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RESEARCH ARTICLE

Standardization of process for development of instant chickpea using *Desi* and *Kabuli* variety

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ABSTRACT

Chickpea is considered among the most important leguminous crops in the world but is not a regular meal pulse due to their long cooking time and lengthy preparatory procedure. This gives rise to the need of converting raw chickpea into convenient food. For the preparation of instant chickpea from *Desi* and *Kabuli* variety, Central Composite Rotatable Design (CCRD) under Response Surface Methodology (RSM) was employed which consisted of four variables *i.e.* sodium chloride (NaCl), sodium bicarbonate ($NaHCO_3$), ammonium carbonate $(NH_4)_2CO_3$ and temperature for soaking treatments. This design was used to develop models for the soaking time, change in colour, split %, alkalinity and cooking time for prepared instant chickpea samples. High-temperature hydration (60 °C) required lesser time to achieve the maximum hydration, whereas low-temperature hydration (30 °C) enhanced the hydration time and reduced the cooking time of instant chickpea significantly ($P \leq 0.01$) but this condition was inverse for the splitting/butterfly defects. Increasing the concentration of sodium bicarbonate and ammonium bicarbonate from 0.5 to 1.5 % during soaking treatments increased the splitting and alkalinity and produced undesirable colours in treated samples of chickpea. RSM optimized values concerning concentrations of different salts *i.e.* NaCl, $NaHCO_3$, and $(NH_4)_2CO_3$ in soaking solution were 0.59, 0.85 % and 0.82 %, respectively at 49.81 °C temperature for *Desi* instant chickpea having 11 minutes of cooking time whereas corresponding values for *Kabuli* chickpea were 1.07 % NaCl, 0.79 % $NaHCO_3$, and 0.70 % $(NH_4)_2CO_3$ at 46.53 °C temperature with 13 min cooking time.

Keywords: Central Composite Rotatable Design, Chickpea, Soaking, Cooking time, Instant

PRACTICAL APPLICATION

Instant pulses are generally not very common in the commercial market. Whole pulses like chickpea, blackgram and soybean etc. are rich in nutrients, especially protein and iron but they require more time for cooking with difficult preparation procedures which is not possible in modern lifestyle, such pulses when converted into ready-to-cook products and prepared with masala pack (just like *maggi* pack) can overcome the above-mentioned problems and save our time in the kitchen during busy and fast running life where most of the women in the family are working. Commercialization of such value-added products especially in the case of pulses can not only be helpful in day-to-day life by acting as convenient food but may also be beneficial in providing a nutritive diet to the present generation.

INTRODUCTION

Pulses are largely cultivated crops all over the world and are considered a rich source of protein, fibre, macro and micronutrients which provide several health benefits to the human body and are mostly consumed after cooking in the form of whole seeds or decorticated splits. The time required to cook a product is an important quality attribute for food processors and consumers because longer cooking time is inconvenient. Some pulses like soybean, horsegram, chickpea etc. require pre-soaking (usually overnight) to reduce cooking time to a more acceptable time. Longer cooking time is accompanied by more energy or fuel consumption, and, therefore, is costly to consumers and processors. This arises a need to convert such hard-to-cook pulses into convenient or instant food. Quick-cooking or instant pulses may also receive premium status in the marketplace because of convenience and reduced energy cost required.

Chickpea (*Cicer arietinum* L.) is a widely consumed pulse in the world. India is the largest chickpea producing country with domestic annual production of 119.11 lakh tonnes during 2020-21 (DPD, 2021) followed by Australia and Turkey in the world with a share of about 65 % and

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contributes 86.03% to Asia's total chickpea production (Solanki et al., 2021, Kaur and Prasad, 2021). It is a drought-resistant crop and can also be cultivated in high rainfall areas. Thus, chickpea may be considered a future food because future food market is more focused on food security and requirement for sustainable protein sources. Chickpea is of two major types, the *Desi* type, and the *Kabuli* type (Falco et al., 2010). The former is generally small-seeded with a coloured seed coat and angular-seed shape while the latter is generally large-seeded with beige seed colour and ram-head shape (Wood and Grusak, 2007). *Desi* chickpea is grown mostly in the semi-arid tropics, while *Kabuli* chickpea is mainly grown in temperate regions (Muehlbauer and Sarker, 2018). Chickpea is mainly consumed for their dry seeds due to their high nutritional value, mainly the protein (16.7 – 30.6 % in *Desi* and 12.6 – 29.0 % in *Kabuli*) content which is commonly 2-3 times higher than other cereal grains (Wood and Grusak, 2007, Kaur and Prasad, 2021). Both varieties of chickpea supply a good amount of dietary fibre, important minerals, vitamins, and several bioactive compounds. *Desi* and *Kabuli* chickpea contains 18.4-22.7 % and 10-6-16.63 % dietary fibre, respectively. It also supplies a good amount of important minerals like Ca (68 – 269 mg/100 g in *Desi* and 40-267 mg/100 g in *Kabuli*), Mg (107-168 mg/100 g in *Desi* and 10-239 mg/100 g in *Kabuli*), K (230-1272 mg/100 g in *Desi and* 220-1333 mg/100 g in *Kabuli*), Fe (3-12 mg/100 g in *Desi* and 4.2 – 1.3 mg/100 g in *Kabuli*), P (169-860 mg/100 g in *Desi* and 159-930 mg/100 g in *Kabuli*), vitamins especially, B_9 (150-557 μg/100 g in *Desi* and 347-437 μg/100 g in *Kabuli*) and several phenolic (bioactive) components (16.3 -74.4 μg/g in *Desi* and 11 μg/g in *Kabuli*) depending on the different genotypes, agronomical practices and cultivars (Wood and Grusak, 2007, Ghadge et al., 2008). Moreover, chickpea has potential health benefits, which include reducing cardiovascular, diabetic, and cancer risks (Merga and Haji, 2019). Some factors limit the regular use of chickpea which includes hardy cooking phenomena, longer cooking time, and difficult preparatory procedures (Moktan and Ojha, 2016). In this context, the research was taken up to develop ready-to-cook or instant chickpea and make it convenient for the consumer by reducing cooking time and difficulty in preparatory methods. To develop the instant chickpea, effect of different concentrations of three salts (NaCl, $NaHCO_3$ and $(NH_4)_2CO_3$) at different levels of temperature (30 to 60 °C) during soaking pre-treatment and formulation of the curry powder for the optimized product were investigated.

MATERIAL AND METHODS

Raw materials and reagents

The local varieties of *Desi* and *Kabuli* chickpea and other ingredients (Tomato powder, onion powder, garlic powder, ginger powder and chana masala) were purchased during the year 2019-20 from the local market of Pantnagar, Udham Singh Nagar (Uttarakhand), India. Seeds of *Desi* and *Kabuli* chickpeas were sorted manually and stored at room temperature in airtight plastic containers to prevent moisture changes during the investigation. All chemicals used in this study were obtained from Himedia and were of analytical grade.

METHODS

Preparation of instant chickpea

Chickpea grains (200 g) were soaked in 800 ml of the soaking solution of different concentrations (0.5, 1 and 1.5 %) of different salts i.e. NaCl, $NaHCO_3$ and $(NH_4)_2CO_3$ as described in Table 1 in a water bath maintained at a definite temperature. The soaked grains were then drained off and washed with fresh tap water. The dehydrated grains were then placed in a pressure cooker (Hawkins classic-3L capacity) containing 800 ml of water. As the whistling began, the time was noted and the grains were cooked until softening of grains. The cooking water was drained off and the cooked grains were dried in a tray drier at 60 ± 2 °C temperature (Fig. 1). Low-temperature drying (60 ± 2 °C) of pulses helps in the reduction of butterfly defects in pulses and maintained the nutritional quality of ready-to-eat pulses. Data on soaking time (minutes) of raw chickpea and colour changes (ΔE) through online colour lab software (R G B colour converter), split or butterfly per centage (Cai and Chang, 1997), alkalinity (Ranganna, 2011), cooking time (minutes) and organoleptic evaluation on 9 points rating hedonic scale (Ranganna, 2011) of instant chickpea pertaining to the effects of varying levels of independent variables on the various responses were recorded for both varieties of chickpea.

Preparation of curry powder mix

The curry powder mix was prepared by using two recipes one was the chana masala and another one was prepared with slight modification in chana masala (Table 2). Preliminary trials were conducted to optimize the ingredients. Onion, tomato, ginger and garlic powder, and cornflour were fried in hot olive oil on a slow flame for 2 min. Thereafter, the rest of the ingredients (garam masala, red chilli powder, turmeric powder, coriander powder, and salt) were added

Table 1: Coded and uncoded (actual) values of independent variables for soaking treatment

Variables	Code	Coded level		
		-1	0	+1
NaCl (%)	X_1	0.5	1.0	1.5
$NaHCO_3$ (%)	X_2	0.5	1.0	1.5
$(NH_4)_2CO_3$ (%)	X_3	0.5	1.0	1.5
Temperature (°C) of soaking solution	X_4	30	45	60

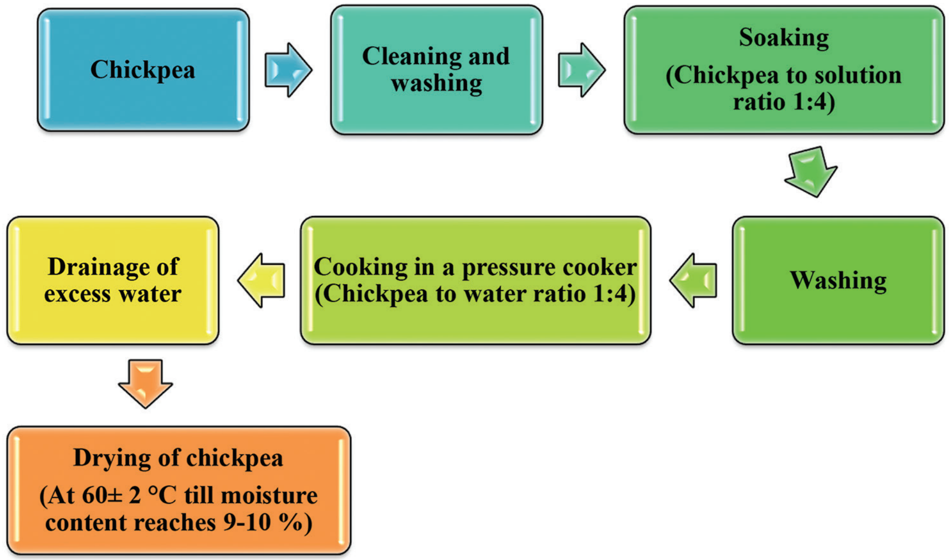

Fig 1. Flow diagram for preparation of instant cooking chickpea.

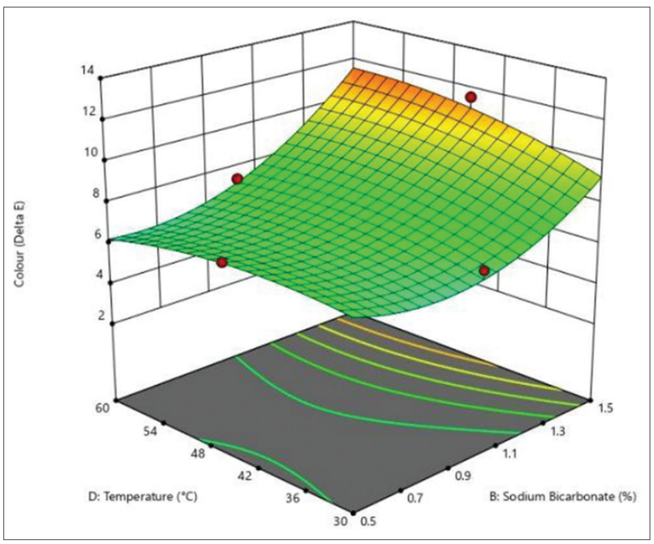

Fig 2. Effect of $NaHCO_3$ and temperature on colour of *Desi* instant chickpea.

Table 2: Recipe for the preparation of curry powder mix

Ingredients	Recipe 1 (g)	Recipe 2 (g)
	Chana masala	Modified chana masala
Onion powder	30	30
Tomato powder	12	12
Ginger powder	-	3
Garlic powder	-	3
Garam masala	-	2
Red chilli powder	-	4
Turmeric powder	-	2.2
Coriander powder	-	4
Corn flour	-	3.2
Olive oil	10	10
Salt	To taste	To taste

to it and mixed. The masala mix samples were cooled to room temperature and then packed in polyethylene bags.

Experimental design

A three-level, four variable Central composite rotatable design (CCRD) of Response Surface Methodology (RSM) was adopted in this study. Based on the preliminary study conducted, three different levels (0.5, 1 and 1.5 %) of three salts *i.e.* NaCl, $NaHCO_3$ and $(NH_4)_2CO_3$ (Independent variables) and three different temperatures (independent variable) i.e. 30, 45 and 60 °C were selected for process optimization of the development of instant-chickpea from both varieties (Table 1). The fractional factorial design consisted of 6 central points and 24 axial points as suggested by Design Expert 13.0. The variables and their levels selected for the study are represented in Table 1. For creating response surfaces, the experimental data obtained based on the above design were fitted to a second-order polynomial equation of the form:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_{11}X_1^2 + \beta_{22}X_2^2 + + \beta_{33}X_3^2 + + \beta_{44}X_4^2 +$$

$$\beta_{12}X_1X_2 + \beta 13X1X3 + \beta 14X1X4 + \beta 23X2X3 + \beta 24X2X4 + \beta 34X3X4$$

Where, Y is the response calculated by the model; X_1, X_2, X_3, and X_4 are coded values of independent variables (X_1 = NaCl concentration X_2 = $NaHCO_3$ concentration X_3 = $(NH_4)_2CO_3$ concentration X_4 = soaking temperature); β_0 is model coefficient; β_1, β_2, β_3, and β_4 are linear regression coefficients; β_{11}, β_{22}, β_{33} and β_{44} are quadratic regression coefficient and, β_{12}, β_{13}, β_{14}, β_{123}, β_{24}, and β_{34} are the interactive regression coefficient (Sangeeta et al., 2016, Barfal et al., 2017). Optimization of the reaction parameters was minimum for all dependent variables (soaking time, change in colour, split %, alkalinity and cooking time) and was obtained through the Software Design Expert 13.0. Regression analysis of the data gives the results in terms of analysis of variance (ANOVA), regression coefficient, coefficient of determination (R^2), Lack of Fit (LOF) and associated statistics etc. These were used to determine the adequacy of the predictive model and the effect of independent variables on various responses (soaking time, change in colour, butterfly effect, alkalinity and cooking time).

Determination of physicochemical characteristics

Raw and instant chickpea samples were analyzed for various physical characteristics such as length, width, bulk density, true density, porosity and 1000 kernel weight using the methods described by Negi et al. (2007) while the colour (L, a and b values) was estimated through online lab software (R G B colour converter). Moisture, crude protein, crude fat, fibre, total carbohydrate and ash of raw and processed chickpea were determined using AOAC (2012) methods. For estimation of calcium, iron and phosphorus of raw and instant chickpea samples was determined by the method described by Ranganna (2011).

RESULTS & DISCUSSION

The effect of different salts (NaCl, $NaHCO_3$, $(NH_4)_2CO_3$) and their concentration and variation in soaking temperature (independent variables) on various responses *i.e.* soaking time, change in colour, split %, alkalinity and cooking time during the preparation of instant *Desi* and *Kabuli* chickpea are presented in Table 3.

Effect on soaking time of raw chickpea

Minimum soaking time was required to facilitate the fast process and reduce solid losses during soaking treatment. Minimum soaking time was recorded in *Desi* and *Kabuli*

Table 3: Effects of different levels of independent variables on various responses of instant chickpea samples of both varieties

Expt no.	Independent coded variables				Dependent variables									
	NaCl (%)	$NaHCO_3$ (%)	$(NH_4)_2CO_3$ (%)	Temperature (ºC)	Soaking time of raw chickpea samples (min)		Colour change (∆E)		Split (%)		Alkalinity (mg/l)		Cooking time (min)	
					Desi	*Kabuli*	*Desi*	*Kabuli*	*Desi*	*Kabuli*	*Desi*	*Kabuli*	*Desi*	*Kabuli*
1.	-1 (0.5)*	-1 (0.5)	-1 (0.5)	-1 (30)	315	495	4.45	3.64	5.6	6.84	60	62	16	19
2.	1 (1.5)	-1 (0.5)	-1 (0.5)	-1 (30)	315	495	5.86	3.21	5.38	5.82	61	63	16	19
3.	-1 (0.5)	1 (0.5)	-1 (0.5)	-1 (30)	315	495	2.86	2.22	5.1	5.96	58	61	16	19
4.	1 (1.5)	1 (1.5)	-1 (0.5)	-1 (30)	315	495	8.5	7.84	6.25	6.8	72	74	15	16
5.	-1 (0.5)	-1 (0.5)	1 (1.5)	-1 (30)	315	495	8.22	7.84	7.2	7.7	74	77	14	15
6.	1 (1.5)	-1 (0.5)	1 (1.5)	-1 (30)	315	495	7.48	7.65	6.8	7.48	72	75	16	17
8.	1 (1.5)	1 (1.5)	1 (1.5)	-1 (30)	315	495	12.54	11.42	8	8.75	86	88	15	17
7.	-1 (0.5)	1 (1.5)	1 (1.5)	-1 (30)	285	435	11.22	10.52	7.44	7.82	86	89	14	15
9.	-1 (0.5)	-1 (0.5)	-1 (0.5)	1 (60)	165	195	3.24	2.89	22.4	24.55	58	61	14	17
10.	1 (1.5)	-1 (0.5)	-1 (0.5)	1 (60)	195	225	4.84	4.27	21.54	22.74	58	62	14	15
11.	-1 (0.5)	1 (1.5)	-1 (0.5)	1 (60)	135	195	10.77	10.17	23.56	25.62	70	73	11	14
12.	1 (1.5)	1 (1.5)	-1 (0.5)	1 (60)	165	195	10.27	9.98	22.22	24.4	70	72	12	15
13.	-1 (0.5)	-1 (0.5)	1 (1.5)	1 (60)	135	195	8.66	8.2	23.74	25.94	71	74	11	15
14.	1 (1.5)	-1 (0.5)	1 (1.5)	1 (60)	165	195	6.6	6.88	21.88	23.2	72	74	13	15
15.	-1 (0.5)	1 (1.5)	1 (1.5)	1 (60)	105	165	11.22	10.52	22.4	24.45	84	87	11	14
16.	1 (1.5)	1 (1.5)	1 (1.5)	1 (60)	135	195	11.99	11.27	20	22.74	83	85	12	13
17.	-1 (0.5)	0 (1.0)	0 (1.0)	0 (45)	255	285	7.21	6.91	11.78	13.85	75	77	12	14
18.	1 (1.5)	0 (1.0)	0 (1.0)	0 (45)	285	285	7.06	6.85	10.8	12.38	76	77	12	14
19.	0 (1.0)	-1 (0.5)	0 (1.0)	0 (45)	255	285	7.24	6.94	12.8	14	72	75	13	14
20.	0 (1.0)	1 (1.5)	0 (1.0)	0 (45)	285	255	11.56	11.24	10.2	12.25	73	76	11	13
21.	0 (1.0)	0 (1.0)	-1 (0.5)	0 (45)	255	285	7.5	7.28	11.84	13.7	73	75	12	13
22.	0 (1.0)	0 (1.0)	1 (1.5)	0 (45)	285	255	8.14	7.94	14.44	15.22	78	78	13	14
23.	0 (1.0)	0 (1.0)	0 (1.0)	-1 (30)	315	495	6.84	6.24	6.45	7.25	72	73	15	16
24.	0 (1.0)	0 (1.0)	0 (1.0)	1 (60)	165	195	7.38	7.12	20.82	22.5	70	71	13	14
25.	0 (1.0)	0 (1.0)	0 (1.0)	0 (45)	225	285	7.14	5.08	10.44	13.46	70	72	9	12
26.	0 (1.0)	0 (1.0)	0 (1.0)	0 (45)	225	285	7.22	5.22	9.88	12.44	70	72	9	11
27.	0 (1.0)	0 (1.0)	0 (1.0)	0 (45)	225	285	6.83	5.13	10.28	12.82	70	72	8	11
28.	0 (1.0)	0 (1.0)	0 (1.0)	0 (45)	225	285	7.25	5.02	10.7	12.22	71	73	8	11
29	0 (1.0)	0 (1.0)	0 (1.0)	0 (45)	225	285	7.1	5.12	10.22	12.7	69	73	8	11
30.	0 (1.0)	0 (1.0)	0 (1.0)	0 (45)	225	285	6.99	5.27	10.4	12.88	71	72	8	11

*Actual values of independent variables.

Table 4: Regression analysis of various responses of instant *Desi* chickpea

Source	Soaking time		Colour		Split ratio		Alkalinity		Cooking time	
	Coeff.	P value	Coeff.	P value	Coeff.	P value	Coeff.	P value	Coeff.	P value
Model	245.26	< 0.0001[a]	7.39	0.0002[a]	10.92	< 0.0001[a]	72	0.0002[a]	9.98	0.0106[a]
Linear										
X_1	10	0.0924	0.4039	0.1694	-0.3528	0.1461	0.778	0.3879	0.3333	0.427
X_2	-6.67	0.2494	1.91	< 0.0001[a]	-0.1206	0.608	4.67	< 0.0001[a]	-0.5556	0.1937
X_3	-6.67	0.2494	1.54	< 0.0001[a]	0.445	0.0723	7	< 0.0001[a]	-0.3889	0.3559
X_4	-80	< 0.0001[a]	0.3888	0.1849	7.8	< 0.0001 a	-0.2778	0.7552	-1.44	0.003[a]
Quadratic										
X_1^2	4.47	0.7645	0.8075	0.4607	0.1323	0.7147	1.67	0.4808	0.364	0.7368
X_2^2	4.47	0.7645	7.55	0.0352[a]	0.0007[a]	0.9794	-1.33	0.5716	0.3684	0.7368
X_3^2	4.47	0.7645	0.0416	0.8658	6.68	0.0172 a	1.67	0.4808	0.8684	0.4323
X_4^2	-25.53	0.1022	0.8784	0.4421	11.63	0.0033 a	-2.83	0.238	2.37	0.0438[a]
Interaction										
X_1X_2	1.87	0.7551	3.07	0.1606	0.1073	0.742	0.8125	0.3949	-0.125	0.7768
X_1X_3	1.87	0.7551	4.9	0.0818	0.5006	0.4798	-1.06	0.27	0.375	0.4001
X_1X_4	5.62	0.3556	3.83	0.1201	3.56	0.0723	-0.8125	0.3949	0.125	0.7768
X_2X_3	-1.88	0.7551	0.256	0.6759	0.995	0.3232	1.06	0.27	0.25	0.5723
X_2X_4	-5.63	0.3556	8.69	0.0253[a]	0.636	0.4268	0.8125	0.3949	-0.25	0.5723
X_3X_4	-5.63	0.3556	4.47	0.0952	4.85	0.0395[a]	0.8125	0.3949	0	0.7368
Coefficient of determination (R2)	93.61%		87.56%		98.81%		87.14%		76.68%	
F-Value	15.7**		7.54**		89.12**		7.26**		3.52*	
Lack of Fit	NS		NS		NS		NS		NS	

[a]denotes significant terms ($P \leq 0.05$)
**,* significant at 1% and 5% levels of significance, respectively.
$F_{(14,15)}$ = 3.66 (1%) and 2.46 (5%);
Coeff. Stands for Regression coefficient
NS stands for non-significant and S stands for significant

Table 5: Regression analysis of various responses of instant Kabuli chickpea

Source	Soaking Time		Colour		Split Ratio		Alkalinity		Cooking Time	
	Coeff.	P value	Coeff.	P value	Coeff.	P value	Coeff.	P value	Coeff.	P value
Model	281.32	< 0.0001[a]	6.19	0.0016[a]	12.98	< 0.0001[a]	73.8	0.0002[a]	12.09	0.0007[a]
Linear										
X_1	6.67	0.0302	0.3588	0.3278	-0.4678	0.017[a]	0.5	0.5643	-0.0556	0.8558
X_2	-8.33	0.0091	1.87	< 0.0001[a]	0.0289	0.8706	4.56	< 0.0001[a]	-0.5556	0.0843[a]
X_3	-8.33	0.0091	1.71	0.0002 [a]	0.3817	0.0448	6.89	< 0.0001[a]	-0.6667	0.0423[a]
X_4	-146.67	< 0.0001[a]	0.5963	0.1135	8.43	< 0.0001[a]	-0.1667	0.8468	-1.17	0.0015[a]
Quadratic										
X_1^2	7.37	0.3313	-0.3456	0.7169	-0.0985	0.8331	1.74	0.4493	0.9912	0.2299
X_2^2	-7.63	0.3149	1.86	0.0647	-0.0885	0.8498	0.2368	0.917	0.4912	0.5444
X_3^2	-7.63	0.3149	-0.3814	0.6891	1.25	0.016[a]	1.24	0.5882	0.4912	0.5444
X_4^2	67.37	< 0.0001[a]	-0.5456	0.5682	1.66	0.0025[a]	-3.26	0.165	1.99	0.0238[a]
Interaction										
X_1X_2	3.75	0.2235	0.4774	0.2238	0.2894	0.1384	0.5625	0.5412	-0.0625	0.8471
X_1X_3	3.75	0.2235	-0.3888	0.3175	-0.0331	0.8602	-1.19	0.2066	0.4375	0.8471
X_1X_4	-3.75	1	-0.3299	0.3944	-0.5006	0.0162[a]	-0.8125	0.3807	-0.1875	0.19
X_2X_3	0	0.2235	-0.1883	0.624	-0.2119	0.2698	1.06	0.2559	0.1875	0.565
X_2X_4	0	1	0.6276	0.1161	-0.0444	0.8136	0.6875	0.4566	-0.1875	0.565
X_3X_4	0	1	-0.6852	0.0886	-0.4569	0.0259[a]	-1.06	0.2559	0.3125	0.3423
Coefficient of determination (R2)	99.50%		82.83%		99.39%		87.38%		84.90%	
F value	214.44**		5.17**		6.03**		7.42**		175.27**	
Lack of Fit	NS		NS		NS		NS		NS	

[a]denotes significant terms ($P \leq 0.05$)
**,* significant at 1% and 5% levels of significance, respectively.
$F_{(14,15)}$ = 3.66 (1%) and 2.46 (5%);
Coeff. Stands for Regression coefficient
NS stands for non-significant and S stands for significant

Table 6: Overall polynomial equations for different responses of *Desi* and *Kabuli* instant chickpea

Dependent variables (Y)	Variety	Predictive models ($Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_{11}X_{12} + \beta_{22}X_{22} + + \beta_{33}X_{32} + + \beta_{44}X_{42} + \beta_{12}X_1X_2 + \beta_{13}X_1X_3 + \beta_{14}X_1X_4 + \beta_{23}X_2X_3 + \beta_{24}X_2X_4 + \beta_{34}X_3X_4$)														
		β_0	β_1	β_2	β_3	β_4	β_{11}	β_{22}	β_{33}	β_{44}	β_{12}	β_{13}	β_{14}	β_{23}	β_{24}	β_{34}
Soaking time	*Desi*	245.26	10	-6.67	-6.67	-80	4.47	4.47	4.47	-25.53	1.87	1.87	5.62	-1.88	-5.63	-5.63
	Kabuli	281.32	6.67	-8.33	-8.33	-146.67	7.37	-7.63	-7.63	67.37	3.75	3.75	-3.75	0	0	0
Colour change	*Desi*	7.39	0.40	1.91	1.54	0.38	0.80	7.55	0.04	0.87	3.07	4.9	3.83	0.256	8.69	4.47
	Kabuli	6.19	0.35	1.87	1.71	0.59	-0.34	1.86	-0.38	-0.54	0.47	-0.38	-0.32	-0.18	0.62	-0.68
Split %	*Desi*	10.92	-0.35	-0.12	0.44	7.8	0.13	0.0007[a]	6.68	11.63	0.10	0.50	3.56	0.995	0.63	4.85
	Kabuli	12.98	-0.46	0.02	0.38	8.43	-0.09	-0.08	1.25	1.66	0.28	-0.03	-0.50	-0.21	-0.04	-0.45
Alkalinity	*Desi*	72	0.77	4.67	7.0	-0.27	1.67	-1.33	1.67	-2.83	0.81	-1.06	-0.81	1.06	0.81	0.81
	Kabuli	73.8	0.5	4.56	6.89	-0.16	1.74	0.23	1.24	-3.26	0.56	-1.19	-0.81	1.06	0.68	-1.06
Cooking time	*Desi*	9.98	0.33	-0.55	-0.38	-1.44	0.36	0.36	0.86	2.37	-0.12	0.37	0.12	0.25	-0.25	0
	Kabuli	12.09	-0.05	-0.05	-0.66	-1.17	0.99	0.49	0.49	1.99	-0.06	0.43	-0.18	0.18	-0.18	0.31

[a]denotes significant terms ($P \leq 0.05$)
**,* significant at 1% and 5% levels of significance, respectively.
$F_{(14,15)}$ = 3.66 (1%) and 2.46 (5%);
Coeff. Stands for Regression coefficient
NS stands for non-significant and S stands for significant

Table 7: Predicted and observed values of various parameters of instant- chickpea

Responses	*Desi* chickpea		*Kabuli* chickpea	
	Predicted	Observed	Predicted	Observed
Soaking time (min)	217.58	217.49	270.61	270.54
Split (%)	14	13.6	14	14.4
Colour (ΔE)	5.90	5.90	4.89	4.89
Alkalinity (mg/L)	68.53	68.6	68.61	68.7
Cooking time (min)	10.27	10.30	12.88	12.90

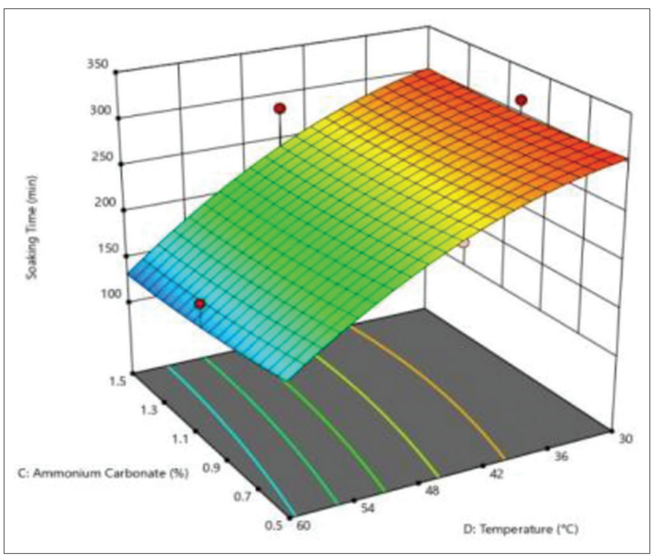

Fig 3. Effect of $(HN_4)_2CO_3$ and temperature on split % of Desi instant chickpea.

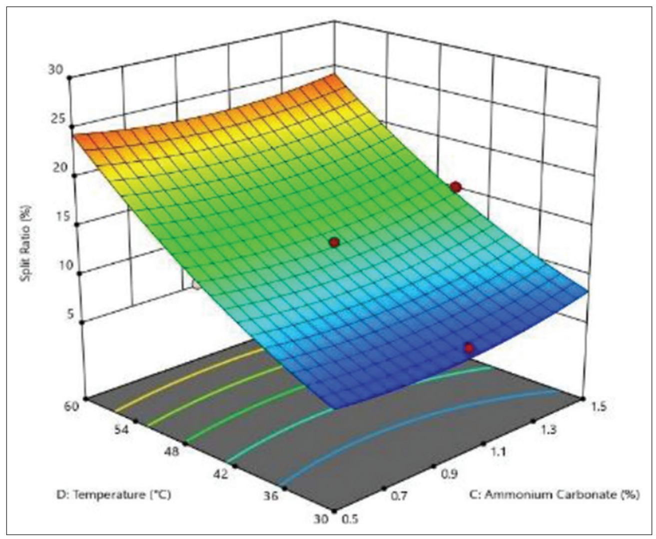

Fig 4. Effect of $(HN_4)_2CO_3$ and temperature on split % of *Kabuli* instant chickpea.

chickpea samples when soaked in 0.5 % NaCl, 1.5 % $NaHCO_3$ and 1.5 % $(NH_4)_2CO_3$ solution at 60 °C and F-value for *Desi* (15.70) and *Kabuli* chickpea (214.44), and high values of coefficient of determination ($R^2 > 0.80$) imply that the model was significant ($P<0.01$) as the data presented in Tables 4 and 5. As per the polynomial equation, soaking time was enhanced with an increase in the level of common salt whereas $NaHCO_3$, $(NH_4)_2CO_3$, and temperature indicate antagonist effect in *Kabuli* chickpea samples (Table 6). Soaking time for both varieties of chickpea is greatly affected by ($P \leq 0.01$) increase in temperature (X_4) because of low surface tension on the surface of pulses which enhances the movement of water towards endosperm. Low-temperature hydration required higher time to achieve maximum hydration as compared to high-temperature hydration (Kumar et al., 2021).

Kabuli chickpea (large-seeded) has a thinner seed coat due to the thinner palisade and parenchyma layers which contained fewer pectic polysaccharides and less protein. In contrast, the *Desi* chickpea (small-seeded) palisade layers were rigid and extensively thickened (Wood et al., 2011). Alkaline conditions due to the presence of $NaHCO_3$ and $(NH_4)_2CO_3$ resulted in alteration in the configuration and conformation of native proteins thereby increasing their solubility, reducing steric hindrance and exposing more peptide bonds to hydrolysis, reduction in the calcium and magnesium mediated interactions between phytic acid and protein and between minerals and pectin, which altered the microstructure of beans, making them more porous and permitting easier penetration of heat and water (Liu et al., 2020). An increase in alkaline salts to the soaking solution also resulted in greater pectin solubility and starch gelatinization (Arntfield et al., 2001); whereas, increase in sodium chloride formed the impervious layer which restricted the water uptake by samples (Agarwal, 2011). Increase in water absorption rate by soaking in sodium bicarbonate solution and ammonium carbonate was also reported earlier by Chakraborty and Williams (2007).

Effect on change in colour of instant chickpea

The colour of instant chickpea should resemble original or raw chickpea for desirable consumer acceptance. The maximum colour change for each variety was recorded in samples soaked in solution containing a maximum concentration (1.5 %) of sodium bicarbonate and ammonium carbonate at the minimum soaking temperature (30 °C). The least colour change was observed in samples treated with 0.5 % concentration of each salt at minimum soaking temperature of 30 °C (Table 3). The obtained F-value suggested that colour change in *Desi* and *Kabuli* chickpea was influenced significantly at $P<0.01$ with F-value of 7.54 and 5.17, respectively. Coefficients of determination were more than 80 % and the P-value ($p<0.05$) indicated that the models are adequate for the colour (Tables 4 and 5). The regression coefficients for colour change indicate that increasing the concentration of $NaHCO_3$ and $(NH_4)_2CO_3$ enhances the colour change of both varieties of chickpea (Table 6). Fig. 2 shows the response surface plot at various salts concentrations and temperatures for colour changes in *Desi* instant chickpea, which depicted that increasing the concentration of sodium bicarbonate from 0.5 to 1.5 % irrespective of temperature level, enhances the colour change of the product.

The dark colour of chickpea after soaking and cooking may be due to the change in physical and chemical properties of denatured proteins, non-enzymatic browning (Maillard browning) and enzymatic browning through phenolase activity during initial stages of heating (Gujral et al*.,* 2011; Murthy et al., 2008).

Effect on split % of instant chickpea

Minimum splitting or butterflying % is desirable for obtaining good quality products with respect to nutritional quality, as minimum solid loss occurs in non-split pulses. The splitting of pulses is greatly influenced by soaking temperature. Minimum splitting was observed in the chickpea samples soaked at lower temperature (30 °C) while maximum split % was recorded in samples soaked at high temperature (60 °C) in *Desi* and *Kabuli* chickpea. F-value ($F_{test} \geq F_{listed}$) and coefficient of determination ($R^2 \geq 80$ %) for split % imply that the models were significant for *Desi* and *Kabuli* instant chickpea (Tables 4 and 5). The data of regression coefficient indicate that increase in split % is due to increase in soaking temperature in *Desi* and *Kabuli* chickpea. The regression coefficient also indicates the possibility of more splitting during the preparation of *Kabuli* instant chickpea at increased concentrations of NaCl (X_1), $NaHCO_3$ (X_2), and $(NH_4)_2CO_3$ (X_3) at higher levels of temperature (Table 6). The thick and intact seed coat of *Desi* chickpea resists the penetration of salts into the cell as suggested by Wood et al. (2011) but increases in solubility of pectin and starch gelatinization due to higher temperature might be responsible for greater disintegration of chickpea. It is also clearly indicated in Figs. 3 and 4 that with the increase in temperature from 30 to 60 ºC there is enhanced level of split grains in the product in both varieties of chickpea.

The increased split % might be due to long soaking time and high soaking temperature (Zhao and Chang, 2008) and the seed coat of chickpea is very susceptible to thermal processing resulting in increased splitting (Guzel and Sayar, 2011). Similar findings were also reported in ready-to-cook kidney beans (Agarwal, 2011).

Effect on the alkalinity of instant chickpea

Maximum alkalinity in instant chickpea samples prepared from both varieties was recorded in samples soaked in higher concentrations of salts while minimum alkalinity was observed in samples soaked in the least amount of salts concentration with respect to temperature variation (Table 3). According to the regression analysis, there was significant increase in alkalinity of the product with increase in the level of sodium bicarbonate and ammonium carbonate in both the varieties of chickpea. The model F-value (7.26 for *Desi* and 7.42 for *Kabuli* instant chickpea) and coefficient of determination ($R^2 \geq 80$ %) implies that the model was significant ($P<0.01$) for both varieties (Tables 4 and 5). The polynomial equation for alkalinity also denotes that the higher concentration of $NaHCO_3$ and $(NH_4)_2CO_3$ in the soaking solution elevated the alkalinity of the final product (Table 6).

Alkalinity is a function of HCO_3^-, and CO_3^{2-}. More alkalinity means higher concentration of HCO_3^-, and CO_3^{2}, which are present in $NaHCO_3$ and $(NH_4)_2CO_3$. Higher concentrations of these salts (1.5 % $NaHCO_3$ and 1.5 % $(NH_4)_2CO_3$) in experiments produced higher alkalinity in the final product. Similar results were also reported in ready-to-cook kidney beans (Agarwal, 2011).

Effect on the cooking time of instant chickpea

Minimum cooking time is considered to save time as well as the fuel consumption of the end-users. The effect of variation in the levels of NaCl, $NaHCO_3$, and $(NH_4)_2CO_3$ at different temperatures used in the preparation of instant chickpea from *Desi* and *Kabuli* varieties of chickpea revealed that chickpea soaked in 1 % concentration of each salt at 45 °C temperature recorded minimum cooking time during cooking of instant chickpea samples (Table 3). Regression analysis based on F-value ($F_{test} \geq F_{listed}$) and coefficient of determination ($R^2 \geq 80$ %) show that cooking time for *Desi* and *Kabuli* instant chickpea was reduced due to increasing the level of temperature and ammonium carbonate during soaking treatment (Tables 4 and 5). The F-value was also intimate that variation in the levels of temperature during soaking treatment affects the cooking time significantly (P<0.01). According to the polynomial equation, as represented in Table 6, levels of $(NH_4)_2CO_3$ and temperature during the soaking period show an antagonistic effect on the cooking time of instant chickpea of both varieties.

Reduction in cooking time might be attributed to more uniform hydration during soaking or decreases in protein solubility, increased pectin solubility, increase in starch gelatinization, and increased pectin solubility as brought about by increased ionic strength of pH towards alkalinity. A negative and significant correlation occurs between hardness and cooking time of the pulses (Clemente et al., 1998). Similar results were also noticed in the development of quick-cooking black chickpea where, ammonium carbonate (1 %) salt solution was used for soaking followed by pressure cooking, and cabinet drying while plain water soaking, vat cooking and fluidized bed drying were the best treatment for the development of quick-cooking white chickpea (Kumar, 2005).

Process optimization

The results obtained by the experimental design showed that the fitted models for different responses were suitable to describe the experimental data. So, the optimization of the instant chickpea process was performed, considering the process condition that results in minimizing the dependent variables. All the responses are equally important for the good acceptance of the final product by the consumers. By applying RSM, it was found that soaking raw *Desi* chickpea with 0.59 % NaCl (X_1), 0.85 % $NaHCO_3$ (X_2), and 0.82 % $(NH_4)_2CO_3$ (X_3) at 49.81 °C (X_4) temperature produced the best quality instant-chickpea with 10.27 min cooking time. Similarly, for *Kabuli* chickpea concentration of salts in soaking solution was 1.07 % NaCl (X_1), 0.79 % $NaHCO_3$ (X_2), and 0.70 % $(NH_4)_2CO_3$ (X_3) at 46.53 °C (X_4) temperature produced good quality instant product with 12.88 min cooking time. It was evident that the experimental or observed values were very close or equal to the predicted value. It clearly indicates that the model was adequate to predict these responses (Table 7).

Comparative study of Physico-chemical characteristics of raw and instant chickpea

The values for almost all physical parameters namely, bulk density, true density, 1000 kernel weight, porosity and colour difference were significantly (P<0.05) reduced in instant chickpea as compared to raw chickpea in both verities as per the data presented in Table 8. It might be due to leaching out of soluble solid during soaking and cooking of chickpea. The amount of solid loss and its rate increased with the increase in temperature of soaking medium (Sayar et al., 2011). The difference in the external colour (Fig. 5) of raw and instant chickpea is due to processing variables during soaking treatment.

Fibre content in both the varieties increased significantly (P<0.05) after processing for making instant chickpea but the reduction in other proximate compositions may be due to a considerable amount of solid lost in water during soaking depending on the temperature of soaking medium and cooking, type of seed and physio-chemical differences in seed as suggested by Berrios et al., (1999) and Seena and Sridhar (2005). In case of chickpea, solid loss levels were reported to vary from 0.81 to 2.80 % after soaking at ambient temperature for 24 h; from 8.19 to 12.95% after complete cooking in boiling water, and from 2.59 to 3.34%, after complete cooking in a pressure cooker (Zhao and Chang 2008). Protein is main component of the solid loss in soaking and cooking water (Sayar et al., 2011). Keyata (2018) reported that the carbohydrate content of chickpea was increased from 55.90 to 62.24 % due to soaking treatment. The total fibre content of *Desi* chickpea is higher than that of *Kabuli* because of the thicker seed coat and hull of *Desi* Chickpea (Kaur and Prashad, 2021).

Optimization of curry-mix powder

Instant chickpea samples of both varieties were prepared by employing three recipes i.e. control (usually prepared at home), chana masala normally available in the market and modified chana masala which was prepared by slight modification in the chana masala. Preliminary trials were conducted to optimize the ingredients. The prepared samples were subjected to sensory analysis on nine-point rating hedonic scale for different sensory attributes namely, appearance, colour, taste, texture, aroma and overall acceptability. The data collected from sensory score cards revealed that ratings for almost all the sensory attributes in respect of both products were significantly ($P<0.05$) higher in modified chana masala (organoleptic score ≥ 8.0). So, it can be concluded that modified chana masala is the best for making instant chickpea recipe mix (Table 9).

Cooking of instant chickpea

Four hundred ml of water was taken into a pan and allowed to boil. After boiling, 100 g of instant chickpea grains were added followed by 63.4 g of curry powder mix. The mixture was stirred and allowed to cook for 11 min for Desi and 13 min for Kabuli instant chickpea, which had been standardized earlier. The products thus prepared were ready to serve.

CONCLUSION

Pulses have shown excellent potential for the production of instant food with good nutrition quality. All processing treatments were very effective in the reduction of cooking time and have a significant effect on the nutritional composition of chickpea. So, instant chickpea has an opportunity to cater to the public as a nutritionally rich market ready-to-cook product and this product can be further recommended for commercialization.

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CONFLICT OF INTEREST

None of the authors has conflict of interest to disclose.

Authors' contributions

Rahul Badola carried out the convenient food studies, conceptualization, experimental work execution, collection of data and analysis, product development, manuscript writing and editing. Sabbu Sangeeta and Anil Kumar coordinate and helped with the conceptualization of the research work, methodology, validation, investigation, data analysis, manuscript reviewing and editing, and supervision. Sweta Rai participated in the formal analysis and review of the manuscript. Preethi Ramachandran helped in drafting and reviewing the manuscript while Shivani Bisht and Mohd. Nazim participated in editing it. All authors read and approved the final manuscript.

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