ABSTRACT

The present invention provides for an improved steam-polished and shelf-stable flour obtained from gluten lacking grain such as Sorghum and Pearl millet grains with the retention of nutritive germ, having an enhanced oil content, and improved coarse grain flour, nutrients and an additive of rice origin and a process for its production.

We Claim:

1. A process for the preparation of improved flour from gluten lacking grains selected from sorghum and Pearl millet, having enhanced shelf life and other characteristics such as described herein, the said process comprising:

a) removing inorganic and organic refractions by subjecting the grains to cleaning

b) steaming the cleaned grains of step (a) in an autoclave at an atmospheric pressure for a period of 5 – 25 minutes at a temperature ranging between 97°-100°C;

c) drying the grains of step (b) in a shade and allowed to stand for 12 – 48 hours;

d) grinding and sieving the whole coarse grains of step (c) to obtain flour;

e) adding an additive of rice origin such as herein described to the flour product of step (d) to get the desired improved flour.

2. A process as claimed in claim 1, wherein the sieving is effected with 60 mesh British Standard Sieve (BS).

3. A process as claimed in claim 1 to 2 wherein in the additive of rice origin used is 1 – 15 % of puffed or popped or flaked rice flour.

4. A process for the preparation of improved flour from gluten lacking grains selected from sorghum and Pearl millet, having enhanced shelf life substantially as herein described with reference to the examples.

Dated this 26th day of March 2002.

Anjana Baruah

(Dr. Anjana Baruah)
Scientist
Intellectual Property Management Division
Council of Scientific & Industrial Research

The present invention relates to a process for the preparation of Sorghum and Pearl millet grain based product having enhanced shelf life.

It is a common practice by sorghum and pearl millet consumers that the grain is ground to flour in small quantities, enough to meet their requirements for a few days only, as the flour is highly susceptible to rancidity during storage. A rapid development of fat acidity in the millet flour, caused mainly due to the action of lipase (Lai, C.C and Varriano-Marston, E, Cereal Chem. 1980), leads to increase in the free fatty acid content and bitterness of meal, thus rendering it unacceptable for use within a week or two (Kaced, I., Hoseney, R. C and Varriano-Marston, E, Cereal Chem., 1984). In India, sorghum and pearl millet are usually consumed in the form of rotis (unleavened pancake). Use of antioxidants, defatting, and heat treatment to the meal has been attempted to increase the shelf life of flour. In other methods involving grains, acid treatment (0.5N HCl) and hot-water blanching of grains has been attempted, before milling. Varriano-Marston and Hoseney (Varriano-Marston, E and Hoseney, R 1983) have suggested that appropriate milling techniques at village level need to be developed, some of processes available, though help in efficient decorticating, do not ensure complete removal of germ, which contains the largest proportion of lipid material in the grain. The germ is deeply embedded in the endosperm, particularly in pearl millet. The size and shape of the millet grains and deep embedding of germ in the endosperm make it rather difficult to produce low fat flour/grits from them.

Relevant references which claim the production of stable millet flour are cited below:

Reference may be made to Kadlag *et al* (Kadlag, R.V., Chavan, J.K and Kachare, D.P., Plant Foods for Human Nutr. 1995), wherein boiling water blanching treatment to the grains before milling has been mentioned to arrest the lipolytic activity. The treatment consists of blanching grains in boiling water at 98^0C for 10 sec., followed by drying and grinding. The treatment however, is not feasible at industrial level and is not, when grains have to be processed in bulk and drying of the blanched grains may require more energy.

It has been reported by the authors that the flour from the blanched grains can be stored only for 30 days, showing its limited improvement.

Reference may be made to another study, Chavan and Kachare, (Chavan, J.K and Kachare D.P., J. Food Sci. Technol. 1994a), who treated the pearl millet by: (a) soaking in 0.05N HCl for 12h at ambient temperature, washing under tap water and drying finally in an hot air oven for 12h, and (b) drying the grains in a hot air oven at 50^0C for 60 min or at 100^0C for 10 min. Of all the above mentioned treatments, acid soaking and hot water blanching was reported to arrest increase in free fatty acid in the flour, while dry heat treatment did not. Draw back of this is that, acid treatment may not be practical for use at industrial level for large quantities of the grain. Further, it is also cumbersome, because it needs thorough washing following acid treatment thus requiring large volumes of water for processing, and drying. Shelf-life of the flour from acid treated grains has not been studied beyond 30 days. It may also have adverse effect on functional properties of the grain.

Reference may be made to yet another study of Kapoor and Kapoor (Kapoor, R and Kapoor, A.C, Food Chem. 1990) reported the effect of different treatments, like addition of antioxidants (BHA, BHT and ascorbic acid), thermal exposure, defatting and salting, on the keeping quality of pearl millet flour. Of the above treatments defatting of the flour significantly retarded the increase in free fatty acid content. The main drawback will be when bulk quantities of flour has to be defatted since large volumes of n-hexane is needed and the storability of the flour is for only 30 days.

Reference may be made to another study by Anju Rao and Vimala (Anju Rao and Vimala, V., J. Food Sci. Technol. 1993) in which tricalcium phosphate was used as additive to the sorghum flour before storage. They reported a slight decrease in the fat acidity value in comparison to the untreated flour, stored for a period of one month. This perhaps may control the insect infestation, but is not effective for long term shelf stability.

Yet another reference may be made to, Bookwalter et al (Bookwalter, G.N., Lyle, A and Warner, K., J. Food Sci., 1987) who subjected the whole millet (adjusted to 15% moisture content) to gradual heating to 97^{0}C for over 12 min by passing through a steam jacketed paddle conveyer to inactivate the lipase. The processed millet was then milled to 50% and 80% extraction level. The 80% extracted flour had high fat content. Both the flours had better shelf life at 49^{0}C for two months (accelerated aging). The milling was carried out using 4 corrugated break rolls, where in grits, bran and germ are separated. This method also improved functional and nutritional properties of the flour. Drawback is the adjustment of the critical moisture content of the grains and also that the technology is sophisticated for popularization in the developing / undeveloped countries where sorghum and pearl millet are primarily used for food purpose.

Reference may be made to yet another investigation, Young *et al* (Young, R., Haidara, M., Rooney, L.W and Waniska, R.D., J. Cereal Sci., 1990) who parboiled the sorghum and used it as rice-like product (whole grain) after decorticating. The process involves soaking and boiling. It enhanced the yield of polished grain from softer varieties. However, this process alters the functional properties of the flour for its use as roti and porridge consistency, which are the most common food use of the grain. Additionally the process is quite lengthy, involving long duration of soaking and drying, thus adding to the cost.

Reference may be made to yet another investigation of Abdul Rahman, 1980 who utilized roller mills to obtain low fat pearl millet grits after moistening the grains to a level of 20-22% moisture. Drawbacks in this method are the low yield (69%) and the nutritive germ is removed during milling, the high moisture in the grain requires extra energy while drying and chances of mold growth is very high. No data on the shelf life of these low-fat grits have been presented.

A reference may be made to US 5547690, (Philip Greenwell and Christopher J Brock, 1996) wherein a method for improving rheological properties of flour dough through the use of an enzyme preparation, contain sulfhydryl oxidase and glucose oxidase, has been established. The drawbacks are that addition of an enzyme is very expensive and may not be feasible for the flour from coarse grains, as these grains are utilized mainly by people in developing and underdeveloped countries.

Reference may be made to recent patent submitted from our institute, it deals (Manisha Guha and Ali S.Z., 391 / DEL / 2001 dated 29.3.2001) with the production of an improved flour for roti making from coarse grains. In this study part of the flour is gelatinized by extrusion cooking or drum drying, powdered to a desired mesh size and mixed with the raw flour at appropriate concentrations. This addition improved the rheological properties of the dough and eliminates the use of hot water required used normally for dough preparation of flour from coarse grains. This invention is cannot be practiced at the village level since processors have to invest heavily on an extruder. Since only a part of the flour is subjected to heat treatment lipase is thus inactivated partly and hence storage of this improved flour for longer duration is not feasible.

The main object of the present invention is to provide a process for the preparation of Sorghum and Pearl millet grain based product having enhanced shelf life.

Another object of the present invention is to prepare a convenience product from sorghum and pearl millet for habitual and non-habitual consumers of the millet in the form of improved, shelf-stable, refined flour.

Another object of the present invention is to decorticate the grains without incipient moistening thus avoiding humid conditions.

Still another object of the present invention is to debran (polish) these grains without incipient moistening. The grains that have been subjected to moist heat for 15 minutes is kept in a loosely closed container until grains cool to room temperature and immediately polished in a cone polisher avoiding incipient moistening and drying.

Yet another object of the present invention is to improve the dough quality, by the addition of an improver from rice origin. Since, these grains lack gluten, hot water (80-90^{0}C) is normally a must to prepare dough with good rolling properties. Addition of this improver eliminates the use of hot water, and a dough with good rolling properties could be obtained by using ordinary potable water, since the additive renders it amenable for rolling the roti / sheeting with the help of a roller pin, similar to that followed in case of wheat flour dough.

Novelty and inventive steps of this invention lie in the fact that the process developed utilizes simple, moist-heat treatment in the form of steaming at atmospheric pressure thus avoiding complicated thermal and milling equipments. The processed grain can be polished without incipient moistening. The additive used is easily available and the dough can be rolled easily without breaking. Secondly a locally available college scale rice product viz. expanded rice /popped rice/ flaked rice is used as additive to improve the rheological properties of the dough.

The present invention provides for an improved steam-polished and shelf-stable flour obtained from Sorghum and Pearl millet grains with the retention of nutritive germ, having an enhanced oil content, and improved coarse grain flour, nutrients and an additive of rice origin and a process for its production.

Accordingly the present invention provides a process for the preparation of improved flour from gluten lacking grains selected from sorghum and Pearl millet, having enhanced shelf life and other characteristics such as described herein, the said process comprising:

a) removing inorganic and organic refractions by subjecting the grains to cleaning

b) steaming the cleaned grains of step (a) in an autoclave at an atmospheric pressure for a period of 5 – 25 minutes at a temperature ranging between 97°-100°C;

c) drying the grains of step (b) in a shade and allowed to stand for 12 – 48 hours;

d) grinding and sieving the whole coarse grains of step (c) to obtain flour;

e) adding an additive of rice origin such as herein described to the flour product of step (d) to get the desired improved flour.

An embodiment of the present invention, a process wherein step (b) size grading is done using 2mm and 3mm sieves.

Yet another embodiment of the present invention, a process wherein size grading the coarse grains by mechanical means is performed to render uniform polishing.

Still another embodiment of the present invention, a process wherein in step (e) the polishing of grains is performed preferably using cone polisher.

Yet another embodiment of the present invention, a process wherein in step (e) the moistening is performed to obtain a moisture level of about 3%.

Still another embodiment of the present invention, a process wherein in step (e) the bran is removed from whole grain to the extent of 12%.

Yet another embodiment of the present invention, a process wherein in steps (f) and (h) the sieves used are 60 mesh British Standard Sieve(BS).

Still another embodiment of the present invention, a process wherein in steps (g) and (h) the additive used is 1-15% of puffed or popped or flaked rice flour.

Yet another embodiment of the present invention, a process wherein in step (h) the fumigating agent used is selected from a group consisting of phosphene, aluminum phosphide and preferably aluminium phosphide.

Still another embodiment of the present invention, a process wherein said additive eliminates usage of hot water to prepare dough from flour.

Yet another embodiment of the present invention, a process wherein in steps (f) and (h) the flour obtained is Pearl millet flour.

Still another embodiment of the present invention, a process wherein in the Pearl miller flour has a shelf life of 4 months.

Yet another embodiment of the present invention, a process wherein said nutrients are protein in the range of 10.6-16.9%, fat 3.8-6.8%, ash 1.1-1.9% and crude fibre 1.3-2.0%, thereby providing an energy of about 350 kcal.

Still another embodiment of the present invention, a process wherein the hydrolytic rancidity is below 10% in the steamed polished flour.

Yet another embodiment of the present invention, a process wherein the food products of this process are softer in texture with lesser chewing counts and with better pliability.

In yet another embodiment of the process, the product having an enhanced shelf life and with a retention of nutritive germ, obtained from Sorghum grains, said grain flour product comprising the following charectristics,

a) a protein content in the range of 10.1-14.4%;
b) a fat content in the range of 1.5-4.0%;
c) an ash content in the range of 1-2.1%
d) a crude fibre content in the range of 1.6 -2.7%;
e) an oil content of about 3%;
f) a rice additive in the range of 1-5%; and
g) having a particle size of flour in the range of 175-246 μ.

In yet another embodiment the said sorghum grain based product having a shelf life of 8 months.

The following examples are given by way of illustration of the present invention and therefore should not be construed to limit the scope of the present invention.

Example 1

Sorghum grains (1 kg) were spread on a wire mesh tray, (bed thickness about 2.5 cm) and steamed for 15 min at atmospheric pressure. The temperature of the chamber ranged between 97-99^{0}C. Care was taken so that moisture did not condense on the grains, by covering the grains with hand-made filter papers. The steamed sorghum grains were then shade dried at room temperature to reach a level of moisture below 12%.

Steamed sorghum grains were shade dried for 2 days and later batches of 100 gms of grains polished in the above mentioned cone polisher (menghetti, Italy) after incipient moistening with 3% water and polished for 3 min such that 90% of the grains were recovered. The polished grains were spread and dried at room temperature for 2 hour. The polished dried grains were ground to flour using a plate mill or hammer mill to pass through 60 mesh BS sieve. The resultant flour was fumigated with appropriate dosage of aluminium phosphide and packed in polypropylene bags (200 g, each). At regular intervals of one month, hydrolytic and oxidative rancidity were estimated using standard procedures. Organoleptic qualities of rotis were also studied from the stored flour. Hydrolytic rancidity, as reflected by the content of free fatty acid, content stayed well below 10% level in 15 steamed polished flour. Oxidative rancidity was similarly lesser in 15 min steamed flours (Table). Rotis prepared from the stored flour were sweeter and did not taste bitter until 8 months of storage. However, in the untreated whole and polished flours FFA content rose beyond the 10% level within 15-30 days of storage, and the rotis prepared from such flour tasted bitter.

Free fatty acid profile in sorghum varieties after steam treatment

(a) Variety CSH 9

Treatment	**Duration (month)**								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**10**
Raw	6.7	30.3	44.8	44.1	51.4	51.6	75.5	78.3	81.2
Raw Polished	7.3	26.9	31.5	31.6	35.2	35.3	54.2	55.1	56.3
Steamed Whole (15 min)	2.9	4.1	4.75	5.5	5.6	6.8	8.4	10.8	11.4
Steamed Polished (15min)	3.8	2.3	4.7	4.5	5.6	5.8	5.4	6.8	7.3

(b) Variety M35-1

Treatment	**Duration (month)**								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**10**

Raw	6.0	32.4	47.6	61.2	57.6	59.2	78.0	92.3	95.1
Raw Polished	6.1	16.3	25.6	26.6	37.2	38.1	54.0	55.8	62.3
Steamed Whole (15min)	5.05	5.1	5.6	6.6	7.6	7.7	7.6	8.2	9.7
Steamed Polished (15min)	3.3	2.7	5.2	4.9	5.3	5.2	5.3	6.1	7.5

(c) Variety Bijapur local

Treatment	**Duration (month)**								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**10**
Raw	5.7	26.6	47.2	61.1	65.8	66.0	76.3	86.0	89.3
Raw Polished	4.5	14.0	22.3	38.4	57.1	57.2	51.3	52.1	57.3
Steamed Whole (15min)	2.5	4.5	4.9	5.1	5.5	5.8	6.5	7.35	8.2
Steamed Polished (15min)	1.7	2.4	5.6	4.1	5.3	6.3	5.8	6.3	7.4

(d) Variety CSH-5

Treatment	**Duration (month)**								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**10**
Raw	14.8	70.1	79.11	74.8	73.6	75.8	100.4	118.4	121.0
Raw Polished	13.4	36.6	53.7	56.3	57.1	56.2	66.0	68.2	72.1
Steamed Whole (15min)	6.8	5.1	5.9	8.0	9.2	9.8	10.6	12.0	12.8
Steamed Polished (15min)	5.5	3.6	5.6	8.8	9.2	9.1	11.1	12.5	13.2

Changes in oxidative rancidity (TBA, O.D. at 530 nm) in sorghum varieties afte steam treatment

(a) Variety CSH 9

Treatment	**Duration (months)**						
	0	**1**	**2**	**3**	**4**	**6**	**8**
Raw	0.054	0.058	0.069	0.081	0.109	0.118	0.221
Raw polished	0.033	0.038	0.052	0.056	0.099	0.109	0.112
Steamed Whole (15 min)	0.024	0.0405	0.053	0.060	0.087	0.098	0.111
Steamed polished (15 min)	0.036	0.039	0.049	0.056	0.081	0.103	0.106

(b) Variety M35-1

Treatment	**Duration (months)**						
	0	**1**	**2**	**3**	**4**	**6**	**8**
Raw	0.057	0.061	0.068	0.089	0.179	0.226	0.229
Raw polished	0.0421	0.048	0.058	0.051	0.105	0.180	0.185
Steamed Whole (15 min)	0.040	0.041	0.052	0.048	0.083	0.128	0.132
Steamed polished (15 min)	0.038	0.051	0.048	0.048	0.085	0.122	0.130

(c) Variety Bijapur local

Treatment	Duration (months)						
	0	1	2	3	4	6	8
Raw	0.068	0.075	0.100	0.114	0.104	0.125	0.138
Raw polished	0.043	0.049	0.075	0.085	0.075	0.133	0.135
Steamed Whole (15 min)	0.040	0.059	0.060	0.062	0.067	0.098	0.112
Steamed polished (15 min)	0.041	0.049	0.058	0.054	0.056	0.102	0.109

(d) Variety CSH-5

Treatment	Duration (months)						
	0	1	2	3	4	6	8
Raw	0.077	0.156	0.161	0.189	0.205	0.250	0.258
Raw polished	0.073	0.146	0.144	0.169	0.198	0.221	0.223
Steamed Whole (15 min)	0.054	0.091	0.098	0.123	0.136	0.169	0.176
Steamed polished (15 min)	0.068	0.0875	0.086	0.111	0.131	0.151	0.172

Example 2

Sorghum grains (1 kg) were spread on a wire mesh tray, (bed thickness about 2.5 cm) and steamed for 15 min at atmospheric pressure. The temperature of the chamber ranged between 97-99^{0}C. Care was taken so that moisture did not condense on the grains, by covering the grains with hand-made filter papers. The steamed sorghum grains were then shade dried at room temperature to reach a level of moisture below 12%.

The dried grains were ground to flour using a plate mill or hammer mill to pass through 60 mesh BS sieve. The resultant flour was fumigated with appropriate dosage of aluminium phosphide and packed in polypropylene bags (200 g, each). At regular intervals of one month, hydrolytic and oxidative rancidity were estimated using standard procedures. Organoleptic qualities of rotis were also studied from the stored flour.

Hydrolytic rancidity, as reflected by the content of free fatty acid, content stayed well below 10% level in 15 steamed whole flour. Oxidative rancidity was similarly lesser in 15 min steamed flours (Table). Rotis prepared from the stored flour were sweeter and did not taste bitter until 8 months of storage. However, in the untreated whole and polished flours FFA content rose beyond the 10% level within 15-30 days of storage, and the rotis prepared from such flour tasted bitter.

Example 3

Pearl millet varieties (1 kg) were spread on a wire-meshed tray (bed thickness about 2.5 cm and steamed for 15 minutes at atmospheric pressure. The temperature of the chamber (97 to 99^{0}C). Care was taken to avoid condensation of water on the grains by covering with filter paper. The steamed grains were shade dried at ambient conditions to a level of below 12%.

Batches of 100 gms of steamed and dried pearl millet grains were polished in a laboratory cone polisher (Minghetti, Italy) after incipient moistening with 3% moisture and resting for 3 minutes. The polished grains were shade dried for 1-2 hour, and ground to flour using a plate mill such that the flour passed through 60 mesh sieve. The flour was fumigated with appropriate dosage of aluminium phosphide and packed in 200μ thick polypropylene bags (200g each) at regular intervals of 7 days. Hydrolytic and oxidative rancidity was estimated in the flour using standard procedures. Organleptic quality of rotis prepared from the flour was also tested.

Hydrolytic rancidity as exhibited by FFA content, stayed below the 10% level in 15 min steamed polished flours (Table). Oxidative rancidity was also low and the organoleptic quality of the rotis prepared from the flour of steamed grains was very good for a period upto 3 months of storage. On the other hand rancidity was observed within 7 days of storage in untreated whole grain flour or polished grain flour.

Example 4

Pearl millet varieties (1 kg) were spread on a wire-meshed tray (bed thickness about 2.5 cm and steamed for 15 minutes at atmospheric pressure. The temperature of the chamber (97^0 to 99^0C). Care was taken to avoid condensation of water on the grains by covering with filter paper. The steamed grains were shade dried at ambient conditions to a level of below 12%.

The steamed whole grains were ground to flour using a plate mill such that the flour passed through 60 mesh sieve. The flour was fumigated with appropriate dosage of aluminium phosphide and packed in polypropylene bags (200g each) at regular intervals of 7 days. Hydrolytic and oxidative rancidity was estimated in the flour using standard procedures. Organleptic quality of rotis prepared from the flour was also tested.

Hydrolytic rancidity as exhibited by FFA content, stayed below the 10% level in 15 min steamed whole flours (Table). Oxidative rancidity was also low and the organoleptic quality of the rotis prepared from the flour of steamed grains was very good for a period upto 3 months of storage. On the other hand rancidity was observed within 7 days of storage in untreated whole grain flour or polished grain flour.

Changes in FFA (%) in Pearl millet variety ICTP 8203 after steam treatment

Treatment	**Duration (weeks)**										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**12**	**16**
Raw	9.5	15.2	31.6	35.0	37.1	51.5	54.5	51.5	54.1	65.3	74.2
Raw polished	6.9	12.5	20.1	21.2	23.6	44.0	45.6	44.0	49.0	62.0	75.0
Steamed 15 min	6.6	5.2	5.0	4.8	4.6	5.6	4.3	5.6	7.7	6.5	12.7

Steamed polished 15 min	5.2	5.4	6.4	5.4	4.4	5.8	5.8	5.8	7.3	6.3	9.1
Steamed polished 15 (bulk)	7.7	5.8	6.2	5.2	8.0	5.0	4.2	6.0	5.5	6.7	9.4

Example 5

Sorghum was processed in bulk. For this 20 kg of the grains were size graded and hydro thermally treated (steamed in a chamber) for 10 min at 97^0-100^0C at atmospheric pressure. The grains were shade dried to a moisture below 12% and polished in a horizontal emery polisher, with appropriate mesh size cage, after incipient moistening with 5% moisture and resting for 5 min. The grains were shade dried and ground to flour in a plate mill to pass through 60 mesh sieve. The so produced stabilized flour was fumigated with appropriate dosage of aluminium phosphide and stored in propylene bags (200μ guage) at ambient conditions. Hydrolytic and oxidative rancidity was estimated by standard procedures. The FFA level in the flour stayed below 10% upto 6 months of storage.

Example 6

Pearl millet was processed in bulk. For this 20 kg of the grains were size graded and hydro thermally treated (steamed in a chamber) for 10 min at 97^0-100^0C at atmospheric pressure. The grains were shade dried to a moisture below 12% and polished in a horizontal emery polisher, with appropriate mesh size cage, after incipient moistening with 7% moisture and resting for 10 min. The grains were shade dried and ground to flour in a plate mill to pass through 60 mesh sieve. The so produced stabilized flour was fumigated with appropriate dosage of aluminium phosphide and stored in propylene bags (200μ guage) at ambient conditions. Hydrolytic and oxidative rancidity was estimated by standard procedures. The FFA level in the flour stayed below 10% upto 3 months of storage.

Example 7

Sorghum grains (1 Kg) was steamed as in example 1, after steaming, sorghum grains were kept in a closed container for 15 minutes to bring down to room temperature and batches of 100 gms of the steamed grains were polished in a cone polisher (Minghetti, Italy) directly without incipient moistening for 5 minutes to remove 6% bran. This avoided incipient moistening and drying of the grains. The polished grains were ground to pass through 60 mesh flour as in example 1.

Example 8

Two grams of flour prepared by grinding expanded rice (puri or murmura) ground to pass through 60 mesh BS sieve was added to 100 g of shelf-stable sorghum flour (produced as per example 1) mixed thoroughly to improve the dough characteristics. Dough from the improved flour could be prepared using ordinary tap water. The rolling quality of the dough was greatly improved (Table) and also sorghum and pearl millet flour after the addition of the improver could be easily extruded to prepare extruded traditional products (*chakli*, *tengolal* etc).

PROPERTIES OF ROTIS FROM IMPROVED SORGHUM FLOUR

Variety/treatment	**Water required to prepare dough (ml/100 g)**	**Maximum diameter that can be rolled (cm)**	**Chewing counts of baked roti (2 g) ***
CSH-5 + ER	102	16.5	10
CSH-5 - ER	104	16.3	23
Bijapur + ER	102	18.5	8
Bijapur – ER	102	16.0	22

ER -1% Expanded rice

*** - Number of masticating counts required for complete chewing and swallowing**

Example 9

Two grams of flour prepared by grinding expanded rice (puri or murmura) ground to pass through 60 mesh BS sieve was added to 100 g of shelf-stable pearl millet flour (produced as per example 1) mixed thoroughly to improve the dough characteristics. Dough from the improved flour could be prepared using ordinary tap water. The rolling quality of the dough was greatly improved (Table) and also sorghum and pearl millet flour after the addition of the improver could be easily extruded to prepare extruded traditional products (*chakli*, *tengolal* etc).

PROPERTIES OF ROTIS FROM IMPROVED PEARL MILLET FLOUR

Variety/treatment	**Water required to prepare dough (ml/100 g)**	**Maximum diameter that can be rolled (cm)**	**Chewing counts of baked roti (2 g) ***
Raw polished -ER	84	13.2	10
Steamed polished +ER	100	16.5	8

ER -1% Expanded rice

*** - Number of masticating counts required for complete chewing and swallowing**

The advantage of the process are as follows:

1. The present invention enables production of sorghum flour, which is stable for a period of 6 to 8 and 3 to 4 months respectively, against deteriorative changes as exhibited by the arrest in the FFA content of the flour.
2. The present invention also enables the production of a shelf-stable whole grain flour and also a stable refined flour.
3. In the present invention, since pearling does not remove germ completely, the oil content in the stabilized refined flour is higher (3.0%) compared to refined raw flour (2-2.3%). Section of sorghum raw and steamed also revealed that most of the germ is retained in the stabilized grain.

4. The present invention direct polishing of the grains is done without incipient moistening, since the moisture acquired during steaming of the grains is sufficient.
5. The process involves machinery commonly used in rice milling industry.
6. The product obtained from the present invention improves the quality of roti prepared from the processed grain. Mixing thoroughly 1-5% expanded rice (puri, murmura) flour with the processed sorghum flour eliminates the use of hot water normally used to prepare dough from coarse grains and renders it rollable by a rolling pin, similar to that of wheat dough.
7. The food products thus obtained from the above flour are softer in texture with lesser chewing counts and better pliability.
8. The flour from the steamed polished grains has better appearance, as it is more white compared to the unprocessed whole grain flour.
9. The improved shelf-stable sorghum and pearl millet flour can be used for the preparation of many traditional extruded snacks normally prepared from rice and wheat, thus diversifying the use of coarse grain among traditional and non-traditional consumers.
10. The use of this process improves and upgrades the grain quality of hybrids that are not so popular among the consumers because of their colour and appearance due to mold growth.
11. The stabilized polished grain can be converted to grits, or flour or used as whole grain.