4	6	7.36
3.	Blanching time (min)	X ₃	0.98	2	3.5	5	6.02

a. \pm - value

b. Centre point

Table 3.2. Design matrix and experimental variables in coded and uncoded (actual) values for canning of green chickpea (Desi and kabuli type)

Expt. No.	Coded form			Un coded form		
	X ₁	X ₂	X ₃	Holding time X ₁	Brine conc. X ₂	Blanching time X ₃
First order interaction						
1	1	1	1	55	6	5
2	-1	1	1	35	6	5
3	1	-1	1	55	2	5
4	-1	-1	1	35	2	5
5	1	1	-1	55	6	2
6	-1	1	-1	35	6	2
7	1	-1	-1	55	2	2
8	-1	-1	-1	35	2	2
Secondary order interaction						
9	1.682	0	0	61.82	4	3.5
10	-1.682	0	0	28.18	4	3.5
11	0	1.682	0	45	7.36	3.5
12	0	-1.682	0	45	0.64	3.5
13	0	0	1.682	45	4	6.02
14	0	0	-1.682	45	4	0.98
Centre point						
15	0	0	0	45	4	3.5
16	0	0	0	45	4	3.5
17	0	0	0	45	4	3.5
18	0	0	0	45	4	3.5
19	0	0	0	45	4	3.5
20	0	0	0	45	4	3.5

3.3.6 Statistical analysis

The data obtained from each experiment planned in central composite rotatable design were processed using Design Expert 8.1 statistical software. The multiple regression analysis, Step wise regression analysis has been done for each independent variable. Response surface graphs of selected responses were developed to study the effect of independent variables and to optimize the levels of parameters. The findings of experiments are presented in subsequent chapter.

RESULTS

The present investigation deals with the development of technology for canning of green chickpea. The findings of the various experiments are presented in this chapter.

A Response Surface Methodology (Myers 1976) was selected as the approach to determine effect of levels of Holding time (X_1), Brine concentration (X_2) and Blanching time (X_3). Three levels of each independent variable were chosen (Tables 3.1 and 3.2). The central composite rotatable design with half replicate was used to determine the combination of variable levels in each experiment. Experimental plan was consisted of 20 experiments, out of them 8 experiments were in first order, 6 in second order and 6 in center point, respectively. To determine the effect of independent variable on some predominant selected responses viz. physical properties (Length, Thickness, Weight), chemical composition (Moisture, Acidity, Total Sugar, Total Phenol), sensory quality attributes (Colour, Taste, Texture) and cut out examination (Drain weight, P^H , Head Space, Vacuum) of product, response surface methodology was used. A full second order equation of following form was fitted in each response to describe it mathematically and to study the effect of variables.

$$Y = \beta_0 + \sum_{i=1}^4 \beta_i X_i + \sum_{i=1}^3 \sum_{j=i+1}^4 \beta_{ij} X_i X_j + \sum_{i=1}^4 \beta_i X_i^2$$

The adequacy of models was tested using F ratio and coefficient of determination (R^2). The model is generally considered adequate when (I) the calculated F ratio was more than that of table value and (II) the R^2 value is more than 70% (Frazier *et al.*, 1983, Henika, 1982). The effect of variables at linear, quadratic and interactive levels on the response was described using significance at 1 and 5 % level of confidence. In order to predict the responses simple models are required. Hence, all

non-significant terms of full second order polynomial model for each response of canned green chickpea (Desi and Kabuli type) were removed and stepwise regression analysis was done. The best-fit empirical equations thus developed did not sacrifice the accuracy of results.

The result of the data obtained from various experiments for physical properties, chemical composition, sensory quality attributes and, cut out examination for desi and kabuli chickpea are given in Section 4.1, 4.2, 4.3 through Table 4.1 to 4.38.

Section A: Canned green chickpea (Desi type)

4.1 Physical properties of canned green chickpea (desi type)

4.1.1 Length

The table 4.1 comprises the result of effect of process parameters on length of canned green chickpea (Desi type). The length of chickpea seeds varied from 0.5 to 0.8 cm. Length were highest at Exp. no. 3, 5, 8, 12, 13 and lowest at Exp. no. 4, 6, 9, 15, 16, 19. The analysis of variance table for full second order regression model (Table 4.3) indicated that the F ratio of the model 1.04 was lower as compared with the table value of 3.02 at 5% level of significance. R^2 value of model was 48%. The model was found unadequate for further analysis.

4.1.2 Thickness

The thickness of canned green chickpea varied from 0.4 to 0.6 cm (Table 4.1) Thickness were highest at Exp. no. 3, 5, 8, 9, 11, 12, 15, 16, 17 and lowest at Exp. no. 7, 19, 20. The analysis of variance table for full second order regression model (Table 4.3) indicated that the F ratio of the model 0.77 was lower as compared with the table value of 3.02 at 5% level of significance. R^2 value of model was 41%. The model was found unadequate for further analysis.

4.1.3 Weight

The weight of canned green chickpea (Desi type) varied from 53.70 to 54.20 g (Table 4.1) Weight were highest at Exp. no. 5, 15 and lowest at Exp. no. 3, 9, 20. These experiments represented the combination of parameter as (35.00 min, 2.00%, 5.00 min), (35.00 min, 6.00%, 2.00 min), (28.18 min, 4.00%, 3.50 min) and (45.00 min, 4.00%, 3.50 min) of holding time (min), brine concentration (%) and blanching time (min) respectively. The analysis of variance table for full second order regression model (Table 4.3) indicated that the model was found to be non significant. R^2 value of model was 57%. The model was found adequate for further analysis.

4.1.4 Colour

The table 4.1 depicts the result of effect of process parameters on weight of canned green chickpea (Desi type) at 60 days storage. The Hunter colour value of canned green chickpea (Desi type) varied from L-value 14.37 to 32.82, a-value -6.47 to 4.13 and b-value 6.35 to 16.15.

4.2 Chemical composition of canned green chickpea (desi type) at 60 days of storage

4.2.1 Moisture

The moisture of canned green chickpea (Desi type) varied from 58.02 to 59.02% (Table 4.5). Moisture was highest at Exp. no. 15, 16, 17, 18, 19, 20 and lowest at Exp. no. 10. These experiments represented the combination of parameter as (45.00 min, 4.00%, 3.50 min) and (61.82 min, 4.00%, 3.50 min) of holding time (min), brine concentration (%) and blanching time (min) respectively. The analysis of variance table for full second order regression model (Table 4.7) indicated that the F ratio of the model 15.56 was higher as compared with the table value of 3.02 at 5% level of significance. R^2 value of model was 93%. The model was found adequate for further analysis.

Table 4.6 indicates that moisture of canned green chickpea (desi type) was significantly affected by holding time, brine concentration and blanching time. The linear effect of brine concentration was highly significant at 1% level of confidence. The interactions of holding time – brine concentration, holding time – blanching time, brine concentration – blanching time were non-significant. The quadratic effect of holding time and blanching time were highly significant at 1% level of confidence and brine concentration was significant at 5% level of confidence.

4.2.2 Protein

The protein of canned green chickpea (Desi type) varied from 8.69 to 8.79% (Table 4.5). Protein was highest at Exp. no. 3 and lowest at Exp. no. 4. These experiments represented the combination of parameter as (35.00 min, 6.00%, 2.00 min) and (55.00 min, 6.00%, 2.00 min) of holding time (min), brine concentration (%) and blanching time (min) respectively.

4.2.3 Fat

The table 4.5 indicates the result of effect of caning process parameters level on fat content of canned green chickpea (Desi type) at 60 days storage. The fat content varied from 2.39 to 2.49%. Fat was highest at Exp. no. 10, 15, 16, 17, 18, 19, 20 and lowest at Exp. no. 1. These experiments represented the combination of parameter as (61.82 min, 4.00%, 3.50 min) (45.00 min, 4.00%, 3.50 min) and (35.00 min, 2.00%, 2.00 min) of holding time (min), brine concentration (%) and blanching time (min) respectively.

4.2.4 Carbohydrate

The table 4.5 presents the carbohydrate content of canned green chickpea (Desi type) at 60 days storage. It varied from 26.1 to 26.37%. The Carbohydrate was highest at Exp. no. 15, 16, 16, 17, 18, 19, 20

and lowest at Exp. no. 2. These experiments represented the combination of parameter as (45.00 min, 4.00%, 3.50 min) and (55.00 min, 2.00%, 2.00 min) of holding time (min), brine concentration (%) and blanching time (min) respectively.

4.2.5 Ash

The Ash content in canned green chickpea (Desi type) at 60 days storage is presented in table 4.5. The ash content varied from 0.9 to 1.4 percent. Ash was highest at Exp. no. 15, 16, 17, 18, 19 and 20 and lowest at Exp. no. 14. These experiments represented the combination of parameter as (45.00 min, 4.00%, 3.50 min) and (45.00 min, 4.00%, 6.02 min) of holding time (min), brine concentration (%) and blanching time (min) respectively.

4.2.6 Fibre

The table 4.5 comprises the result of effect of canning conditions on fibre content of canned green chickpea (Desi type) at 60 days storage. The fibre of canned varied from 7.3 to 7.39%. Fibre was highest at Exp. no. 1, 15, 16, 17, 18, 19, 20 and lowest at Exp. no. 3, 14. These experiments represented the combination of parameter as (35.00 min, 2.00%, 2.00 min), (45.00 min, 4.00%, 3.50 min), (35.00 min, 6.00%, 2.00 min), and (45.00 min, 4.00%, 6.02 min) of holding time (min), brine concentration (%) and blanching time (min) respectively.

4.2.7 Acidity

The table 4.5 presents the findings of acidity content of canned green chickpea (Desi type) at 60 days storage. The acidity of chickpea (Desi type) varied from 0.07 to 0.10%. Acidity was highest at Exp. no. 12 and lowest at Exp. no. 1, 3, 5. These experiments represented the combination of parameter as (45.00 min, 7.36%, 3.50 min), (35.00 min, 2.00%, 2.00 min), (35.00 min, 6.00%, 2.00 min) and (35.00 min, 2.00%, 5.00 min) of holding time (min), brine concentration (%) and blanching

time (min) respectively. The analysis of variance table for full second order regression model (Table 4.7) indicated that the F ratio of the model 1.58 was lower as compared with the table value of 3.02 at 5% level of significance. R^2 value of model was 59%.

The multiple regression analysis model was non-significant in Table 4.6 however linear effect of independent variable i.e holding time and brine concentration were significant at 5% level of confidence.

4.2.8 Total Sugar

Total sugar of canned green chickpea (Desi type) varied from 4.7 to 5.3 % (Table 4.5). Total sugar was highest at Exp. no. 11 and lowest at Exp. no. 7. These experiments represented the combination of parameter as (45.00 min, 0.64%, 3.50 min) and (35.00 min, 6.00%, 5.00 min) of holding time (min), brine concentration (%) and blanching time (min) respectively. The analysis of variance table for full second order regression model (Table 4.7) indicated that the F ratio of the model (7) was higher as compared with the table value of 3.02 at 5% level of significance. R^2 value of model was also 86%. The model was found adequate for further analysis and evaluation.

Table 4.6 indicates that the linear effect of addition of brine concentration was highly significant at 1% level of confidence. The rest of the interactions and quadratic term of model were non-significant even at 1% and 5% level of significance.

4.2.9 Total Phenol

Table 4.5 presents the result of effect of process parameters level on total phenol content of canned green chickpea (Desi type). It varied from 2.2 to 2.49%. Total phenol was highest at Exp. no. 13 and lowest at Exp. no. 7, 14. These experiments represented the combination of process parameter as (45.00 min, 4.00%, 0.98 min), (35.00 min, 6.00%, 5.00 min) and (45.00 min, 4.00%, 6.02 min) of holding time (min), brine

concentration (%) and blanching time (min) respectively. The ANOVA table of regression model (Table 4.7) indicated that the F ratio of the model, 5.35 was higher as compared with the table value of 3.02 at 5% level of significance. The R^2 value of model was 83%. The model was further analyzed to see the linear, interactive and quadratic effect of variables on phenol content.

Table 4.6 indicates that total phenol of canned green chickpea (desi type) were significant in model of variance. The linear effect of blanching time, interaction of holding time – brine concentration and quadratic effect of holding time was highly significant at 1% level of confidence. The rest of the linear, interactions and quadratic term of model were non-significant even at 1% and 5% level of significance.

4.3 Sensory quality attributes of canned green chickpea (desi type) at 60 days of storage

4.3.1 Colour

The table 4.9 indicates the result of effect of combination of processing parameters on colour score sensory attribute of canned green chickpea at 60 days of storage. The colour score of canned green chickpea (Desi type) varied from 6.9 to 8.0. It was highest at Exp. no. 9 and lowest at Exp. no. 2, 6, 10. These experiments represented the combination of parameter as (28.18 min, 4.00%, 3.50 min), (55.00 min, 2.00%, 2.00 min), (55.00 min, 2.00%, 5.00 min) and (61.28 min, 4.00%, 3.50 min) of holding time (min), brine concentration (%) and blanching time (min) respectively. The analysis of variance table for full second order regression model (Table 4.11) indicated that the F ratio of the model 1.57 was lower as compared with the table value of 3.02 at 5% level of significance. The R^2 value of model was 59%.

Table 4.10 indicates that colour of canned green chickpea (desi type) were non-significant as regards for model however a linear

significant effect of holding time was observed at 5% level of confidence. The rest of the linear, interactive and quadratic terms of model were non-significant even at 1% and 5% level of significance.

4.3.2 Taste

Table 4.9 comprises the result of effect of canning condition on taste of canned green chickpea (Desi type) at 60 days storage. The taste score of canned green chickpea (Desi type) varied from 6.8 to 8.1. The mean value Taste score was highest at Exp. no. 11 and lowest at Exp. no. 4, 8, 10, 12. These experiments represented the combination of parameter as (45.00 min 0.64%, 3.50 min), (55.00 min, 6.00%, 2.00 min), (55.00 min, 6.00%, 5.00 min), (61.82 min, 4.00%, 3.50 min) and (45.00 min, 7.36%, 3.50 min) of holding time (min), brine concentration (%) and blanching time (min) respectively. The analysis of variance table for full second order regression model (Table 4.11) indicated that the F ratio of the model, 4.43 was higher as compared with the table value, 3.02 at 5% level of significance. The calculated R^2 value of model was 80% therefore model was further evaluated for linear interactive and quadratic effect.

Table 4.10 indicates that the linear effect of holding time at level of 5% and brine concentration was highly at 1% significant level of confidence. The quadratic effect of addition of holding time was significant at level of 5%. The rest of the linear, interactions and quadratic term of model were non-significant even at 1% and 5% level of significance.

4.3.3 Texture

The table 4.9 depicts the result of texture score of canned green chickpea. The texture score varied from 6.8 to 7.9 in Exp. no. 13 and 10 respectively. These experiments of highest and lowest value represent

the combination of canning parameter as 45.00 min, 4.00%, 0.98 min and 61.82 min, 4.00%, 3.50 min of holding time (min), brine concentration (%) and blanching time (min) respectively. The analysis of variance table for full second order regression model (Table 4.11) indicated that the F ratio of the model 9.42 was higher as compared with the table value of 3.02 at 5% level of significance. The R^2 value of regression model was 89%.

Table 4.10 indicates that the linear effect of holding time and blanching time was highly significant at 1% level of confidence. The quadratic effect of addition of holding time at 5% level of confidence and brine concentration was highly significant at level of 1%. The rest of the linear, interactions and quadratic term of model were non-significant.

4.4 Cut out examination of canned green chickpea (desi type) at 60 days of storage

4.4.1 Drain weight

The drain weight of canned green chickpea (Desi type) varied from 101 to 105 (Table 13). It was highest in combination of variables at Exp. no. 14 (45.00 min, 4.00%, 6.02 min) and lowest at Exp. no. 2, 18, 19 (55 min, 2.00%, 2.00 min) and (45.00 min, 4.00%, 3.50 min), respectively. The analysis of variance of regression model (Table 4.15) indicated that the F ratio 1.57 was lower as compared with the table value of 3.02 at 5% level of significance. The R^2 value of model was also very low (59%). However, the quadratic effect of blanching time was significant at 5% level of confidence. The rest of the terms of model were non-significant even at 1% and 5% level of significance.

4.4.2 pH

The table 4.13 comprises the result of effect of canning process independent variables level on pH of canned green chickpea (Desi type)

at 60 days storage. The pH varies from 5.4 to 5.8. pH The analysis of variance (Table 4.15) indicated that the F ratio of the model was not significant at 5% level of significance. The R^2 value of model was only 58%.

Table 4.14 indicates that the linear effect of addition of brine concentration was highly at 1% significant level of confidence. The rest of the terms of model were non-significant even at 1% and 5% level of significance.

4.4.3 Head space

The table 4.13 reveals the result of effect of canning condition on head space of canned green chickpea (Desi type). It varied from 0.05 to 0.30 cm. Head space was observed highest at Exp. no. 1, 3, 6, 8, 10, 13, 15, 18, 20 and lowest at Exp. no. 14. The analysis of variance table for full second order regression model (Table 4.15) indicated that the F ratio of the model 2.39 was lower as compared with the table value of 3.02 at 5% level of significance. The R^2 value of model was only 68%.

Table 4.14 indicates the linear effect of blanching time was significant at 5% level of confidence. The interaction between holding time and blanching was also significant at level of 5%. The rest of the linear, interactive and quadratic terms of model were non-significant even at 1% and 5% level of significance.

4.4.4 Vacuum pressure

The result of effect of process parameters level on vacuum pressure of canned green chickpea (Desi type) at 60 days storage are presented in table 4.13. The vacuum pressure of canned green chickpea (Desi type) varied from 0.07 to 0.18. The Vacuum pressure was highest at Exp. no. 10 and lowest at Exp. no. 9. These experiments represented the combination of parameter as 61.82 min, 4.00%, 3.50 min and 28.18 min, 4.00%, 3.50 min of holding time (min), brine

concentration (%) and blanching time (min) respectively. The analysis of variance table for full second order regression model (Table 4.15) indicated that the F ratio (1.34) of the model was lower as compared with the table value (3.02) at 5% level of significance. The R^2 value of model was 55%.

Table 4.14 explains that the quadratic effect of holding time was significant at 5% level of confidence. The rest of the linear, interactive and quadratic terms of model were non-significant even at 1% and 5% level of significance.

4.4.5 Total bacterial plate count in canned green chickpea (desi type) at 60 days of storage

The total bacterial plate count of canned green chickpea (Desi type) varied from 5 to 24 CFU per ml (Table 4.13). It was highest at Exp. no. 9 and lowest at Exp. no. 2, 4 which represents the canning conditions to be 28.18 min, 4.00%, 3.50 min, 55.00 min, 2.00%, 2.00 min and 55 min, 6.00%, 2.00 min of holding time (min), brine concentration (%) and blanching time (min) respectively. The F ratio (22.92) of the model was higher as compared with the table value (3.02) at 5% level of significance. The R^2 value of model was 95%. The model fitting results were found adequate for further analysis.

Table 4.14 indicates the linear effect of holding time was highly significant at 1% level of confidence and brine concentration at 5% level of confidence. It was observed that rests of the linear, interactive and quadratic term of model were non-significant even at 1% and 5% level of significance.

Table 4.1. Physical properties of canned green chickpea (Desi type)

Exp.No.	Length (cm)	Thickness (mm)	Weight (g)	Hunter colour value		
				L	a	b
1	0.7	0.6	54.00	32.82	-6.42	15.99
2	0.6	0.5	53.95	23.08	2.96	10.35
3	0.8	0.6	53.72	32.29	-6.33	16.17
4	0.5	0.5	54.00	26.34	4.13	12.22
5	0.8	0.6	54.20	31.10	-6.47	15.91
6	0.5	0.5	54.08	31.10	-6.47	15.91
7	0.7	0.4	53.78	32.20	-6.30	15.70
8	0.8	0.6	53.83	32.20	-6.30	15.70
9	0.5	0.6	53.72	32.10	-6.10	16.10
10	0.6	0.5	54.00	14.37	2.91	6.35
11	0.7	0.6	54.08	31.10	-6.47	15.91
12	0.8	0.6	53.78	32.28	-6.30	16.10
13	0.8	0.5	53.83	32.20	-6.31	16.15
14	0.6	0.5	54.00	14.37	2.91	6.35
15	0.5	0.6	54.20	29.11	-6.21	14.42
16	0.5	0.6	54.08	26.34	4.13	12.22
17	0.6	0.5	53.78	16.01	2.65	6.58
18	0.6	0.6	53.83	29.14	-6.04	14.60
19	0.5	0.4	53.95	23.08	2.96	10.35
20	0.7	0.4	53.72	29.10	-6.20	14.40

Table 4.2. Regression coefficient of full second order model and significant terms for physical properties of canned green chickpea (Desi type)

Coefficient	Length	Thickness	Weight
Constant	0.57	0.52	53.93
Linear			
1	-0.032	-0.02	0.046
2	0.027	-0.007	-0.1**
3	-0.01	-0.007	0.037
Interactive			
1.2	0.025	0.038	0.063
1.3	0.025	0.038	-0.037
2.3	0.025	-0.013	-0.055
Quadratic			
1.1	-0.0054	0.0087	-0.014
2.2	0.065	0.026	0.011
3.3	0.048	-0.009	0.0053

*** Significant at 1%

** Significant at 5%

1 Holding time

2 Brine conc.

3 Blanching time

Table 4.3. ANOVA for full second order regression model for physical properties of canned green chickpea (Desi type)

Source	Length	Thickness	Weight
Model S.S	0.13	0.043	0.26
Model M.S.	0.014	0.005	0.029
Model DF	9	9	9
Error S.S.	0.14	0.062	0.2
Error M.S.	0.014	0.006	0.02
Error DF	10	10	10
F ratio	1.04	0.77	1.48
F Table	3.02	3.02	3.02
R square%	48	41	57
Std. dev.	0.12	0.079	0.14
Mean	0.64	0.54	53.93
C.V.%	18.38	14.75	0.26

Table 4.4. ANOVA for best fit model for physical properties of canned green chickpea (Desi type)

Source	Length	Thickness	Weight
Model S.S	0.089	0	0.14
Model M.S.	0.045	0	0.14
Model DF	2	0	1
Error S.S.	0.18	0.11	0.32
Error M.S.	0.011	0.006	0.018
Error DF	17	19	18
F ratio	4.24	0	8.16
F Table	3.95	0	4.41
R square%	33	0	31
Std. dev.	0.1	0.075	0.13
Mean	0.64	0.55	53.93
C.V.%	16.02	13.93	0.25

Table 4.5. Chemical composition of canned green chickpea (Desi type)

Exp.No.	Moisture %	Protein %	Fat %	Carbohydrate %	Ash %	Fibre %	Acidity %	Total sugar %	Total phenol %
1	58.30	8.72	2.39	26.30	1.0	7.39	0.07	5.1	2.29
2	58.10	8.70	2.43	26.10	1.2	7.31	0.09	5.1	2.40
3	58.60	8.79	2.44	26.23	1.0	7.30	0.07	4.9	2.29
4	58.50	8.69	2.47	26.31	1.1	7.32	0.09	4.9	2.49
5	58.00	8.71	2.45	26.20	1.3	7.35	0.07	5.1	2.40
6	58.34	8.73	2.43	26.16	1.0	7.34	0.09	5.1	2.29
7	58.58	8.72	2.47	26.13	1.2	7.33	0.08	4.7	2.20
8	58.39	8.75	2.46	26.15	1.3	7.31	0.09	5.0	2.33
9	58.15	8.74	2.45	26.18	1.0	7.36	0.08	5.1	2.29
10	58.02	8.78	2.49	26.13	1.1	7.35	0.08	5.1	2.29
11	58.72	8.71	2.48	26.14	1.0	7.36	0.06	5.3	2.33
12	59.00	8.70	2.47	26.13	1.0	7.32	0.10	4.8	2.40
13	58.47	8.77	2.46	26.16	1.2	7.33	0.08	5.0	2.49
14	58.63	8.74	2.43	26.15	0.9	7.30	0.09	5.1	2.20
15	59.02	8.73	2.49	26.37	1.4	7.39	0.08	5.1	2.40
16	59.02	8.73	2.49	26.37	1.4	7.39	0.08	5.1	2.40
17	59.02	8.73	2.49	26.37	1.4	7.39	0.08	5.1	2.40
18	59.02	8.73	2.49	26.37	1.4	7.39	0.08	5.1	2.40
19	59.02	8.73	2.49	26.37	1.4	7.39	0.08	5.1	2.40
20	59.02	8.73	2.49	26.37	1.4	7.39	0.08	5.1	2.40

Table 4.6 Regression coefficients of full second order model and significant term for chemical attributes of canned green chickpea (Desi type)

Co-efficient	Moisture	Acidity	Total sugar	Total phenol
Constant	59.02	0.08	5.1	2.4
linear				
1	-0.005	0.005**	0.022	0.024
2	0.132***	0.006**	-0.127***	0.003
3	0.006	0.002	0.005	-0.054***
Interactive				
1.2	-0.054	-0.001	0.038	0.041**
1.3	0.056	-0.001	0.038	-0.036
2.3	-0.009	0.001	-0.012	-0.031
Quadratic				
1.1	-0.33***	0	-0.016	-0.037***
2.2	-0.088**	0	-0.034	-0.011
3.3	-0.197***	0.002	-0.034	-0.018

*** Significant at 1%

** Significant at 5%

1 Holding time

2 Brine conc.

3 Blanching time

Table 4.7. ANOVA for full second order regression model for chemical composition of canned green chickpea (Desi type)

Source	Moisture	Acidity	Total Sugar	Total phenol
Model S.S	2.27	0.00093	0.28	0.104
Model MS.	0.25	0.0001	0.032	0.012
Model DF.	9	9	9	9
Error SS.	0.16	0.00065	0.045	0.022
Error MS.	0.016	6.50E-05	0.0045	0.0022
Error DF.	10	10	10	10
F ratio	15.56	1.58	7	5.35
F Table	3.02	3.02	3.02	3.02
R Square %	93	59	86	83
Std. dev.	0.13	0.0081	0.067	0.046
Mean	58.61	0.081	5.05	2.35
C.V.%	0.22	9.97	1.33	1.97

Table 4.8. ANOVA for best fit model for chemical composition canned green chickpea (Desi type)

Source	Moisture	Acidity	Total Sugar	Total phenol
Model S.S	2.22	0.0008	0.22	0.098
Model MS.	0.56	0.0004	0.22	0.016
Model DF.	4	2	1	6
Error SS.	0.21	0.00078	0.11	0.028
Error MS.	0.014	4.61E-05	0.006	0.0021
Error DF.	15	17	18	13
F ratio	39.29	8.63	37.13	7.67
F Table	3.06	3.59	4.41	2.92
R Square %	91	50	67	78
Std. dev.	0.12	0.0068	0.077	0.046
Mean	58.61	0.081	5.05	2.35
C.V.%	0.2	8.38	1.53	1.96

Table 4.9 Sensory qualities attribute score of canned green chickpea (Desi type)

Exp.No.	Colour	Taste	Texture
1	7.2	7.9	7.4
2	6.9	7.2	7.2
3	7.3	6.9	7.9
4	7.3	6.8	7.3
5	7.0	7.1	6.9
6	6.9	7.1	7.1
7	7.2	6.9	7.2
8	7.0	6.8	6.9
9	8.0	8.0	7.9
10	6.8	6.8	6.8
11	7.6	8.1	7.1
12	7.2	6.8	7.3
13	7.6	7.6	7.9
14	7.6	7.3	7.0
15	7.8	7.7	7.6
16	7.7	7.8	7.5
17	7.6	7.5	7.8
18	7.5	7.6	7.6
19	7.6	7.6	7.6
20	7.7	7.8	7.5

Table 4.10. Regression coefficient of full second order model and significant term for sensory attributes of canned green chickpea (Desi type)

Co-efficient	Colour	Taste	Texture
Constant	7.66	7.68	7.6
Linear			
1	-0.19**	-0.21**	-0.2***
2	0.009	-0.3***	-0.076
3	-0.044	-0.103	-0.24***
Interactive			
1.2	0.025	0.063	-0.11
1.3	0	0.088	0.088
2.3	-0.025	0.11	-0.062
Quadratic			
1.1	-0.16	-0.16**	-0.11**
2.2	-0.16	-0.15	-0.16***
3.3	-0.09	-0.15	-0.07

*** Significant at 1%

** Significant at 5%

1 Holding time

2 Brine conc.

3 Blanching time

Table 4.11. ANOVA for full second order regression model for sensory properties of canned green chickpea (Desi type)

Source	Colour	Taste	Texture
Model S.S	1.3	3.027	2.091
Model M.S.	0.14	0.34	0.23
Model DF	9	9	9
Error S.S.	0.92	0.76	0.25
Error MS	0.092	0.076	0.025
Error DF	10	10	10
F ratio	1.57	4.43	9.42
F Table	3.02	3.02	3.02
R square %	59	80	89
Std. dev.	0.3	0.28	0.16
Mean	7.37	7.36	7.37
C.V.%	4.11	3.74	2.13

Table 4.12. ANOVA for best fit regression model of sensory properties of canned green chickpea (Desi type)

Source	Colour	Taste	Texture
Model S.S	1.14	1.85	1.75
Model M.S.	0.38	0.92	0.44
Model DF	3	2	4
Error S.S.	1.081	1.94	0.59
Error MS	0.068	0.11	0.039
Error DF	16	17	15
F ratio	5.61	8.09	1.12
F Table	3.24	3.59	3.06
R square %	51	49	75
Std. dev.	0.26	0.34	0.2
Mean	7.38	7.37	7.38
C.V.%	3.52	4.59	2.69

Table 4.13. Cut out examination of canned green chickpea (Desi type)

Exp. No.	Ext. app.	Weight				Inspection of contents	Internal condition of the can	Brine appearance			pH content	Head space (mm)	Vacuum (Kg/cm ²)	CFU Per ml
		Gross Wt.	Net Wt.	Drain Wt.	Can Wt.			Colour	Clarity	Flavor				
1	Swell	557	496	102	61	S	S	Light green	Translucent	Acidic	5.6	0.3	0.09	21
2	N	557	498	101	59	S	S	Light green	Translucent	Acidic	5.6	0.2	0.14	05
3	N	558	498	103	60	S	S	Light green	Translucent	Acidic	5.7	0.3	0.11	19
4	Swell	559	499	103	60	S	S	Light green	Translucent	Acidic	5.8	0.2	0.16	05
5	N	571	509	104	62	S	S	Light green	Translucent	Acidic	5.8	0.1	0.08	21
6	N	560	499	103	61	S	S	Light green	Translucent	Acidic	5.7	0.3	0.15	07
7	N	563	503	103	60	S	S	Light green	Translucent	Acidic	5.7	0.1	0.11	20
8	N	557	496	102	61	S	S	Light green	Translucent	Acidic	5.8	0.3	0.13	07
9	Swell	559	498	102	61	S	S	Light green	Translucent	Acidic	5.8	0.2	0.7	24
10	N	564	503	104	61	S	S	Light green	Translucent	Acidic	5.7	0.3	0.18	04
11	N	563	503	102	60	S	S	Light green	Translucent	Acidic	5.4	0.1	0.12	17
12	N	562	503	103	59	S	S	Light green	Translucent	Acidic	6.3	0.1	0.13	08
13	N	568	506	104	62	S	S	Light green	Translucent	Acidic	5.8	0.3	0.11	12
14	N	571	510	105	61	S	S	Light green	Translucent	Acidic	5.8	0.05	0.13	14
15	N	558	499	102	59	S	S	Light green	Translucent	Acidic	5.8	0.3	0.11	12
16	N	565	505	102	60	S	S	Light green	Translucent	Acidic	5.8	0.2	0.12	12
17	N	557	496	103	61	S	S	Light green	Translucent	Acidic	5.8	0.1	0.11	10
18	N	560	499	101	61	S	S	Light green	Translucent	Acidic	5.8	0.3	0.13	12
19	N	558	498	101	60	S	S	Light green	Translucent	Acidic	5.8	0.2	0.12	11
20	N	560	501	103	59	S	S	Light green	Translucent	Acidic	5.8	0.3	0.12	14

Table 4.14. Regression coefficient of full second order model and significant term for cut out examination of canned green chickpea (Desi type)

Coefficient	Drain Weight	pH	Head space	Vacuum	CFU Per ml
Constant	102	5.8	0.23	0.12	11.84
Linear					
1	0.03	0	0.03	-0.05	-6.64***
2	0.2	0.13***	0	0	-1.33**
3	0.34	0.02	-0.05**	0	0.61
Interaction					
1.2	0.13	0.04	0	-0.01	0.38
1.3	-0.12	-0.01	0.08**	0	0.38
2.3	-0.62	-0.04	0	0	0.13
Quadratic					
1.1	0.19	-0.04	0.02	0.09**	0.74
2.2	0.01	0	-0.04	-0.02	0.21
3.3	0.72**	-0.02	-0.01	-0.02	0.39

*** Significant at 1%

** Significant at 5%

1 Holding time.

2 Brine conc.

3 Blanching time.

Table 4.15. ANOVA for full second order regression model for cut out examination of canned green chickpea (Desi type)

Source	Drain weight	pH content	Head space	Vacuum	CFU per ml
Model S.S	13.2	0.29	0.11	0.18	642
Model MS.	1.47	0.033	0.012	0.02	71.4
Model DF.	9	9	9	9	9
Error SS.	9.35	0.21	0.051	0.15	31.16
Error MS.	0.93	0.021	0.005	0.0015	3.12
Error DF.	10	10	10	10	10
F ratio	1.57	1.54	2.39	1.34	22.92
F Table	3.02	3.02	3.02	3.02	3.02
R Square %	59	58	68	55	95
Std. dev.	0.97	0.15	0.071	0.12	1.77
Mean	103	5.77	0.21	0.15	12.75
C.V.%	0.94	2.52	33.48	79.69	13.84

Table 4.16. ANOVA for best fit regression model of cut out examination of canned green chickpea (Desi type)

Source	Drain weight	pH content	Head space	Vacuum	CFU Per ml
Model S.S	10.31	0.24	0.093	0.16	625
Model MS.	5.15	0.24	0.031	0.082	313
Model DF.	2	1	3	2	2
Error SS.	12.24	0.26	0.067	0.16	48.15
Error MS.	0.72	0.015	0.004	0.009	2.83
Error DF.	17	18	16	17	17
F ratio	7.15	6.38	7.43	8.59	110
F Table	3.59	4.41	3.24	3.59	3.59
R Square %	46	48	58	50	93
Std. dev.	0.85	0.12	0.065	0.098	1.68
Mean	103	5.77	0.21	0.15	12.75
C.V.%	0.83	2.1	30.36	63.97	13.2

Table 4.17. Best fit models of chemical composition for various responses of canned green chickpea (Desi type)

Moisture	YD ₄	$58.34064+0.14801X_2-4.56665E-005X_1-0.010259X_2-2.89446E-003X_3$
Total sugar	YD ₁₁	$5.29995-0.063737X_2$
Total phenol	YD ₁₂	$1.30999+0.037697X_1+0.12733X_3+1.12746E-003X_1*X_2-2.41667E-003X_1*X_3-0.013649X_2*X_3-3.48132E-044X_1$

Table 4.18. Best fit models of sensory for various responses of canned green chickpea (Desi type)

Taste	YD ₁₄	$8.92497-0.021368X_1-0.14961X_2$
Texture	YD ₁₅	$7.15056+0.055323X_1-0.15687X_3-8.38439E-004X_1^2+2.08457E-003X_2^2$

Table 4.19. Best fit models of cut out examination for various responses of canned green chickpea (Desi type)

Total bacterial plate count	YD ₂₀	$45.27093-0.66367X_1-0.66399X_2$
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Section B: Canned green chickpea (Kabuli type)

4.5 Physical properties of canned green chickpea (kabuli type)

4.5.1 Length

The table 4.20 indicates the result of effect of canning process parameter level on length of canned green chickpea (kabuli type) at 60 days storage. It varied from 0.9 to 1.3 cm. Length was highest at Exp. no. 5, 9, 14 and 19 and lowest at Exp. no. 1, 3, 8, 16 and 18. The analysis of variance table for full second order regression model (Table 4.22) indicated that the F ratio of the model 1.48 was lower as compared with the table value of 3.02 at 5% level of significance. The R^2 value of model was 60%.

4.5.2 Thickness

The thickness of canned green chickpea (kabuli type) varied from 0.6 to 0.9 cm (Table 4.20). Thickness was highest at Exp. no. 5, 6, 13, 14, 19 and 20 and lowest at Exp. no. 1, 8, 12 and 18. The quadratic model fitting results shows that F ratio (2.22) of the model was lower as compared with the table value of (3.02) at 5% level of significance. The R^2 value of model was only 67%. The lower R^2 value and insignificant F value reveals that linear, quadratic and interactive terms of model are not significant therefore the model was not considered for further analysis

4.5.3 Weight

The table 4.20 depicts the result of effect of process parameters on weight of canned green chickpea. The weight of canned green chickpea (kabuli type) varied from 58.70 to 59.00 g. Weight was highest at Exp. no. 6 and lowest at Exp. no. 15. These experiments represented the combination of parameter as 55.00 min, 2.00%, 5.00 min and 45.00 min, 4.00%, 3.50 min of holding time (min), brine concentration (%) and

blanching time (min) respectively. The ANOVA table of regression model (Table 4.22) indicated that the F ratio (0.79) of the model was lower as compared with the table value (3.02) at 5% level of significance. The R^2 value of model was 42%. The model was found unadequate for further analysis.

4.5.4 Colour

The table 4.20 reveals the result of effect of process parameters on colour of canned green chickpea (kabuli type) during storage. The Hunter colour value of canned green chickpea varied from L-value 14.37 to 42.86, a-value -6.47 to 4.86 and b-value 6.58 to 20.63.

4.6 Chemical composition of canned green chickpea (kabuli type)

4.6.1 Moisture

The moisture content of canned green chickpea (kabuli type) varied from 60.21 to 60.54% (Table 4.24). It was highest at Exp. no. 11 and lowest at Exp. no. 14. These experiments represented the combination of independent variables of holding time (min), brine concentration (%) and blanching time (min) as 45.00 min, 0.64%, 3.50 min and 45.00 min, 4.00%, 6.02 min respectively. The ANOVA table for regression model (Table 4.26) indicated that model F ratio was 23.48 higher as compared with the table value of 3.02 at 5% level of significance. The R^2 value of model was 95%. The model was found adequate for further analysis.

Table 4.25 indicates that moisture content of canned green chickpea (kabuli type) was significantly affected by holding time, brine concentration and blanching time. The linear effect of holding time was highly significant at 1% level of confidence. The interactions of holding time – brine concentration was at 5% level of significance. The quadratic effect of holding time and blanching time were highly

significant at 1% level of confidence and brine concentration was significant at 5% level of confidence. The rest of term of model were non-significant.

4.6.2 Protein

The protein content in canned green chickpea (kabuli type) varied from 8.94 to 9.17% (Table 4.24). It was highest at Exp. no. 15, 16, 17, 18, 19 and 20 and lowest at Exp. no. 5 and 14. These experiments represented the combination of parameter as (45.00 min, 4.00%, 3.50 min), (45.00 min, 4.00%, 6.02 min) and (35.00 min, 2.00%, 5.00 min) of holding time (min), brine concentration (%) and blanching time (min) respectively.

4.6.3 Fat

Table 4.24 exhibits the result of fat content in kabuli type canned green chickpea at 60 days storage. It was observed highest at Exp. no. 11 (2.74) and lowest at Exp. no. 12 (2.57) percent. These experiments represented the combination of canning variables as 45.00 min, 0.64%, 3.50 min and 45.00 min, 7.36%, 3.50 min of holding time (min), brine concentration (%) and blanching time (min) respectively.

4.6.4 Carbohydrate

The carbohydrate content of canned green chickpea (kabuli type) varied from 27.4 to 27.53%. Carbohydrate was highest at Exp. no. 5 and lowest at Exp. no. 1, 3, 4, 7, 8, 10, 11, 15, 16, 17, 18, 19 and 20.

4.6.5 Ash

The Ash content in canned green chickpea (kabuli type) at 60 days storage is presented in table 4.24. The ash of canned green chickpea (kabuli type) varied from 1.8 to 2.04%. Ash was highest at Exp. no. 15, 16, 17, 18, 19 and 20 and lowest at Exp. no. 1, 8. These experiments represented the combination of parameter as (45.00 min,

4.00%, 3.50 min), (35.00 min, 2.00%, 2.00 min) and (55.00 min, 6.00%, 5.00 min) of holding time (min), brine concentration (%) and blanching time (min) respectively.

4.6.6 Fibre

The fibre content of canned green chickpea (kabuli type) varied from 7.60 to 7.69% (table 4.24) It was highest at Exp. no. 5 and lowest at Exp. no. 9. These experiments represented the combination of parameter as (35.00 min, 2.00%, 5.00 min) and (28.18 min, 4.00%, 3.50 min) of holding time (min), brine concentration (%) and blanching time (min) respectively.

4.6.7 Acidity

The acidity of canned green chickpea (kabuli type) varied from 0.06 to 0.09% (Table 4.24) The acidity of chickpea was highest at Exp. no. 11 and lowest at Exp. no. 12. These experiments represented the combination of parameter as 45.00 min, 0.64%, 3.50 min and 45.00 min, 7.36%, 3.50 min of holding time (min), brine concentration (%) and blanching time (min) respectively. The analysis of variance table for full second order regression model (Table 4.26) indicated that the F ratio of the model 2.09 was lower as compared with the table value of 3.02 at 5% level of significance. The R^2 value of model was 65%.

Table 4.25 indicates the linear effect of brine concentration was significant at 5% level of confidence. The rest of linear, interaction and quadratic term of model were non-significant even at 1% and 5% level of significance.

4.6.8 Total Sugar

Table 4.24 shows the results of total sugar content kabuli type canned green chickpea. The sugars were found to varied from 4.6 to 4.8 percent. Total sugar was highest at Exp. no. 3, 5, 7, 10, 14 and lowest at Exp. no. 1, 6, 9. The ANOVA table shows that the F ratio (1.4) of the

model was lower as compared with the table value (3.02) at 5% level of significance. The R^2 value of model was 56 percent.

4.6.9 Total Phenol

The table 4.24 presents the result of effect of process parameter on total phenol of canned green chickpea (kabuli type) at 60 days storage. The total phenol of canned green chickpea (kabuli type) varied from 2.4 to 2.5 percent. Total phenol was highest at Exp. no. 1, 2, 3, 5, 6, 9, 10, 11, 13, 17 and 18 and lowest at Exp. no. 20. The analysis of variance table for full second order regression model (Table 4.26) indicated that the F ratio of the model 0.73 was lower as compared with the table value of 3.02 at 5% level of significance. R^2 value of model was 40%. The model was found adequate for further analysis.

4.7 Sensory quality attributes of canned green chickpea (kabuli type) at 60 days storage

4.7.1 Colour

The result of effect of combination canning parameter on colour score of canned green chickpea (kabuli type) varied from 7.0 to 8.0. The Colour score was highest at Exp. no. 9 and lowest at Exp. no. 2, 6, 10. These experiments represented the combination of parameter as (28.18 min, 4.00%, 3.50 min), (55.00 min, 2.00%, 2.00 min), (55.00 min, 2.00%, 5.00 min) and (61.28 min, 4.00%, 3.50 min) of holding time (min), brine concentration (%) and blanching time (min) respectively. The regression model analysis of variance (Table 4.30) shows that the F ratio (1.48) of the model was lower as compared with the table value (3.02) at 5% level of significance. The R^2 value of model was 57%. The model was found inadequate for further analysis.

Table 4.29 indicates that model fitting results for colour score of canned green chickpea (kabuli type) were non-significant. The linear effect of holding time was significant at 5% level of confidence. The rest

of the linear, quadratic and interactions of model were non-significant at 1% and 5% level of significance.

4.7.3 Taste

The table 4.28 informs the result of taste sensory core of caned chickpea. It varied from 6.9 to 8.1. The taste score was highest at Exp. no. 11 and lowest at Exp. no. 4 and 8. These experiments represented the combination of parameter as (45.00 min 0.64%, 3.50 min), (55.00 min, 6.00%, 2.00 min) and (55.00 min, 6.00%, 5.00 min) of holding time (min), brine concentration (%) and blanching time (min) respectively. The analysis of variance table for full second order regression model (Table 4.30) indicated that the F ratio of the model 5.15 was higher as compared with the table value of 3.02 at 5% level of significance. R^2 value of model was 82%. The model was found adequate for further analysis.

Table 4.29 indicates that taste of canned green chickpea (kabuli type) were significant in model of variance. The linear effect of addition of holding time and brine concentration was highly at 1% significant level of confidence. The quadratic effect of addition of blanching time was significant at level of 5%. The rest of the linear, interactions and quadratic term of model were non-significant even at 1% and 5% level of significance.

4.7.4 Texture

The table 4.28 shows the result of effect of process parameter on texture of canned green chickpea (kabuli type). It varied from 7.0 to 8.0. Texture was highest at Exp. no. 3 and 13 and lowest at Exp. no. 5 and 8. The results of analysis of variance test shows that F ratio (13.13) of the model was higher as compared with the table value of 3.02 at 5% level of significance. The higher R^2 value (92%) of model shows that model is acceptable.

Table 4.29 indicates that the linear effect of holding time and blanching time was highly significant at 1% level of confidence. The interaction between holding time – brine concentration and holding time – blanching time was significant at 5% level of significance. The quadratic effect of addition of brine concentration was also highly significant at 1% level of confidence. The rest of terms of model were non-significant even at 1% and 5% level of significance.

4.8 Cut out examination of canned green chickpea (kabuli type) at 60 days of storage

4.8.1 Drain weight

The drain weight of canned green chickpea (kabuli type) is presented in Table 4.32. It varied from 101g to 105 g. Drain weight was highest at Exp. no. 14 and lowest at Exp. no. 19. These experiments represented the combination conditions of holding time (min), brine concentration (%) and blanching time (min) parameter as 45.00 min, 4.00%, 6.02 min and 45.00 min, 4.00%, 3.50 min respectively. The F ratio (0.64) of the model was lower as compared with the table value 3.02 at 5% level of significance. The R^2 value of model was also very low i.e. 37 percent.

4.8.2 pH content

The pH content of canned green chickpea (kabuli type) varied from 5.4 to 5.8 (Table 4.32). pH content was highest at Exp. no. 4, 5, 8, 9, 13, 14, 15, 16, 17, 18, 19, 20 and lowest at Exp. no. 10. The calculated F ratio (1.54) of the model was lower as compared with the table value 3.02 at 5% level of significance (Table 4.34). The R^2 value of model was 58%

Table 4.33 indicates that the linear effect of addition of brine concentration was highly at 1% significant level of confidence. The rest

of terms of model were non-significant even at 1% and 5% level of significance.

4.8.3 Head space

The table 4.32 comprises the result of effect of canning condition on head space of canned green chickpea (kabuli type). The head space in cans varied from 0.05 to 0.30. Head space was highest at Exp. no. 4, 8, 9, 10, 13, 15, 20 and lowest at Exp. no. 14. The analysis of variance table for full second order regression model (Table 4.34) indicated that the F ratio (2.23) of model was lower as compared with the table value of 3.02 at 5% level of significance. The R^2 value of model was 67%.

Table 4.33 indicates that the linear effect of addition of blanching time at 5% significant level of confidence. The other linear, interactive and quadratic terms of model were non-significant even at 1% and 5% level of significance.

4.8.4 Vacuum pressure

The effect of process parameter on vacuum pressure of canned green chickpea (kabuli type) at 60 days storage is presented in table 4.32. The vacuum pressure of cans varies from 0.07 to 0.18 bar. Vacuum pressure was highest at Exp. no. 9 and lowest at Exp. no. 10. These experiments represented the combination of parameter as 28.18 min, 4.00%, 3.50 min and 61.82 min, 4.00%, 3.50 min of holding time (min), brine concentration (%) and blanching time (min) respectively. The F ratio (1.34) of model was lower as compared with the table value of 3.02 at 5% level of significance along with 55% R^2 value of model.

Table 4.33 indicates that the quadratic effect of addition of holding time was significant at level of 5%. The rest of the linear, interactions and quadratic terms of model were non-significant.

4.8.5 Total bacterial plate count in canned green kabuli type chickpea

The table 4.32 shows that total bacterial plate count of canned green varies from 3 to 21 CFU per ml. The Total plate count was highest at Exp. no. 9 (28.18 min, 4.00%, 3.50 min) and lowest at Exp. no. 2. (55.00 min, 2.00%, 2.00 min) that represents combination independent variables of holding time (min), brine concentration (%) and blanching time (min) respectively. The analysis of variance table for full second order regression model (Table 4.34) indicated that the F ratio (12.01) of the model was higher as compared with the table value of 3.02 at 5% level of significance. The R^2 value of model was 92%. The model was found to be adequate for further analysis and evaluation.

Table 4.33 indicates that the linear effect of holding time was highly significant at 1% level of confidence. The rest of the linear, interactions and quadratic term of model were non-significant even at 1% and 5% level of significance.

Table 4.20. Physical properties of canned green chickpea (Kabuli type)

Exp.No.	Length (cm)	Thickness (mm)	Weight (g)	Hunter colour value		
				L	a	b
1	0.9	0.6	57.32	42.86	4.32	20.35
2	1.2	0.8	58.03	39.70	2.96	14.15
3	0.9	0.7	58.70	42.81	4.86	20.63
4	1.1	0.8	58.00	38.60	3.01	15.10
5	1.3	0.9	57.74	40.25	4.25	19.05
6	1.1	0.9	59.00	32.29	6.33	16.17
7	1.2	0.8	58.99	41.20	4.20	18.90
8	0.9	0.6	58.99	33.40	4.30	17.10
9	1.3	0.7	58.00	42.46	4.32	20.35
10	0.9	0.7	58.70	37.60	3.10	14.60
11	1.2	0.8	58.00	31.10	-6.47	15.91
12	0.9	0.6	57.74	32.28	-6.30	16.10
13	1.1	0.9	59.00	32.20	-6.31	16.15
14	1.3	0.9	58.03	14.37	2.91	6.35
15	1.2	0.7	58.70	29.11	-6.21	14.42
16	0.9	0.7	58.00	26.34	4.13	12.22
17	1.1	0.8	57.74	16.01	2.65	6.58
18	0.9	0.6	58.99	29.14	-6.04	14.60
19	1.3	0.9	58.99	23.08	2.96	10.35
20	1.2	0.9	58.00	29.10	-6.20	14.40

Table 4.21. Regression coefficient of full second order model and significant terms for physical properties of canned green chickpea (Kabuli type)

Coefficient	Length	Thickness	Weight
Constant	1.1	0.77	58.4
linear			
1	-0.049	0.007	0.179
2	-0.066	-0.047	0.158
3	0.054	0.022	0.076
Interactive			
1.2	-0.025	-0.038	-0.334
1.3	-0.125**	-0.063	0.156
2.3	-0.025	-0.063	-0.014
Quadrative			
1.1	-0.009	-0.024	0.005
2.2	-0.027	-0.024	-0.17
3.3	0.026	0.046	0.063

*** Significant at 1%

** Significant at 5%

1 Holding time

2 Brine conc.

3 Blanching time

Table 4.22. ANOVA for full second order regression model for physical properties of canned green chickpea (Kabuli type)

Source	Length	Thickness	Weight
Model S.S	0.29	0.16	2.34
Model M.S.	0.032	0.018	0.27
Model DF	9	9	9
Error S.S.	0.2	0.081	3.41
Error M.S.	0.02	0.0081	0.34
Error DF	10	10	10
F ratio	1.63	2.24	0.79
F Table	3.02	3.02	3.02
R square%	60	67	42
Std. dev.	0.14	0.09	0.58
Mean	1.1	0.77	58.33
C.V.%	12.85	11.79	1.001

Table 4.23. ANOVA for best fit model for physical properties of canned green chickpea (Kabuli type)

Source	Length	Thickness	Weight
Model S.S	0.18	0.038	0.89
Model M.S.	0.092	0.038	0.038
Model DF	2	1	1
Error S.S.	0.3	0.21	4.95
Error M.S.	0.018	0.021	0.27
Error DF	17	18	18
F ratio	5.16	3.26	3.24
F Table	3.59	4.41	4.41
R square%	38	15	15
Std. dev.	0.13	0.11	0.52
Mean	1.1	0.77	58.33
C.V.%	12.22	14.05	0.9

Table 4.24. Chemical composition of canned green chickpea (Kabuli type)

Exp.No.	Moisture %	Protein %	Fat %	Carbohydrate %	Ash %	Fibre %	Acidity %	Total sugar %	Total phenol %
1	60.40	8.95	2.68	27.40	1.08	7.08	0.07	4.8	2.40
2	60.30	8.99	2.66	27.43	1.09	7.65	0.08	4.8	2.49
3	60.29	9.10	2.70	27.40	1.85	7.62	0.07	4.8	2.50
4	60.32	9.00	2.69	27.40	1.86	7.66	0.08	4.7	2.49
5	60.41	8.94	2.71	27.53	1.88	7.69	0.08	4.8	2.50
6	60.28	8.96	2.70	27.50	1.91	7.62	0.08	4.8	2.40
7	60.37	8.95	2.64	27.40	1.95	7.67	0.08	4.6	2.50
8	60.34	8.95	2.56	27.40	1.08	7.61	0.08	4.7	2.49
9	60.42	9.14	2.68	27.49	1.93	7.60	0.08	4.8	2.40
10	60.32	9.00	2.69	27.40	1.86	7.66	0.08	4.8	2.50
11	60.54	9.11	2.74	27.43	1.84	7.66	0.06	4.8	2.49
12	60.47	9.15	2.57	27.40	2.00	7.07	0.09	4.7	2.40
13	60.33	9.14	2.70	27.48	2.01	7.68	0.08	4.8	2.49
14	60.21	8.94	2.63	27.50	1.94	7.64	0.08	4.7	2.50
15	60.55	9.17	2.72	27.40	2.04	7.65	0.07	4.7	2.49
16	60.55	9.17	2.72	27.40	2.04	7.65	0.07	4.6	2.49
17	60.55	9.17	2.72	27.40	2.04	7.65	0.07	4.8	2.49
18	60.55	9.17	2.72	27.40	2.04	7.65	0.07	4.7	2.49
19	60.55	9.17	2.72	27.40	2.04	7.65	0.07	4.8	2.49
20	60.55	9.17	2.72	27.40	2.04	7.65	0.07	4.6	2.49

Table 4.25 Regression coefficients of full second order model and significant term for chemical attributes of canned green chickpea (Kabuli type)

Co-efficient	Moisture	Acidity	Total sugar	Total phenol
Constant	66.55	0.07	4.7	2.49
Linear				
1	-0.029***	0.001	0	0.01
2	-0.014	0.004**	-0.042	0.003
3	-0.008	0.001	-0.027	0.002
Interactive				
1.2	0.029**	0	0	-0.001
1.3	-0.011	-0.003	0.025	-0.024
2.3	0.014	0	-0.025	-0.001
Quadratic				
1.1	-0.071***	0.003	0.031	-0.012
2.2	-0.023**	0.001	0.013	-0.014
3.3	-0.106***	0.003	0.013	0.004

*** Significant at 1%

** Significant at 5%

1 Holding time

2 Brine conc.

3 Blanching time

Table 4.26 ANOVA for full second order regression model for chemical composition of canned green chickpea (Kabuli type)

Source	Moisture	Acidity	Total Sugar	Total phenol
Model S.S	0.24	0.0058	0.06	0.011
Model MS.	0.027	6.50E-05	0.0067	0.0012
Model DF.	9	9	9	9
Error SS.	0.011	0.00031	0.048	0.017
Error MS.	0.0011	3.10E-05	0.0048	0.0017
Error DF.	10	10	10	10
F ratio	23.48	2.09	1.4	0.73
F Table	3.02	3.02	3.02	3.02
R Square %	95	65	56	40
Std. dev.	0.034	0.006	0.069	0.041
Mean	60.42	0.076	4.74	2.47
C.V.%	0.056	7.38	1.46	1.67

Table 4.27 ANOVA for best fit model for chemical composition canned green chickpea (Kabuli type)

Source	Moisture	Acidity	Total Sugar	Total phenol
Model S.S	0.23	0.0004	0.024	0.004
Model MS.	0.047	0.00015	0.024	0.0045
Model DF.	5	3	1	1
Error SS.	0.017	0.00045	0.084	0.024
Error MS.	0.0012	2.80E-05	0.0047	0.0013
Error DF.	14	16	18	18
F ratio	37.64	5.25	5.04	3.44
F Table	2.96	3.24	4.41	4.41
R Square %	93	50	22	16
Std. dev.	0.035	0.0053	0.068	0.036
Mean	60.42	0.076	4.74	2.47
C.V.%	0.058	7.033	1.44	1.46

Table 4.28 Sensory qualities attribute score of canned green chickpea (Kabuli type)

Exp.No.	Colour	Taste	Texture
1	7.3	8.0	7.5
2	7.0	7.3	7.3
3	7.4	7.0	8.0
4	7.4	6.9	7.4
5	7.1	7.2	7.0
6	7.0	7.2	7.3
7	7.3	7.1	7.3
8	7.1	6.9	7.0
9	8.0	8.0	7.9
10	7.0	7.0	7.0
11	7.7	8.1	7.1
12	7.3	7.0	7.3
13	7.6	7.4	8.0
14	7.6	7.3	7.1
15	7.8	7.7	7.6
16	7.7	7.8	7.5
17	7.6	7.5	7.7
18	7.6	7.6	7.6
19	7.7	7.6	7.6
20	7.7	7.8	7.5

Table 4.29 Regression coefficient of full second order model and significant term for sensory attributes of canned green chickpea (Kabuli type)

Co-efficient	Colour	Taste	Texture
Constant	7.69	7.67	7.58
Linear			
1	-0.17**	-0.2***	-0.17***
2	0.01	-0.27***	0.07
3	-0.04	-0.07	-0.23***
Interactive			
1.2	0.025	0.05	-0.125**
1.3	0	0.075	0.1**
2.3	-0.025	0.125	-0.075
Quadratic			
1.1	-0.013	-0.11	-0.06
2.2	-0.013	-0.09	-0.14***
3.3	-0.1	-0.17**	-0.02

*** Significant at 1%

** Significant at 5%

₁ Holding time

₂ Brine conc.

₃ Blanching time

Table 4.30 ANOVA for full second order regression model for sensory properties of canned green chickpea (Kabuli type)

Source	Colour	Taste	Texture
Model S.S	0.96	2.36	1.74
Model M.S.	0.96	2.36	0.19
Model DF	9	9	9
Error S.S.	0.73	0.51	0.15
Error MS	0.073	0.051	0.015
Error DF	10	10	10
F ratio	1.48	5.15	13.13
F Table	3.02	3.02	3.02
R square %	57	82	92
Std. dev.	0.27	0.23	0.12
Mean	7.45	7.42	7.44
C.V.%	3.62	3.042	1.63

Table 4.31 ANOVA for best fit regression model of sensory properties of canned green chickpea (Kabuli type)

Source	Colour	Taste	Texture
Model S.S	0.38	1.82	1.65
Model M.S.	0.38	0.61	0.25
Model DF	1	3	6
Error S.S.	1.31	1.053	0.24
Error MS	0.073	0.066	0.018
Error DF	18	16	13
F ratio	5.25	9.21	14.9
F Table	4.4	3.24	2.92
R square %	23	63	87
Std. dev.	0.27	0.26	0.14
Mean	7.45	7.42	7.44
C.V.%	3.62	3.46	1.82

Table 4.32 Cut out examination of canned green chickpea (Kabuli type)

Exp. No.	Ext. app.	Weight				Inspection of contents	Internal condition of the can	Brine appearance			pH content	Head space (mm)	Vacuum (Kg/cm ²)	CFU Per ml
		Gross Wt.	Net Wt.	Drain Wt.	Wt. of can			Colour	Clarity	Flavor				
1	Swell	568	506	104	62	S	S	Light green	Translucent	Acidic	5.6	0.2	0.09	17
2	N	559	499	103	60	S	S	Light green	Translucent	Acidic	5.6	0.2	0.14	03
3	N	558	498	103	60	S	S	Light green	Translucent	Acidic	5.7	0.2	0.11	15
4	N	559	499	103	60	S	S	Light green	Translucent	Acidic	5.8	0.3	0.16	05
5	Swell	571	509	104	62	S	S	Light green	Translucent	Acidic	5.8	0.2	0.08	17
6	N	560	499	103	61	S	S	Light green	Translucent	Acidic	5.7	0.1	0.15	07
7	N	563	503	103	60	S	S	Light green	Translucent	Acidic	5.7	0.1	0.11	16
8	N	557	496	102	61	S	S	Light green	Translucent	Acidic	5.8	0.3	0.13	07
9	N	568	506	104	62	S	S	Light green	Translucent	Acidic	5.8	0.3	0.07	21
10	N	564	503	104	61	S	S	Light green	Translucent	Acidic	5.7	0.3	0.18	04
11	N	559	499	103	60	S	S	Light green	Translucent	Acidic	5.4	0.1	0.12	15
12	N	562	503	103	59	S	S	Light green	Translucent	Acidic	6.3	0.2	0.13	08
13	Swell	568	506	104	62	S	S	Light green	Translucent	Acidic	5.8	0.3	0.11	11
14	N	571	510	105	61	S	S	Light green	Translucent	Acidic	5.8	0.05	0.13	13
15	N	558	499	102	59	S	S	Light green	Translucent	Acidic	5.8	0.3	0.11	11
16	N	565	505	102	60	S	S	Light green	Translucent	Acidic	5.8	0.2	0.12	10
17	N	559	499	103	60	S	S	Light green	Translucent	Acidic	5.8	0.1	0.11	10
18	N	568	506	104	62	S	S	Light green	Translucent	Acidic	5.8	0.2	0.13	12
19	N	558	498	101	60	S	S	Light green	Translucent	Acidic	5.8	0.2	0.12	13
20	N	568	506	104	62	S	S	Light green	Translucent	Acidic	5.8	0.3	0.12	15

Table 4.33 Regression coefficient of full second order model and significant term for cut out examination of canned green chickpea (Kabuli type)

Coefficient	Drain Weight	pH	Head space	Vacuum	CFU Per ml
Constant	102.69	5.8	0.22	0.12	17.07
Linear					
1	-0.22	-0.005	0.015	-0.05	-30.39***
2	-0.22	0.13***	0.027	0.0049	-1.16
3	0.05	0.022	-0.045**	0.00027	-0.54
Interaction					
1.2	0.13	0.04	0.05	-0.01	0.63
1.3	-0.12	-0.012	0	-0.0013	1.38
2.3	-0.12	-0.037	0	-0.0037	-1.88
Quadratic					
1.1	0.31	-0.036	0.028	0.09**	16.06
2.2	-0.047	- 0.0007	-0.025	-0.022	2.98
3.3	0.48	-0.018	-0.016	-0.023	2.45

*** Significant at 1%

** Significant at 5%

₁ Holding time.

₂ Brine conc.

₃ Blanching time.

Table 4.34 ANOVA for full second order regression model for cut out examination of canned green chickpea (Kabuli type)

Source	Drain weight	pH content	Head space	Vacuum	CFU per ml
Model S.S	6.28	0.29	0.088	0.18	403.65
Model MS.	0.7	0.033	0.01	0.02	44.85
Model DF.	9	9	9	9	9
Error SS.	10.92	0.21	0.044	0.15	37.35
Error MS.	1.092	0.021	0.0004	0.015	3.74
Error DF.	10	10	10	10	10
F ratio	0.64	1.54	2.23	1.34	12.01
F Table	3.02	3.02	3.02	3.02	3.02
R Square %	37	58	67	55	92
Std. dev.	1.045	0.15	0.066	0.12	1.93
Mean	103.2	5.77	0.21	0.15	11.5
C.V.%	1.013	2.52	31.87	79.69	16.81

Table 4.35 ANOVA for best fit regression model of cut out examination of canned green chickpea (Kabuli type)

Source	Drain weight	pH content	Head space	Vacuum	CFU per ml
Model S.S	3.11	0.24	0.063	0.16	387
Model MS.	3.11	0.24	0.021	0.082	194
Model DF.	1	1	3	2	2
Error SS.	14.09	0.26	0.069	0.16	53.77
Error MS.	0.78	0.015	0.004	0.01	3.16
Error DF.	18	18	16	17	17
F ratio	3.97	16.38	4.89	8.59	61.21
F Table	4.41	4.41	3.24	3.59	3.59
R Square %	18	48	48	50	88
Std. dev.	0.88	0.12	0.07	0.1	1.78
Mean	103.2	5.77	0.21	0.15	11.5
C.V.%	0.86	2.1	31.55	63.97	15.47

Table 4.36 Best fit models of chemical composition for various responses of canned green chickpea (Kabuli type)

Moisture	YK ₄	$59.47967+0.049272X_1+7.44100E-004X_1*X_2-6.12936E-004X_1^2-4.93185E-003X_2^2-2.93282E-003X_3^2$
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Table 4.37 Best fit models of sensory for various responses of canned green chickpea (Kabuli type)

Taste	YK ₁₄	$8.96922-0.019637X_1-0.13363X_2-9.50458E-003X_3^2$
Texture	YK ₁₅	$8.06298-0.015274X_1+0.58939X_2-0.45199X_3-6.25000E-003X_1*X_2+6.66667E-003X_1*X_3-0.034232X_2^2$

Table 4.38 Best fit models of cut out examination for various responses of canned green chickpea (Kabuli type)

Total bacterial plate count	YK ₂₀	$36.95991-0.52421X_1-0.46762X_2$
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DISCUSSION

Intensified health problems of the society resulted in a change of human attitude to the quality of consumed products. Within the last few years the interest in “safe food” has increased significantly. Utilization of canned food products is an area of current interest because of nutritional awareness of consumer and changing demographics. This chapter deals with the justification of the findings obtained in the experiments related to development of canned green chickpea (desi and kabuli type). The results have been explained with the help of reported values of various parameters given by different researchers and they are discussed as under.

5.1 Physical properties of canned green chickpea (Desi and Kabuli type)

The Length, Thickness, Weight of desi and kabuli type canned green chickpea at 60 days of storage varied from 0.5 to 0.8 cm, 0.4 to 0.6 cm, 53.70 to 54.20 g and 0.9 to 1.3 cm, 0.6 to 0.9 cm, 58.70 to 59.00 g respectively. The Hunter colour value of Desi type and Kabuli type was found to be L-value 14.37 to 32.82 & 14.37 to 42.86, a-value -6.47 to 4.13 & -6.47 to 4.86 and b-value 6.35 to 16.15 & 6.58 to 20.63 respectively. The effect of different processing parameter of canning physical properties of stored green chickpea exhibit a non significant effect on product properties in both type of cultivars. However level of brine concentration has caused marginal increase in weight of desi chickpea type during storage. The result a significant effect of brine concentration has been observed at 5% level of confidence. The present finding could be substantiated with the reported results of Yadav *et al.* (1999) and Gupta *et al.* (2005), Erge *et al.* (2008) and Koca *et al.* (2008) Segner *et al.* (1982) Laborde *et al.* (1994). The best fit equation for physical properties could not be developed for want of any significant independent variable terms of model.

5.2 Chemical composition of canned chickpea (Desi and Kabuli type)

The proximate constituents composition in canned green chickpea (desi and kabuli type) during storage were moisture (58.02 to 59.02%; 60.21 to 60.54%) protein (8.69 to 8.79%; 8.94 to 9.17%) carbohydrate (26.1 to 26.37%; 27.4 to 27.53%), fat (2.39 to 2.49%; 2.57 to 2.74%) ash (0.9 to 1.4%; 1.8 to 2.04%) and crude fibre (7.3 to 7.39%; 7.60 to 7.69%). The effect of different independent processing variables of canning has exhibited a non significant effect on chemical attributes (proximate composition) in both type of cultivar, except moisture content of stored green chickpea. The holding time variable has got significant effect on increase in moisture content of chick pea. This is might be due to absorption of water in the seed during storage. The non significant effect in proximate attributes is due to no external addition of biochemical nutrient in canned chickpea. The present findings of moisture, protein, carbohydrate, fat, ash and crude fibre content are in conformity with the findings of Khan *et al.* (1995), Vasishtha *et al.* (2009) and Ros *et al.* (1993).

The observation of acidity, total sugar and total phenol content of canned green chickpea (desi and Kabuli type) sample varied from 0.07 to 0.10%, 4.7 to 5.3 and 2.2 to 2.49% and 0.06 to 0.09%, 4.6 to 4.8 and 2.4 to 2.5%, respectively. The effect of processing parameters viz holding time, brine concentration and blanching time have exhibited significant effect on total sugar and total phenol content of stored chickpea (desi type) only, while a non significant model terms in case of acidity, phenol and total sugar content in kabuli type of chickpea was also observed. The effect of parameters on sugars and phenol is might be due to hydrolysis of major polysaccharides during canning and liberation of sugars and phenols during storage (Ranganna, 1991). The increase in sugars and phenols in soybean has also been reported by Tripathi (2003), Paredes *et al.* (1988) and Chukwumah *et al.* (2012).

The best fit equation for moisture, acidity, total sugars, and total phenol of canned green chickpea (Desi and Kabuli type) is as under.

$$YD_4 = 58.34064 + 0.14801x_2 - 4.56665E-005x_1 - 0.010259x_2 - 2.89446E-003x_3$$

$$YD_{11} = 5.29995 - 0.063737x_2$$

$$YD_{12} = 1.30999 + 0.037697x_1 + 0.12733x_3 + 1.12746E-003x_1^*x_2 - 2.41667E-003x_1^*x_3 - 0.013649x_2^*x_3 - 3.48132E-044x_1$$

$$YK_4 = 59.47967 + 0.049272x_1 + 7.44100E-004x_1^*x_2 - 6.12936E-004x_1^2 - 4.93185E-003x_2^2 - 2.93282E-003x_3^2$$

5.3 Sensory attributes of canned chickpea (Desi and Kabuli type)

The products prepared from experiments of different sets of combination of parameter were evaluated for sensory quality attributes viz colour, taste, and texture and score. The sensory quality attributes of canned green chickpea at 60 days of storage shows no marked variability in colour score of seeds in desi and kabuli type. However the taste and texture score were significantly affected during storage in both varieties of chickpea. The sensory score for different attributes was, colour (6.9 to 8.0; 7.0 to 8.0) taste (6.8 to 8.1; 6.9 to 8.1) and texture 6.8 to 7.9; 7.0 to 8.0. From the present findings, it exhibits that processing temperature and holding time along with blanching condition hold good to retain colour of product. The holding time and brine concentration in desi and kabuli type chick pea has got significant effect on taste score of product. The holding time and blanching time also contribute significant effect on texture of both varieties of chickpea. The long term storage may bring about change in taste and texture of chickpea. The reports of sensory evaluation panelist inform that taste of chickpea can be improved by continuous washing in running tap water. The similar finding change in sensory quality attributes of canned

products are also reported by Islam *et al.* (1979), Laborde *et al.* (1994), Lav *et al.* (2000) Paredes *et al.* (1988) and Tyler *et al.* (2000).

The best fit equation for taste and texture of canned green chickpea (desi and kabuli type) are as under.

$$YD_{14} = 8.92497 - 0.021368 x_1 - 0.14961 x_2$$

$$YD_{15} = 7.15056 + 0.055323 x_1 - 0.15687 x_3 - 8.38439E-004 x_1^2 + 2.08457E-003 x_2^2$$

$$YK_{14} = 8.96922 - 0.019637 x_1 - 0.13363 x_2 - 9.50458E-003 x_3^2$$

$$YK_{15} = 8.06298 - 0.015274 x_1 + 0.58939 x_2 - 0.45199 x_3 - 6.25000E-003 x_1 * x_2 + 6.66667E-003 x_1 * x_3 - 0.034232 x_2^2$$

5.4 Cut out examination of canned green chickpea (Desi and Kabuli type)

The cut out examination report of canned green chickpea at 60 days of storage presents that external appearance of can was normal (N) except the cans of Expt no 1,4; 1,5 and 9;13 found swell in desi and kabuli type respectively. The observations of inspection of content and internal condition of the cans were found satisfactory. The appearance of brine colour, clarity and flavour were light green, translucent and acidic in both varieties of chickpea respectively.

A cursory view of findings informs that drain weight, pH, Head space, vacuum and total bacterial plate count were ranges from 101 to 105 g, 5.4 to 5.8, 0.05 to 0.30 mm, 0.07 to 0.18 Kg/cm², 5 to 24 CFU per ml and 101 to 105 g, 5.4 to 5.8, 0.05 to 0.30 mm, 0.07 to 0.18 Kg/cm² and 3 to 21 CFU per ml in Desi and kabuli type chickpea respectively. The effects of canning variables were non-significant for drain weight pH Head space and vacuum of cans, however it was significant in case of total bacterial plate count in both type of cultivars. The effect of treatments can be justified with the facts that heat

treatment during canning causes destruction of microorganisms Tripathi *et al.*, (2004), Ranganna (1991). The processing temperature do not cause change in pH of content in the cans. The present finding can be supported with reported literature of Davis *et al.*, (1980) Sharma *et al.*, (1992) Koca *et al.* (2008) Rafique *et al.*, (2009) Patwardhan (1999) and Tripathi *et al.*, (2003).

The best fit equation for total plate count of canned green chickpea (desi and kabuli type) is as under

$$YD_{20} = 45.27093 - 0.66367x_1 - 0.66399x_2$$

$$YK_{20} = 36.95991 - 0.52421x_1 - 0.46762x_2$$

In a nutshell it is deduced from the findings of present investigation and their justification that different treatment combination of holding time, brine concentration and blanching time can be successfully utilized for development of canned green chickpea of Desi and Kabuli type chickpea without sacrificing the quality of canned product. The canning technology got great potential for value addition in food processing industries. The standardized optimum condition of canning can be successfully translated at commercial scale for domestic and commercial application.

SUMMARY, CONCLUSION AND SUGGESTION FOR FURTHER WORK

Chickpea (*Cicer arietinum* L.) is recognized as a valuable source of protein, vitamins and minerals in human diet. Desi chickpea is used as whole seeds, dehulled splits (dhal) while Kabuli chickpea is used as whole grain. At green stage of crop the grains of desi and Kabuli chickpea are also consumed as a fresh green seed (boots) or green roasted/baked grain. Every year huge stock of green chickpea and kabuli chana remains unutilized and untraded. Therefore in order to minimize the losses and develop value added product, canning of green chickpea in brine solution can be economical activity. As such no scientific information is available in the literature on canning of green chickpea. Therefore the present investigation has been planned. The findings are summarized as under.

1. The Length, Thickness, Weight of desi and kabuli type canned green chickpea varied from 0.5 to 0.8 cm, 0.4 to 0.6 cm, 53.70 to 54.20 g and 0.9 to 1.3 cm, 0.6 to 0.9 cm, 58.70 to 59.00 g respectively.
2. The proximate composition of canned green chickpea (desi and kabuli type) during storage were moisture (58.02 to 59.02%; 60.21 to 60.54%) protein (8.69 to 8.79%; 8.94 to 9.17%) carbohydrate (26.1 to 26.37%; 27.4 to 27.53 %,) fat (2.39 to 2.49%; 2.57 to 2.74%) ash (0.9 to 1.4%; 1.8 to 2.04%) and crude fibre (7.3 to 7.39%; 7.60 to 7.69%).
3. The acidity, total sugar and total phenol content of canned green chickpea varied from 0.07 to 0.10%, 4.7 to 5.3 and 2.2 to 2.49% and 0.06 to 0.09%, 4.6 to 4.8 and 2.4 to 2.5 % respectively.
4. The sensory quality attributes of canned green chickpea shows no marked variability in colour score.

5. The drain weight, pH, Head space, vacuum and total bacterial plate count were ranges from 101 to 105 g, 5.4 to 5.8, 0.05 to 0.30 mm, 0.07 to 0.18 Kg/cm², 5 to 24 CFU per ml and 101 to 105 g, 5.4 to 5.8, 0.05 to 0.30 mm, 0.07 to 0.18 Kg/cm² and 3 to 21 CFU per ml in Desi and kabuli type chickpea respectively.
6. The effect of different independent processing variables of canning has exhibited a non-significant effect on physical properties, chemical attributes (proximate composition) in both type of cultivar, except moisture content of stored green chickpea.
7. The effect of processing parameters viz., holding time, brine concentration and blanching time have exhibited significant effect on total sugar and total phenol content of stored chickpea (desi type) only
8. The cut out examination report shows internal condition of the cans were satisfactory. The brine was light green, translucent and acidic in both varieties of chickpea. The effects of canning variables was significant for total bacterial plate count in both type of cultivars.

6.1 Conclusion

It could be concluded that green chickpea Dasi and kabuli type cultivars can be utilized for canning purpose. The best quality acceptable canned green chickpea product can be made by using the Canning variables viz., holding time 45 min, Brine concentration 4% and Blanching time 3.5 min.

6.2 Suggestion for further work

1. To study long term storage stability characteristics of canned product.
2. To evaluate the canning quality of chickpea in glass container and pet bottles.
3. To study the effect different preservatives, and canning media such as tomato sauce, brine on canned product quality.

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APPENDIX

Name :
Designation :
Address :

Sir,

Given sample is newly developed product Name: **Canned green chick pea**, of our laboratory. Please give the rating of the food product on the various sensory attributed based on the following 9 point hedonic scale.

1. Like extremely : 9
2. Like every much : 8
3. Like moderately : 7
4. Like slightly : 6
5. Neither like nor dislike : 5
6. Dislike : 4
7. Dislike moderately : 3
8. Dislike slightly : 2
9. Dislike extremely : 1

Sensory attributes	Sample code	Sample code	Sample code	Sample code	Sample code	Sample code
Colour						
Taste						
Texture						

Remark:

Date:

Signature

ABSTRACT

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ABSTRACT

The present investigation on “Optimization of process temperature and brine concentration for canning of desi and kabuli type chickpea” was conducted in the laboratory of department of Food Science and Technology. Two types of canned green chickpea (i.e. desi and kabuli type) were developed with different holding time, brine concentration and blanching time. Developed canned green chickpea prepared at different combinations of holding time, brine concentration and blanching time. The results confirmed sensory attributes of all canned green chickpea were graded as “good” and “very good” while Exp no. 15 to 20 (desi and kabuli type) at the ratio of 45.00 min., 4.00% and 3.5 min were the best canned green chickpea. Developed canned green chickpea were nutritionally superior, physical and functional appropriate. Exp. No. 15, 16, 17, 18, 19, 20 (desi and kabuli type) at the combination of 45.00 min, 4.00% and 3.50 min were found to be the best for storage point of view.

VITA

*The author of this manuscript, **Mr. Milind M. Patil** S/o Mr. Madhavrao N. Patil and Mrs. Surekha Patil was born on 15th, April 1989 at Jalgaon District of Maharashtra.*

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*For the partial fulfillment of the Master's Degree Programme, he allotted a research problem on "**Optimization of Process Temperature and Brine Concentration for Canning of Desi and Kabuli Type Green Chickpea**" which was successfully conducted by her and being submitted in the form of this manuscript.*