Process Development and Optimization of Pearl Millet based Gluten Free Cookies; Utilization of Flour of Germinated Bajra and Masoor along with Sangri (Prosopis Cineraria) for Fortification

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Abstract – *Celiac disease, is an inflammatory disease of small intestine prompted by gluten proteins from wheat, barley etc. Its occurrence in individuals is 1:100 to 1:200. Despite of the fact that CD has huge prevalence, it is difficult to diagnose it as symptoms of CD are very common e.g. lethargy. Patients suffering from CD must adhere to a strict gluten-free diet. Hence, commercialization of gluten-free products has grown at a rate of 28% annually in recent years. CD patients, especially children who adhere to a strict gluten-free diet, remain undernourished due to ceasing of large amount of energy, which they undertake from wheat-based foodstuffs previously. Germination additionally enhances the bioavailability of micronutrients and reduces the anti-nutritional factors in the food grains. Food grains which are germinated are utilized for the development of bakery products.*

This study also aims to be the first, on incorporation of an under-utilized and unconventional legume from the Thar desert. Prosopis cineraria is regarded as golden tree of Indian deserts and also known as Khejri in Rajasthan and adjacent states. "The dried pods of the tree are consumed as a vegetable in the state of Rajasthan, India and are known to prevent protein and mineral deficiency" (USNAS, 1980). Sangri is an underutilized ingredient and has not been incorporated in any commercial product. Hence, the present investigation provides an ingredient delivery system and methods of producing gluten-free cookies that were much superior to conventional cookies in terms of nutrition and at a much lower cost.

***Key Words*: Gluten-free, Celiac Disease, Process Development, Prosopis Cineraria, Khejri, Pearl Millet.**

1.INTRODUCTION

1.1 Bajra or Pearl Millets

Pearl millet [*Pennisetum typhoides* (Burm.) Stapfand E. C. Hubbard] grain is considered more nutritious to grain of wheat (*Triticumaestium* L.), corn (*Zeamays* L.), sorghum (*Sorghum bicolor* Moench), and rice (*oryzasativa* L.) in protein and oil content. It also contains considerable amounts of Ca and P and more Fe than other cereals.

Pearl Millet is healthy, thanks to its rich content of minerals and proteins. It is rich in fiber and aids digestion and is also known for its high vitamin B content, assisting it in the break-down of the carbohydrates and fat.

100 grams of bajra contains 16% iron, 20% vitamin B-6, and 28% magnesium. This is according to the daily recommended dosage for an adult.

Fig -1: Pearl Millet (Bajra)

1.2 Sangri

Prosopis cineraria is regarded as golden tree of Indian deserts and also known as Khejri in Rajasthan and adjacent states. The dried pods are consumed as a vegetable in the state of Rajasthan, India. Studies suggest that the dry pods of Khejri also prevents protein and mineral deficiency (USNAS, 1980).

Dry pods of Sangri are beneficial to a large extent. Foliage are also rich in protein, carbohydrates and other mineral matter. Pods are very nutritious, being rich in vitamin C, Calcium and Phosphorus contents too.

The pods contain 23% protein, 56% carbohydrates, 20% fiber and 2% fat and every 100 gm of pods also contain 523 mg of vitamin C, 414 mg Calcium and 400 mg phosphorous. (Mala Rathore, 2009). The pods have also shown functional food properties in a recent study.

Fig -2: Prosopis Cineraria

1.3 Masoor dal or Red Lentils

Lentils are known to be a rich source of proteins. The protein content in lentils is considerably high as compared to other pulses and this makes Lentils a great source of nutrition for developing nations and people from underprivileged sections of the societies.

Talking about starch yield percent derived from lentils, it stands as the second highest among all 23 pulse grains i.e. up to 47.1 %. Also, the mineral composition of lentils is on relatively higher levels. Containing all important minerals viz. Mg, P, Ca, S, Fe and Zn. A 100-gram serving of masoor dal holds 352 calories and about 25 g protein.

Fig -3: Red Lentils (Masoor Dal)

2. EFFECT OF GERMINATION ON PEARL MILLETS AND LENTILS

2.1 Pearl Millets:

2.1.1 Protein content- The protein content of pearl millets was greatly increased by germination of the grains. This increase in protein content may be due to synthesis of proteins during germination.

2.1.2 Protein digestibility- Considerable improvements in protein digestibility were observed as shown in the table.

2.1.3 Carbohydrate content- A small reduction in the total available carbohydrates has been shown which may be due to utilization of some of the sugars during the growth metabolic activity.

2.1.4 Starch Digestibility- When pearl millet grains were subjected to germination for a whole day, the in-vitro starch digestibility increases by more than three times.

2.1.5 Anti-nutritional factors- There was a very emphasized reduction in the amounts of Tannins and phytic acid and a little lowering in number of total polyphenols.

Table-1: Effect of germination on Pearl Millet

	Protein Content (%)	Carbohydrate Content (%)	Protein Digestibility (%)	Tannins (mg/100g flour)	Phytic Acid (mg/100g flour)
Before Germination (approx.)	14	76.3	51	0.51	990
After Germination (approx.)	19.4	71.1	77.2	0.38	375

2.2 Red Lentils:

2.2.1 Protein content- The total protein content of the lentils upon germination for 4 days increased significantly

2.2.2 Total soluble sugars- The total soluble sugars increased by a large extent

2.2.3 Total alpha galactosides- Significant reduction was observed in the total alpha galactosides like raffinose, stachyose.

2.2.4 Ascorbic Acid- Ascorbic acid concentration increased tremendously upon germination and led to an increased

2.2.5 Vitamin B1 (thiamine)- No considerable change was observed

2.2.6 Vitamin B2 (riboflavin)- Significant increase in its concentration was observed upon germination

2.2.7 Phytic acid- In Legumes, germination is one of key process for the reduction of phytic acid. The considerable loss may be due to the enzyme phytase.

2.2.8 Trypsin Inhibitor Activity- Germination when performed for total of 6 days, gives the highest reduction of TIA, in darkness along with daily rinses. Also, by the end of the experiment the activity gives a total decrement of 45%.

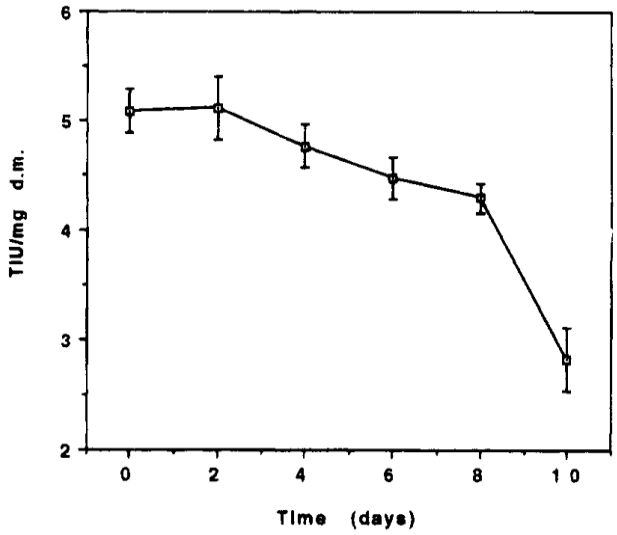

Chart -1: Lentils: Result of Germination on activity of Trypsin Inhibitor.

Table-2: Effect of germination on Red Lentils

	Protein Content	Total soluble sugars (%)	Ascorbic acid (mg/100g)	Thiamine (mg/100g)	Phytic Acid (mg/100g)
Before Germination (approx.)	26.7	0.65	0.9	0.52	6.2
After Germination (approx.)	28.9	1.3	77.5	0.51	2.1

3. RECIPIE OPTIMIZATION

At a preliminary level, the Cookies were developed by varying the amount of the three ingredients in various permutations and combinations.

The cookies developed underwent organoleptic evaluation to determine the optimum concentration of the ingredients for development of cookies which will provide great nutrition and the best possible taste, given the limitations.

The following composition of flour was found to have the best possible taste given the best possible nutrition.

Table-3: Optimized Recipe of Base Flour

BASE FLOUR	Weight in gram	Out of Total (g)
Bajra	**40**	100
Masoor	**30**	100
Sangri	**30**	100

4. OPTIMIZED PROCESS

A) Creaming of fat and powdered sugar

B) Addition of dry ingredients

C) Kneading of dough

D) Sheeting of dough

E) Cutting into desired shapes

F) Transferring to tray

G) Baking Temperature: 180°C top, 100°C bottom.

Time: 12 minutes

H) Allowing to cool

I) Packaging

5. COST ESTIMATION

Table -4: Cost Estimation of the Product

INGREDIENT	QUANTITY (grams per Kg of formulation)	PRICE (Rs.)
Bajra flour	259	5.18
Sangri flour	173	8.65
Masoor dal flour	173	14
Margarine	216	16
Powdered Sugar	216	6.6
Water	108.2	-
TOTAL	1000	**50.43**

Hence, the cost of raw material for a 100 g sample of the cookies will be Rs. 5 only.

6. MARKET POTENTIAL

The product is not only aimed at people suffering from celiac disease and gluten sensitivity but also at the growing percentage of people that consider gluten-free cookies a healthier alternative to conventional snacks.

Blending of underutilized natural ingredients with high nutritive values brings an interesting mix of flavors for the consumers while also satisfying their increasing nutrition conscious tendencies.

The high nutritive value of *Prosopis cineraria (Sangri)* combined with the right blend of flavor, nutrients and texture provided by pearl millet and red lentil flour will provide the masses with a highly preferable alternative at an economical price.

The gluten-free products market has been rapidly increasing in India as well as around the world owing to a change in consumer perception and preferences. Over 15% of consumers are consuming gluten-free products as part of their lifestyle and not only due to dietary constraints.

According to the Institute of Agri-Business Management, India has a potential of 2347 kilo tons of gluten-free products against 7.55 kilo tons produced in 2016. This signifies that there is an enormous untapped potential for innovative gluten-free foods that can be utilized for the proposed product.

It will also cater to the needs of ever rising consumer awareness base that focuses on the nutritive content of the snacks they intake while also wanting to satisfy their taste buds and at the same time, the gluten intolerant segment of population as the nutritive value of the proposed cookies is higher than most gluten-free products currently available in the market.

Since the Bajra cookie market is almost essentially untapped, the product can cater to a far-reaching consumer base especially within India.

7. CONCLUSIONS

Till date very limited research is focused on utilization of germinated food grain in bakery industry specially cookies owing to its added advantages.

Additionally, there is no such study reported on the utilization of Sangri in the bakery products to enhance the protein content. Sangri, an underutilized and unconventional ingredient is very nutritious and offers functional food properties as well. (Liuetal.,2012, USNAS,1980).

The product is not only aimed at people suffering from celiac disease and gluten sensitivity but also at the growing percentage of people that consider gluten-free cookies a healthier alternative to conventional snacks. Ensuring greater bioavailability of the nutrients by the use of germinated flour.

Overall, the product is a great source of plant-based proteins at a very economical cost and can be targeted towards reducing the protein energy malnutrition in the country. The product is extremely cost-effective and can be directed towards benefitting the masses.

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