PARC

ANNUAL REPORT 1989

105

Pakistan Agricultural Research Council
Islamabad

Fodder Crops

INTRODUCTION

Studies in the field of Food Technology and Nutrition are in progress at NARC, to conduct quality research on food and nutrition problems related to agriculture in Pakistan and incorporate nutritional considerations into the national agricultural policy. This would make the farmer and consumer more conscious about the nutritive value of the food produced and consumed in the country. The farmer would select for cultivation those crop varieties which not only give high yield per acre and are more resistant to diseases, but also have high nutritive values and consumer acceptance.

HISTORY

The Food Technology and Nutrition Research Laboratories were established in 1984 at NARC.

OBJECTIVES

1. To screen food crop varieties for nutritional quality and consumer acceptance.
2. To identify and resolve nutritional problems of selected crops and provide facilities and service support to the national agricultural research system.
3. To strengthen linkages with national and international institutions in developing collaborative research to solve priority food and nutrition problems and provide training/workshop, etc.
4. To provide analytical services to the plant and animal scientists working in provincial institutions.

ACHIEVEMENTS UPTO 1988

- Assistance was provided to the plant breeders in the country in screening of germplasm, early lines, advanced lines and commercial varieties of cereals, legumes and oilseeds grown in different ecologies for nutritional quality and consumer acceptance.
- Method for *chapati* making was standardized and more bread was produced from less wheat by blending it with traditional grains.
- Studies were conducted to improve the quality of bread by supplementing with pulses, soybean, potato and different salts.
- The nutritional quality and technological value of wheat flour, supplied by ration depots in Rawalpindi and Islamabad was studied.
- The nutritional quality of cereals and legumes as affected by production environment was studied.
- A technique was standardized to enhance the storage life of whole wheat flour by using polythene packaging material.
- Studies were conducted to improve the quality of pulses by reducing phytate and tannin contents through different processing methods.
- The nutritional quality and acceptance of soybean and date products were determined.
- Supervised and provided research facilities to 12 post-graduate students from local/foreign Agricultural Universities.

ACHIEVEMENTS - 1989

- Twenty-one wheat varieties collected from different research stations were analysed for nutritional quality and consumer acceptance.
- Five commercial wheat varieties sown on different dates were analysed for quality parameters.
- Fifty-six milled rice samples from NIAB, Faisalabad, had intermediate gelatinization temperature and medium gel consistency.
- Twenty-one rice cultivars grown at Mingora, Swat, were screened for their milling recovery.
- Sorghum variety, BR-123 was found to contain highest percentage of tannins and millet variety, Pak-compt contains highest percentage of protein and average amount of tannins, but is deficient in minerals.
- The average ingredients of six products prepared from *desi* and *kabuli* chickpeas were evaluated. *Missi Roti, Pakoras* and roasted chickpeas were found to be better source of iron than the other chickpea products. A 100g of roasted chickpea and *Missi Roti* as dry weight basis can meet 50-100% of the daily iron requirements of an adult male.
- Overnight soaking of lentil before cooking, reduces 50% of the tannin contents which are undesirable.
- Highest protein quality was obtained in diet containing 80% wheat flour and 20% soy flour with biological value of

80% which is 29% higher than wheat and 16% higher than soybean flour.

Four thousand samples of sunflower, 3,000 samples of rapeseed and mustard, 250 samples of safflower, 200 samples of soybean and 100 samples of groundnut were evaluated for oil contents. Twelve hundred samples of rapeseed and mustard were evaluated for erucic acid to suggest batches of rapeseed to be crushed for Canola to present in the market. Three thousand samples of rapeseed and mustard were evaluated for glucosinolate and more than 2,000 samples were analysed for fatty acid profile to identify line having high oil contents and better profile.

RESEARCH RESULTS

WHEAT

Quality Characteristics of some Varieties Grown at Different Locations

Twenty-one samples of 12 different varieties collected from various research stations including NARC were evaluated for quality parameters. Thousand kernel weight (1000-kwt) ranged from 34.2 g in Sutlej 86 from AARI, Bahawalpur, to 43.7g in Pirsabak 85 from NARC. The test weight ranged from 74.3 to 81.0 kg/hl. Flour yield was lowest in Rawal 87 from NARC and highest in Punjnad 88 from AARI, Bahawalpur. With a few exceptions, generally a low amylase activity was noted as is evident from high falling number value. Dry gluten ranged from 8.4 Pak 81 from CCRI, Pirsabak to 11.4 for Lyp 73 from BARI, Chakwal. Water absorption percentage ranged from 57.2 in Khyber 87 from NARC to 66.9 in Sutluj 86 from AARI, Bahawalpur. Dough development time range was 2.3-5.5 min while BARI, Chakwal, showed stronger quality of gluten. Higher time to breakdown also supported it.

Effect of Different Sowing Times

Five commercial varieties, Faisalabad 85, Pirsabak 85, Chakwal 86, Khyber 87 and Rawal 87 sown on October 8 and 22, November 5 and December 6, 17 and 29 were selected for the study. The samples were tested for 1000 Kwt, test weight, flour yield, PSI, falling number, dry gluten, farinographic characteristics, moisture, protein and ash contents. Crop sown in December gave less 1000 Kwt and test weight as compared to crop sown in October and November in almost all varieties. The flour yield did not exhibit consistency with sowing dates. Flour yield in Faisalabad 85 and Chakwal 86 was lowest for crop sown on October 8, while Pirsabak 85 and Rawal 87 gave the lowest flour yield when sown on December 29. All the varieties gave highest falling number in crop from first week of December except Faisalabad 85 which showed less starch damage and low amylase activity. Gluten contents showed a variation of 1.4 - 2.5% in crop sown on different dates within the variety.

The water absorption is more widely affected by differences of sowing time in each variety. The strength also improved in the November and December-sown crop. Protein contents were highest in almost all the varieties sown in November and December. Wide variations in ash contents of white flour were noted except for Chakwal 86.

Optimum Conditions for Better Flour Extraction

Three varieties (Pak 81, Lyp-73 and Barani 83) were subjected to five levels (14-18%) of moisture contents for 1-30h. All the three varieties showed a poor performance at 17-18% moisture, while for Lyp 73, even 16% moisture level was not yield showing a gradual decrease with every increase in moisture level. Twelve hours of resting period after conditioning gave very wide variations within varieties.

In Pak 81, rest period of 18h, 24h with 15% moisture gave a better flour yield while 14% moisture level was suitable with 30h post conditioning rest period. In Lyp 73, a moisture level of 14% was better yielding after 18h rest period, while 15% moisture level performed better at 24 and 30 h rest period. In Barani 83, better performance was noted at 14% and 15% moisture level with rest period of 18h and 24h.

Effect of Laboratory Sprouting

Three varieties viz., Pak 81, Lyp 83 and Barani 83 were selected for this study. Treatments included three temperatures (i.e. 20°C, 25°C and 30°C) and four moisture levels (soaking, 15%, 20% and 25%) for 1, 2, 3 and 6 days of exposure. All varieties at 20% moisture level and 25°C were completely damaged by fungal growth. Similarly Lyp 73 at 20% moisture and 30°C and Barani-83 at 25% moisture and 30°C were damaged by fungal growth.

Soaked samples of each variety under each temperature treatment showed a high percentage of sprouting, while rest of the treatments did not show any visible effect in this respect.

The 1000 Kwt was not significantly affected by different treatments in all three varieties. The break flour yield generally increased in each variety as compared to control value. The ratio between break to reduction flour was also higher because reduction flour yield showed a general decline as compared to control. In Lyp 73, reduction flour showed an increase with respect to control value. Total flour yield, however, declined in Barani 83 and Pak 81 while in Lyp 73 yield was inconsistent.

Soaked samples recorded

content was not significantly affected by different treatments. Pak 81 showed more decrease in gluten contents as compared to other varieties. In Pak 81 and Lyp 73, soaking affected gluten contents more with temperature treatment of 20°C and 25°C than with 30°C.

Protein contents in whole meal flour of each variety showed a general trend of decrease from control value. In Barani 83 (30°C, 15% and 20% moisture level) protein contents were decreased. Ash contents were generally increased in each variety as compared to the control value. The Pak 81 samples (20°C, soaking) showed a decrease in ash contents. Further extensive study is suggested on quality sprouting deterioration.

MAIZE

Physico-chemical and Nutritional Quality

Four samples of maize population-10, obtained from Maize Programme, NARC, were analysed for physico-chemical and nutritional quality but no significant effect of fertilizer or herbicide was evident (Table 1).

RICE

Physico-chemical Characteristics

Fifty-six milled rice samples, received from NIAB, Faisalabad, were analyzed for various physico-chemical properties. The values for kernel length, breadth, thickness, cooked kernel length, amylose content, alkali spreading value and gel consistency varied from 6.10 to 7.50, 1.49 to 2.50, 1.35 to 1.80 and 10.00 to 13.40 mm, 20.5% to 28.0%, 4.5 to 7.0 and 47 to 63 mm, respectively. Length/breadth and elongation ratio were computed which ranged from 2.44 to 4.50 and 1.4 to 1.9. On the basis of chalkiness, five samples had white core, one white belly and the rest, translucent grains. The aroma was moderate in most of the samples, strong in a few, while it was absent in two samples. Four samples contained high amylose, while all the others had intermediate value. Using alkali spreading value as indirect method for the determination of gelatinization temperature (GT), two samples were categorized as low whereas all the others were intermediate GT rices. Gel consistency was found soft for three and medium for rest of the samples.

Milling Recovery and Physical Dimensions

The physico-chemical characters of some rice cultivars grown at Mingora, Swat, were studied. The data on brown rice, husk, total milled rice, bran, head rice and broken rice ranged from 75.39 to 82.64%, 17.36 to 24.61%, 65.39 to 70.61%, 8.51 to 15.76%, 46.72 to 59.12% and 7.76 to 22.69%, respectively (Table 2). The overall performance of variety No. 8 was found better. The higher value for quality index was found for variety No. 3 and lower for variety No. 4.

SORGHUM

Chemical Composition

Seven sorghum varieties, Giza 3, IC 1039, Pak SS II, DS 75, Bagdar, BR 123 and PU 7 received from Sorghum and Millet Programme, NARC, Islamabad, were analyzed for moisture, protein, ash and tannin contents. The moisture contents of these samples ranged from 8.8% to 9.6%. Crude protein and ash contents on dry matter basis ranged from 10.2% to 13.6% and 1.6% to 2.2%, respectively. Tannin contents were minimum (151 mg/100 g) in Giza 3 and maximum (548 mg/100 g) in BR 123. There was much variation in tannin contents of sorghum varieties. The plant breeders should consider this parameter in breeding programmes as tannins are nutritionally not desirable.

MILLET

Chemical Composition

Seven millet varieties, DB V, C 47, K 8206, IVSP 78, Pak Compt, Y 84 and Ugandi received from Sorghum and Millet Programme, NARC, Islamabad, were analyzed. The moisture contents varied from 8.3 to 8.8%. Crude protein on dry matter basis ranged from 10.8 to 17.6%. Ash contents ranged from 1.4 to 5.4%. There is a lot of variation in protein and ash contents of analysed millet varieties. Tannin contents ranged from 266 mg/100 g to 334 mg/100 g.

CHICKPEA

Physico-chemical and Nutritional Quality

Ten chickpea samples received from major varietal yield trials of Pulses Programme, NARC, were analyzed for physico-chemical characteristics and nutritional quality. The 100-seed weight ranged from 12.5 to 31.7 g with a mean value of 22.8 g.

The hydration index was 0.74, varying between 0.47 and 1.01. It is related to the degree to which a seed can absorb water and is important in cooking time. Swelling index is the increase in volume of a seed after overnight soaking. Swelling index of variety, CM 1918 was highest (1.29) while that of variety C 141 was lowest (0.64) and the mean value of swelling index was 0.93. The range of cooking time was 90-142 minutes in dry

Table 1. Physico-chemical and nutritional quality of maize analyzed during 1989

Treatment	Moisture (%)	Protein (DM%)	Ash (DM%)	Fat (%)	Test Wt. kg/hl	Flour Extract (%)
DAP (120N: 60 P kg/ha)	10.7	12.5	1.5	3.7	77.4	88.8
No fertilizer	10.9	10.3	1.3	3.6	77.3	89.7
Primextra @ 1.5 l/ha	11.9	11.6	1.5	4.7	74.7	89.2
No herbicide	10.8	11.5	1.4	3.8	74.2	87.0

samples and 35-65 minutes in soaked samples. The cooking time is important to select a variety.

Chemical analysis showed that protein content of these chickpea samples ranged from 22 to 27% with a mean of 23.7%. CM-68 had maximum protein (26.9%). Ash content was almost uniform (2.7-

Table 2. Milling quality and physical measurements of some cultivars planted at ARS, Mingora, Swat-1989

Variety	Brown rice (%)	Husk (%)	Total milled (%)	Bran (%)	Head rice (%)	Broken rice (%)	Grain length (mm)	Grain brea-dth(mm)	Grain thick-ness (mm)	Quality index (L) BxT
1	77.20 FGH	22.80 ABC	67.52 BCDEFS	9.81 EFGHI	57.01 AB	10.37 EF	5.60 DE	2.00 ABCD	1.80 AB	1.57 BCD
2	77.89 FG	22.11 BC	66.37 EFG	11.52 DCEPG	50.61 DEF	15.76 BCD	6.47 ABC	1.73 CD	1.60 BC	2.37 ABC
3	78.08 FG	21.92 BC	69.57 ABC	8.51 HI	56.48 AB	13.09 CDE	6.40 ABCD	1.67 D	1.57 BC	2.57 A
4	82.32 AB	17.68 GH	70.61 A	11.71 CDEF	57.79 AB	12.83 CDE	4.73 F	2.33 A	2.00 A	1.03 D
5	77.57 FG	22.43 BC	66.43 DEFG	11.15 DEFGH	50.56 DEP	15.87 BCD	6.93 A	1.93 BCD	1.80 AB	2.00 ABC
6	76.69 GH	23.31 AB	68.56 ABCDEF	8.13 I	49.65 EFG	18.91 B	6.33 ABCD	1.87 BCD	1.67 ABC	2.13 ABC
7	78.27 FG	21.73 BC	69.47 ABCD	8.80 GHI	52.85 CDE	16.61 BC	6.20 ABCDE	1.93 BCD	1.80 AB	1.80 ABCD
8	82.64 A	17.36 H	66.55 CDEFG	8.80 A	52.85 A	16.61 F	6.20 E	2.00 ABCD	1.80 AB	1.47 CD
9	76.72 GH	23.28 AB	65.39 G	8.67 HI	54.83 BC	13.23 CDE	7.00 A	1.93 ABCD	1.73 AB	2.13 CD
10	77.65 FG	22.35 BC	68.03 ABCDEFG	9.63 EFGHI	50.33 DEF	17.70 B	6.00 BCDE	1.93 BCD	1.77 AB	1.83 ABCD
11	81.15 ABC	18.85 FGH	69.60 ABC	11.55 CDEFG	51.33 DEF	18.27 B	6.73 AB	1.93 BCD	1.77 AB	2.00 ABC
12	82.37 AB	17.63 GH	67.68 ABCDEFG	14.69 AB	58.05 AB	9.63 EF	6.33 ABCD	2.00 ABCD	1.83 C	1.77 ABCD
13	79.01 DEF	20.99 CDE	67.87 ABCDEFG	11.15 DEFGH	49.60 EFG	18.27 B	5.80 CDE	1.73 CD	1.40 C	2.43 AB
14	81.60 ABC	18.40 FGH	67.33 BCDEFG	14.27 ABC	56.35 AB	10.99 EF	6.07 BCDE	2.17 AB	1.67 ABC	1.73 ABCD
15	81.33 ABC	18.67 FGH	69.71 AB	11.63 CDEFG	50.59 DEF	19.12 AB	6.80 AB	2.00 AB	1.60 BC	2.17 ABC
16	80.24 CDE	19.76 DEF	66.21 FG	14.03 ABC	53.04 CD	13.17 CDE	6.33 ABCD	2.00 ABCD	1.67 BC	1.93 ABCD
17	81.20 ABC	18.80 FGH	68.16 ABCDEFG	13.04 BCD	55.92 ABC	12.24 DE	6.33 ABCD	1.87 BCD	1.53 BC	2.23 ABC
18	80.60 BCD	19.40 EFG	69.41 ABCDE	11.19 DEFGH	46.72 G	22.69 A	6.00 BCDE	2.00 ABCD	1.67 ABC	1.83 ABCD
19	77.63 FG	22.37 BC	66.43 DEFG	11.20 DEFGH	46.80 G	19.63 AB	6.07 BCDE	2.07 ABC	1.73 ABC	1.73 ABCD
20	78.48 EFG	21.52 BCD	66.12 FG	12.29 BCDE	49.47 FG	17.39 B	6.37 ABCD	2.07 ABC	1.73 ABC	1.80 ABCD
21	75.39	24.61	65.83	9.23	48.83	17.33	6.27	2.00	1.80	1.77

3.4%). Fat percentage ranged between 3.4 and 4.9%, while crude fibre content varied from 7.1 to 11.6%.

Nutritive Value of Chickpea-based Products

From the stand-point of practical dietetics, nutritive value of foods eaten by man and the availability of dietary constituents in the cooked state is more important than the evaluation of food in the raw state. The average ingredients of some products prepared from *desi* and *kabuli* chickpeas were evaluated.

The protein content (Nx6.25) of the chickpea products varied between 8.9 and 21.1%. Roasted chickpea, *desi dhal* curry and *chaat* contained more protein than the other products. The energy values ranged between 333 Kcals/100 g for *Missi Roti* to 614 Kcal/100 g for *Halwa. Pakora* and roasted chickpea were very high in crude fibre content (11.1 and 10.6%, respectively). The calcium content of these products varied from 226 mg/100 g for *desi dhal* curry to 360 mg/100 g for whole *kabuli* curry and 100g of the dry products provides about 50-75% calcium requirements of an adult. The iron content of these products ranged from 3.9 mg/100 g for *desi dhal* curry to 8.2 mg/100 g for roasted chickpeas. *Missi Roti, pakoras* and roasted chickpeas were found better sources of iron than the other chickpea products (Table 3). As iron deficiency anemia is a public health problem in Pakistan, the use of these recipes can help in ameliorating iron deficiency in the local population. The 100 g of roasted chickpea and Missi Roti on dry weight basis can meet 50 to 100% daily iron requirements of an adult. The zinc content of these recipes ranged between 1.8 and 5.4 mg/100 g. The copper content of these products varied between 0.6 and 1.1 mg/100 g and whole *kabuli* curry and roasted chickpea had the highest amount of copper (1.1 mg/100 g) among these products.

LENTIL

Physico-chemical Characters and Nutrient Composition

Ten advanced lines of lentils received from Pulses Programme, NARC, were analyzed for physico-chemical and nutrient composition. The average seed wt was 3.2 g/100 seed. Line, Laird x Precoz-7 was the heaviest (4.8 g/100 seed). The hydration co-efficient varied from 168 to 183% with an average value of 176%. Rapid uptake of water is a desirable attribute of legume grain used for food. The value for hydration co-efficient was highest in variety, Masoor 85. The cooking process makes hard seed soft by improving the plasticity of the cell wall and gelatinization of starch. The mean time for cooking of dry seed was 33.4 min. Seeds of ILL-5562 x ILL-936 were quickest to cook (17 min.) while seeds of Precoz took longer time to cook (50 min). However, soaking overnight reduced the cooking time. The value ranged from 10-23 minutes.

The protein content was highest in Laird x Precoz-6 (27.8%) and lowest in Masoor 85 (20.9%). The mean value of ash content was 3.0% with a range of 2.6 - 4.6. Fat content varied from 0.5 to 1.1%, while crude fibre value had a mean of 5.3% ranging from 4.8 to 5.8%. There was an urgent need to increase the yield, improve the quantity and quality of protein and to eliminate anti-nutritional factors. As the decortication loss has been related to seed size, the breeders should introduce larger size varieties.

Effect of Processing on the Tannin Content

The effect of processing on the tannin content of three lentil varieties/advance lines, Masoor 85 (Comm), 18-12 (adv. line) and AARIL 337 (adv. line) grown at NARC was studied. The tannin content of the raw grain varied between 0.85 (Masoor 85) and 0.96% (18-12). Cooking decreased the tannin content by 34% for Masoor-85, 36% for 18-12 and 38% for AARIL 337. Soaking of lentils overnight in water and subsequent cooking further decreased the tannin content by 47 to 49%. Maximum

Table 3. Chemical composition (dry basis) of some Pakistani chickpea products analyzed during 1989

Product	Protein (Nx6.25)	Fat	Carbo-hydrate	Crude fibre	Ash	Calories (Kcal/100g)	Ca	P	Fe	Zn	Mn	Cu
	g/100g						(mg/100g)					
Curry Whole *Kabuli*	17.7	12.6	60.9	4.4	4.4	402	360	315	5.3	3.9	2.6	1.1
Dhal desi	20.3	12.8	60.9	1.6	4.4	393	226	273	3.9	3.3	2.6	0.7
Missi Roti	14.6	3.1	75.9	4.1	2.3	333	239	284	6.9	4.6	5.4	0.9
Pakora	17.2	12.4	53.4	11.1	5.9	453	239	243	7.2	2.5	2.9	0.8
Chaat	19.3	5.3	68.2	3.9	3.3	371	328	279	5.8	3.6	1.6	0.9
Halwa	8.9	21.8	63.7	4.4	1.2	614	247	126	3.8	1.8	1.5	0.6
Roasted chickpea	21.1	5.0	60.3	10.6	3.0	361	268	264	8.2	5.4	2.6	1.1

reduction in tannin content was achieved by either soaking the grain in water for 12h and cooking or by germination for 24h followed by cooking. Increasing the germination for 48h and cooking had virtually the same effect. Tannins are major anti-nutritional factors. The nutritional importance of the process of water soaking or germination of the grain prior to cooking should be stressed upon the housewives to increase the nutritional quality of the grain.

MUNG

Physico-chemical and Nutritional Qualities

Six commercial varieties of mung grown at NARC were evaluated for physical characteristics, cookability and nutritional quality. The 100 seed weight ranged from 3.2 to 3.6 g. The hydration co-efficient varied from 170 to 188%. The mean cooking time of dry seeds was 30 min which reduced significantly when the seeds were soaked overnight in water. A range of 16 to 21 minutes was observed in cooking time of soaked seeds of the various varieties. The protein content (Nx5.7) ranged from 21.5% in variety, NM-20-21 to 25.5% in variety NM-121-25, the overall mean value being 23.3%. Crude fibre content was almost uniform in all these varieties (5.2-5.8%). The ash content varied from 2.6 to 3.6% and the fat content was almost uniform in all these varieties (0.8-1.1%).

Effect of Processing on the Tannin Content

The effect of processing on the tannin content of five mung varieties received from Pulses Programme, NARC, was studied. The tannin content of the raw grain varied from 0.85 to 0.98%. Cooking decreased the tannin content by 30% for NM-20-21 and 28% for NM-121-25. Overnight soaking in water and subsequent cooking further decreased the tannin content from 49 to 54% in NM-19-19 and NM-13-1, respectively. Germination for 24h followed by cooking decreased the tannin content by 57-60%. Increasing the germination period to 48h and cooking did not cause any further decrease in the tannin content. Tannin is a major anti-nutritional factor, so soaking or germination of the grain before cooking is strongly advocated to improve the bioavailability of nutrient in the diet.

Nutritional Quality of Advance Lines

Six advance lines of mung received from Pulses Programme, NARC, were screened for quality parameters (Table 4). The 100 seed weight varied from 3.4 to 6.2. The hydration co-efficient ranged from 159% to 185% in cultivar 'NCM-68'. The mean cooking time of dry seeds was 30.7, min while after overnight soaking in water it reduced to 18.2 min. The protein content (Nx5.7) ranged from 22.3% to 24.9%. The mean value of ash and fat content were 3.5% and 1.1%, respectively.

Effect of Processing on the Protein Quality

Mung beans (NM-19-19) received from Pulses Programme, NARC, were evaluated for protein quality in raw, soaked and soaked-cooked beans, at the 10% dietary protein level using weanling rats. Biological value, true digestibility and net protein utilization in soaked cooked beans were improved significantly from 52% to 57%, 83% to 86% and 43% to 49%, respectively, while in soaked beans there was no significant improvement.

MASH

Nutritional Quality

Six advance lines and two

Table 4.Physico-chemical and nutritional quality of mung (advance lines) analyzed during 1989

Advance lines	Seed size (100 seed wt.) (g)	Hydration co-efficient (%)	Cooking time (min) Dry	Soaked	Protein (% dry basis)	Ash	Fat
NCM-87	3.6	159	29	17	22.3	2.7	0.9
NCM-79	5.6	160	35	16	24.9	3.8	1.1
NCM-68	3.4	185	31	22	23.8	4.0	1.2
NCM-89	6.2	169	29	15	24.4	2.9	1.1
NCM-10	4.4	163	31	20	23.6	3.5	1.1
NCM-7	3.4	164	29	19	22.4	3.8	1.0
Mean	4.43	166.66	30.66	18.16	23.56	3.45	1.06
S.E.	0.49	3.938	0.954	1.077	0.427	0.217	0.042

commercial varieties of mash grown at NARC were evaluated for physical characters, cookability and nutritional quality. In advance lines viz., Mash 216, Mash early, Mash AARIM 191, Mash AARIM 118, Mash AARIM 114 and Mash AARIM 113, the 100-seed weight ranged from 4.0 to 4.8g. The hydration co-efficient varied from 158 to 192%. The average cooking time of dry seeds was 35.5 min which reduced to 22.5 min after overnight soaking in water. Cooking time is expected to be affected by the starch itself, the permeability of the seed coat, and the internal structure of the seed endosperm material. The protein content (Nx5.7) ranged from 23.4% in cultivar Mash early to 26.4% in cultivar Mash AARIM 113, with a mean value of 24.9%. The fat content was almost uniform in all these lines (0.4 to 0.7%), and the ash content varied from 3.1 to 4.1%. The 100-seed weight of the two commercial varieties, Mash 80 and Mash 59, ranged from 4.0 to 4.6%. Hydration co-efficient varied from 109 to 162%. The mean cooking time of dry seeds and after soaking in water overnight was 36.5 and 23 min, respectively. The protein content (Nx5.7) ranged from 24.9 to 25.1%. The fat and ash content varied from 0.3-0.5% and 3.0-3.8%, respectively.

Effect of Processing on the Tannin Content

Three commercial varieties, Mash 80, Mash 51 and Mash 216 and two advance lines Mash AARIM 119 and Mash AARIM 113 received from Pulses Programme, NARC, were subjected to the effect of various processing methods on the tannin content. The tannin content of the raw grain varied between 0.75 and 0.85%. Cooking reduced the tannin content significantly by a minimum of 32% for Mash 80 and Mash AARIM 113 to 39% for Mash AARIM 119. Overnight soaking in water and subsequent cooking of the grain reduced the tannin content by 53%. Maximum reduction in tannin content (62%) was achieved by germination for 24h followed by cooking. While germination for 48h and subsequent cooking had virtually the same effect. So soaking the grains overnight in water and germination for 24-48h followed by cooking maximally reduced the tannin content. Since tannin is major anti-nutritional factor, the nutritional importance of the process of water soaking or germination of the grain prior to cooking should be stressed upon the housewives.

COWPEA

Physico-chemical and Nutritional Quality

Six advance lines of cowpea received from Pulses Programme, NARC, were evaluated for physico-chemical characteristics and nutritional quality (Table 5). Seed size is critical for selection of genetic material and in general, the larger seed size is considered to be of better quality. The larger seeds are also preferred for consumption. Although seed size is a highly variable characteristic, it can be affected up to 25% by growing location, season and disease. Hydration capacity is the degree to which the seeds absorb water to become fully saturated. The hydration index of these lines was almost uniform. Mean cooking time reduced from 43 to 18.8 minutes on soaking overnight. The cooking time is a function of permeability of the seed coat and the hard seed coatedness and poor hydration capacity resulted in longer cooking time. The mean value of protein content was 21.5%.

OILSEED CROPS

Supplementary Effect of Soy Flour on Protein Quality of Flour

The low quality of protein in wheat products is due to low level of essential amino acid (lysine) which can be enriched by blending with legumes like chickpea, lentil and soybean containing higher level of lysine.

The present work was undertaken to study the nutritive value of wheat flour supplemented with different levels of whole soybean flour. In the supplemented diets wheat supplied 95%, 90%, 85% and 80% of flour, while the rest was provided by soy flour. These diets

Table 5. Physico-chemical and nutritional quality of cowpea (advance lines) analysed during 1989

Advance lines	100 seed wt. (g)	Seed volume (ml/seed)	Hydration capacity	Hydration index	Swelling capacity	Swelling index	Cooking dry	Time (min) soaked	Protein	Ash (% dry basis)	Fat
IT82E-32	16.4	0.15	0.18	1.08	0.19	1.27	48	22	20.5	3.7	1.7
Cowpea No. 9	12.6	0.10	0.13	1.03	0.14	1.40	45	17	21.1	3.7	1.8
IT84E-124	20.0	0.17	0.22	1.08	0.25	1.47	32	15	21.2	3.6	1.9
TVx1949-OIF	14.8	0.13	0.16	1.11	0.17	1.31	44	17	23.1	4.3	1.6
IT83D-442	17.6	0.15	0.19	1.09	0.21	1.40	42	19	20.4	3.7	1.9
IT83S-872	14.0	0.12	0.16	1.16	0.18	1.50	47	23	22.5	4.0	2.3
Mean	15.9	0.136	0.173	1.091	0.19	1.391	43	18.83	21.46	3.83	1.86
S.E.	1.09	0.01	0.012	0.017	0.015	0.036	2.366	1.275	0.447	0.108	0.098
C.V.	16.796	18.317	17.75	3.904	19.692	6.385	13.48	16.593	5.108	6.934	12.975

were fed to weanling rats at 10% dietary protein level for 10 days. The true protein digestibility (TD), net protein utilization (NPU), biological value (BV) and net dietary protein calorie percent (ND pCal%) of supplemented diet varied from 81 to 86%, from 59 to 67%, from 74 to 80% and from 6.6 to 6.9%, respectively. Highest protein quality was obtained in diet containing 80% wheat flour and 20% soybean flour. This mixture had biological value of 80% which was 29% higher than wheat and 16% higher than soybean flour *chapati*. The improving effect of soybean flour was due to correction of lysine deficiency in wheat protein and methionine deficiency of soybean flour. The net dietary protein calories (ND pCal%) in supplemented diet ranged from 6.6 to 6.9 and can meet the protein requirements of children (4-9 years) and adults only. Best *chapati* was produced with a mixture of 90 wheat: 10 soy flour and had NPU of 63%.

Oil Contents Screening

As many as 4203 samples of sunflower early/advance lines, 3083 advance lines of rapeseed and mustard, 257 samples of safflower germplasm/advance lines, 182 samples of soybean varieties/advance lines and 86 samples of groundnut advance lines received from BARD Project and Oilseed Research Programme, NARC, were screened for their oil contents. The highest oil contents were found in 64%, 73%, 41%, 20% and 95% samples of sunflower, rapeseed and mustard, safflower, soybean and groundnut, respectively.

BARD Project has introduced Canola oil in the local market. Its production involves cooperation from oilseed laboratory at all stages. Low erucic acid lots can be used for crushing, therefore, 1255 representative samples of rapeseed were analysed. The data showed a wide range (0.2-57.3%) of erucic acid which depicted that either the rapeseed farmer intentionally mixed picture suggested need for a strict check, while selecting rapeseed for crushing, to maintain highest standard of Canola oil.

About 3146 samples of whole seed of rapeseed and mustard were analyzed for total glucosinolates by glucose release method spectrophotometrically, of which 55% had glucosinolate contents ranging from 20 to 50 μm/g whole seed.

Sunflower advance lines (810 samples) received from Oilseeds Research Programme, NARC, were analyzed for fatty acids. The data when subjected to statistical analysis revealed that the oleic acid and linoleic acid ranged from 4.0 to 70.4% and 16.3 to 86.3%, respectively.

Advance lines of rapeseed and mustard (numbering 1586) were analyzed for fatty acid profile. The results revealed that the linoleic and linolenic acid ranged from 9.0 to 35.0% and 3.0 to 17.0%, respectively, and erucic acid from 0.1 to 58.0%.

MUSHROOMS

Nutritional Evaluation

Five varieties of mushroom were analyzed for moisture, protein and ash contents and it was found that mushrooms are good source of protein and minerals.. The results revealed a moisture content range of 10.8-12.2% (Table 6). The protein (on dry matter basis) ranged from 2.25 to 25.8%. The ash contents varied from 5.4 to 9.5% mushrooms are good source of protein and minerals.

FRUITS AND MALT EXTRACT

Chemical Analysis

Two samples of malt extract

Table 6. Nutritive value of mushroom (% DM) analysed during 1989

Variety	Moisture (%)	Dry matter (%)	Protein (%)	Ash (%)
P-572	10.82	(89.2)	25.6	8.06
P-401-Local	12.00	(88.1)	24.5	9.60
NARC-Local	11.60	(88.4)	23.0	9.50
Exotic-594	12.20	(87.8)	22.2	9.00
Lentinus	10.50	(89.5)	25.8	5.40

Table 7. Chemical analysis of malt extract and fruit juices undertaken during 1989

Parameter	Sample No. 1	Sample No. 2
Brix (%) (for soluble solids)	80	81
Reducing sugars (%)	34.43	35.06
Vitamin-C (mg/100 g)	3.56	3.83
Protein (%)	1.67	1.63
Ash (%)	2.18	1.89
	% Fruit content	
Mango juice (Drink)	1.02	

received from Tops Food and Beverages were analyzed for Brix (soluble solids), reducing sugars, protein, ash and vitamin C contents. Brix was 80% in sample No. 1 and 81% in sample No. 2. Sample No. 1 contained 34.4% reducing sugar, while sample No. 2 contained 35.06%. Vitamin C content was 3.562 mg/100 g in sample No. 1 and 3.83 (mg/100 g) in sample No. 2 (Table 7)

Fruit content percentage of two samples of mango juice drink and mango juice preserved 1.02% and 6.6%, respectively.

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