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DEVELOPMENT OF CEREAL-BASED NUTRI BAR COMBINING WITH DIFFERENT LEVELS OF PARTIALLY SPROUTED CHICKPEAS FLOUR

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Abstract:

Modern consumers prefer snacks not only to satisfy their hunger but also to provide themselves with essential nutrients. Nutri bar is a convenient and healthy ready-to-eat food which supplies balanced nutrients. The nutritional value of the bars depends heavily on their ingredients used. Cereal-legume complementation is one of the strategies to produce the nutri bar with good protein quality and therefore the present research was conducted to evaluate the effects of partially sprouted chickpea flour (PSCF) with high protein content and nutrients on physicochemical properties of cereal-based nutri bar. Five levels (0, 10, 20, 30 and 40%) of PSCF were combined with other ingredients based on 100% reducing cereals (wheat and oat). Physical and chemical properties were determined and sensory evaluation was assessed using 9 hedonic scales by 55 panelists. Nutri bar with 40% of PSCF was highest in crude protein (20.58%) and crude fiber content (8.91%) among the treatments. Although most of the physicochemical properties were good in 40% PSCF, the score of overall acceptability in sensory evaluation was highest in 20% PSCF. Therefore, PSCF can be successfully added up to 20% levels for high quality protein and balanced nutrients for manufacturing of cereal-based nutri bars.

Keywords: Ready-to-eat food, nutri bar, partially sprouted chickpea flour, high quality protein

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1. Introduction:

Nowadays, modern consumers prefer snacks not only to satisfy their hunger but also to provide themselves with essential nutrients. In this regard, food scientists today are aiming to develop formulations of cereal bars with various highly nutritious ingredients (Haibiba et al., 2021). The consumption of fast-foods and snacks has increased globally and therefore, a cereal bar could be considered as a practical choice for a quick meal due to its high nutritional value (Sharma et al., 2014).

Cereal bars are the products that contain some processed cereals including wheat, oat, rice, barley as the main ingredient and others include nuts, fruit chunks, chocolate chips or coatings (Yadav & Bhatnagar, 2017). Cereal bars are easy to manufacture in practically and can be conveniently added to a packed lunch or eaten as a snack (Luciana et al., 2011). Moreover, cereal bars can be sold at a low price depending on the ingredients used (Sharma & Mridula, 2015).

Nutri bar, a kind of cereal bars is a convenient and healthy ready-to-eat food which supplies balanced nutrients (protein, fat, minerals, vitamins, calories, and carbohydrate) can be used to abate hunger (Hol, et al., 2016). The nutri bar is a category of bar-shaped products comprised of proteins, carbohydrates, fats and in addition vitamins and minerals (Fin, 2016). Nutri bars are so popular today with people of all ages (Jan et al., 2012).

Cereals and cereal products are an important source of energy, carbohydrate, protein and fibre, as well as containing a range of micronutrients such as vitamin E, some of the B vitamins, magnesium and zinc (McKevith, 2005). Cereals are a rich source of starch and sulphur-containing amino acids but contain a lower amount of proteins which are deficient in lysine. Cereals are also poor in vitamin A and C and therefore require supplementation with other food groups such as pulses, vegetables, fruits, or animal products to make the diet more balanced and adequate, particularly with respect to vitamin A, iron, and riboflavin (Shewry & Sandra, 2015). Animal protein is thought to be a good source of protein but it may be expensive (Ahmad et al., 2017).

Legumes are important inexpensive sources of protein, dietary fiber, and starch and contain almost two to three times more protein than cereals. They are good sources of supplementary protein when added to cereal grains (Perla et al., 2003). Chickpea is very important part of the human diet due to their nutritional and bioactive composition (Raza et al., 2019) and their protein is considered better than some pulses (Jukanti et al., 2012) such as black bean and pigeon pea (Aurelia et al., 2009). Though the nutrients content of food legumes is high, they contain a number of bioactives that are traditionally classified as anti-nutritional compounds, which may reduce the bioavailability of nutrients. Sprouting seeds increase vitamin concentrations and bioavailability of trace elements and minerals (El-Adawy et al., 2004).

Cereal-legume complementation is one of the strategies to produce the nutri bar with good protein quality (Yadav & Bhatnagar, 2017). Therefore, the present research was conducted to evaluate the effects of partially sprouted chickpea flour with high protein content and nutrients on physicochemical properties of nutri bar.

2. Materials and Methods:

2.1 Raw Materials

Wheat flour, oat flakes, almonds, raisins, canola oil and glucose syrup were purchased from the local market of bakery ingredients shop in Nay Pyi Taw. Honey and jaggery were procured from the original wholesaler located in Magway Region. The bar mold was obtained from the welding of "Steel Fighter" in Nay Pyi Taw. The experiment was conducted in the laboratory of Advanced Centre of Agricultural Research and Education, Yezin Agricultural University.

2.2 Preparation of Partially Sprouted Chickpeas Flour

Chickpea, Yezin-6 variety (Desi type) that is widely grown in Myanmar was sprouted at 25°C and 90 % relative humidity. After 48 hr of sprouting time, chickpeas sprouts were oven dried at 60°C until constant moisture was received and prepared for partially sprouted chickpea flour (PSCF) using mixer grinder (Panasonic Mx-AC300), and passed through 52 meshes (Jayant Test Sieve). Partially sprouted chickpea flour stored in air-tight glass container was used in the present research with different levels.

2.3 Preparation of Nutri Bars

The recipes of ingredients used in this research were as shown in Table 1. For bar preparation, hot/oven process (Sharma et al., 2014) was used and the process was shown in Figure 1.

Table: 1. Formulations and Ingredients of Nutri Bar

Ingredients	Formulations				
	T_1	T_2	T_3	T_4	T_5
Wheat flour	30	25	20	15	10
Oat flakes	25	20	15	10	5
Sprouted chickpea flour	0	10	20	30	40
Honey	2	2	2	2	2
Almonds	3	3	3	3	3
Raisins	4	4	4	4	4
Jiggery	10	10	10	10	10
Canola oil	10	10	10	10	10
Glucose syrup	10	10	10	10	10
Water	6	6	6	6	6
Total	100%	100%	100%	100%	100%

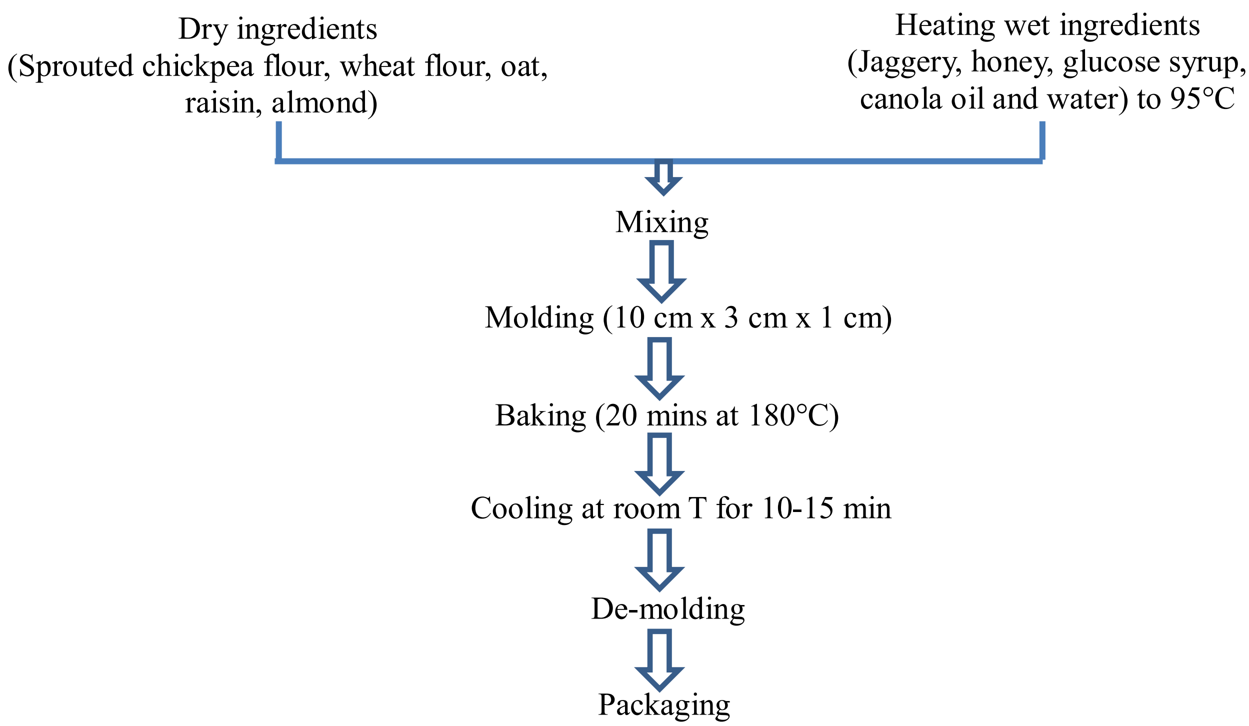

Figure: 1. Flow Chart of Nutri Bars

2.4 Physical Properties

2.4.1 Color analysis

The color of nutri bars were analyzed by using colorimeter (SHIMADZU, UV-3600 Plus) according to L*a* b* system. The L* (lightness), a* (red intensity) and b* (yellow color intensity) values were measured at six different points for each sample.

2.4.2 Hardness

The hardness of nutri bars was determined using a texture analyzer (Texture meter TA-XT2), attached to a 50 kg load cell. To determine the hardness, a 5 mm probe was used at test speed. Hardness was determined as maximum force in the force-time curve (Lazou & Krokida, 2010). The operation of texture analysis was done 15 replicates for each treatment.

2.4.3 Water activity

Water activity of nutri bars was measured using water activity meter (Aqua Lab model 4TE). Before measuring, the bar samples were grinded using mixer grinder (Panasonic Mx-AC300). The homogenized samples were measured directly in water activity meter for 5 times.

2.5 Chemical Properties

The chemical composition (moisture, crude protein, crude fat, crude fibre and ash) of the nutri bars were determined according to the procedures of AOAC, (2000). Moisture was determined by oven drying method at 105°C±2°C. Crude protein was determined by Kjeldahl's method; crude fat content was determined by Soxhlet method and crude fibre content was determined by gravimetric method, respectively. Crude protein, crude fat and crude fibre were analyzed using analytical instruments Velp Scientifica, UDK 159 Automatic Kjeldahl Nitrogen Protein Analyzer; Velp Scientifica, SER 158 and ANKOM 200 Fiber Analyzer). Ash content was determined by incineration in a muffle furnace at 550°C (AOAC, 2000). Total carbohydrate was calculated by difference (Ali et al., 2016); % total carbohydrate = 100 - % (Protein + Fat + Fiber + Ash + Moisture). Calorie was determined by "4, 4, 9" method (FAO, 2003). The chemicals used in this study were of analytical grade and all analyses were carried out in four replicates.

2.6` Sensory Evaluation

Sensory evaluation of nutri bar was carried out by 55 semi-trained panelists from the university campus including faculty members, staffs, and postgraduate students of Yezin Agricultural University. The parameters recorded from the sensory evaluation were color, texture, taste, flavor and overall acceptability. For scoring, 9-point hedonic scale system as described by Meilgaard et al., (2007) was used.

2.7 Statistical Analysis

The data were analyzed by Statistix version (8.0) software and the mean values were determined using Least Significant Difference (LSD) test and significant differences were defined at 5% level.

3. Results and Discussion:

3.1 Physical Properties

The results of hardness, color and water activity of the nutri bars with different levels of partially sprouted chickpeas were as shown in Table 2. The color of food products is critical parameter because the color appearance plays the basic attractiveness of a product. In the presence results, the lightness (L*) was decreased with increasing levels of PSCF. Nutri bars formulated with 40% of PSCF significantly lower ($P<0.05$) in L* value than the other treatments. For the redness (a*), 40% of PSCF was highest (9.24) in all formulations. In the case of yellowness (b*), the formulation with 40% PSCF was significantly higher ($P<0.05$) in b* value (32.92) than the others. However, 10%, 20% and 30% of PSCF were not significantly different among the formulations. Decreasing of lightness (L*) value means more darken in color and therefore, it can be said that increasing the levels of PSCF, the color of nutri bars was darker in color. According to the color rating scales, the color of nutri bars increased darkness; redness and yellowness with the levels of increasing PSCF levels. The present finding was similar to the results of Atudorei et al., (2022) who reported that the bread samples become more darkened in color with the addition in sprouted chickpea flour and the other two values (a* and b*) also increased. Moreover, Perri et al., (2021) has also been reported that pulse flour leads to darker color of bakery products' surface.

The hardness of the bar samples obtained by measuring with texture analyzer were shown in Table 2. The formulation with 0% PSCF was the highest hardness while, 40% PSCF had the lowest hardness (115.67 N). The hardness of nutri bar combined with 10% and 20% of PSCF were not significantly different. In general, high pea flavour intensities, harder and crunchier texture, darker colour and a less uniform surface and shape in rice-flour-based extrudates was reported by Philipp et al., (2017). However, the present results showed that nutri bars with higher levels of PSCF were significantly decreased in hardness than the bars with lower levels of PSCF contents ($p < 0.05$). This may be due to the effects of PSCF content on higher fracturability of the nutri bars. Koukoumaki et al., (2022) stated that the hardness of crackers was decreased when substitution of chickpeas flour was higher than 60%.

Table: 2. Physical Properties of Nutri Bars with Different Levels of PSCF

Formulations (PSCF %)	Color			Water activity a_w	Hardness (N)
	L*	a*	b*		
0	68.36±0.21a	5.45±0.07d	28.82±0.08c	0.339 ±0.001	212.13±1.08a
10	60.89±0.03bc	7.98 ±0.11c	32.41 ±0.06b	0.337± 0.001	206.69 ±1.87ab
20	62.58±1.82b	8.32 ±0.03bc	32.07 ±0.09b	0.334 ±0.002	201.72 ±1.46b
30	58.96±0.59cd	8.42 ±0.16b	32.41±0.12b	0.334 ±0.003	154.74±1.64c
40	56.63±0.08d	9.24 ±0.03a	32.92±0.17a	0.335 ±0.001	115.67 ±1.76d
$LSD_{0.05}$	1.41	0.16	0.18	0.61_{ns}	8.73
Pr>F	<0.0001	<0.0001	<0.0001	0.0560	<0.0001
CV%	3.25	2.91	0.31	1.52	3.25

Data were expressed as mean±SD. Different letters in the same column indicate significant different at p<0.05.

T1 T2 T3 T4 T5

Figure: 2. Nutri Bars Combining with Different Levels of PSCF (T1=0%, T2=10%, T3=20%, T4=30%, T5=40%)

Water activity (a_w) of nutri bars from all formulations was not significantly different and the values were below 0.4. Srebernich et al., (2016) stated that water activity of cereal bars below 6.0 prevents the proliferation of spoilage microorganisms, especially osmophilic yeasts and xerophilic fungi. Therefore, the lowering of water activity may extend the shelf-life of the food products.

3.2 Chemical Properties

The approximate composition of nutri bars were shown in Table 3. The moisture content of the nutri bars were varying from 7.12% to 7.44%. The moisture contents were non-significant among the different levels of PSCF though they were numerically slightly different. The same condition of processing and temperature for all treatments was reasonable for the same moisture content of nutri bars. Similar finding was stated by Ahmad et al., (2017) who reported that the moisture content of granola bars with similar processing time, temperature conditions and a constant level of brown sugar were not significantly different. The stability of cereal bars is highly related to low moisture content and water activity (Pallavi et al., 2015). Kassegn, (2018) indicated that the low moisture content would enhance its storage ability by avoiding mold growth and biochemical reactions and extend shelf life of the product.

Regarding protein content of the nutri bars, combining higher levels PSCF effected on the higher protein content of the bars. The crude protein content was ranged within 14.26% and 20.58%. The highest crude protein content was found in 40% of PSCF, whereas the lowest crude protein content was 0% PSCF. This may be due to the increasing levels of PSCF instead of cereal flour. Dietary protein is one of the vital nutrients for human due to its functional properties, including the improving of health growing of muscles (Habiba et al., 2021). The present finding was in agreement with Saadat et al., (2020) who indicated that values of protein, ash and energy increased as legumes proportions were increased in treatments.

In the table, and the formulation with combining 0% PSCF was lowest in crude fat content (13.29%) and 40% PSCF was highest (13.80%). For the crude fiber content, it was ranged within 4.7% and 8.91%. Although the crude fiber contents of 0%, 10% and 20% were non-significantly different with each other, 30% and 40% of PSCF levels were highly significant ($P<0.05$) than the former three. Dandachy et al. (2019) reported that increased combining of sprouted chickpea flour caused increasing in crude fat and fiber content of flour in Mankoushe Zaatar.

The ash content was significantly different ($P<0.05$) among all of the formulations. The results are in agreement with findings of Ahmad et al. (2017) who described that increasing the levels of oats and chickpea would increase in ash content in granola bars. The total carbohydrate content of nutri bars was highest (59.80%) in 0% PSCF level in which cereals were maximized and lowest (47.49%) in 40% PSCF. The total carbohydrate contents were significantly lower ($P<0.05$) as the increased levels of PSCF. This revealed that carbohydrate content was lower in increased incorporation of chickpea flour in Mankoushe Zaatar (Dandachy et al., 2019). The calorie (energy) content was decreased with the addition of PSCF levels but it was ranged within 396.39 kcal and 415.83 kcal.

Table: 3. Chemical Properties of Nutri Bars with Different Levels of PSCF

Formulations (PSCF %)	Crude Protein (g/100g)	Crude Fat (g/100g)	Crude Fiber (g/100g)	Ash (g/100g)	Moisture (g/100g)	CHO (g/100g)	Energy (kcal)
0	14.26±0.07e	13.29±0.06d	4.70±0.13c	0.84±0.02e	7.12±0.19	59.80±0.25a	415.82±1.01a
10	16.71±0.02d	13.34 ±0.05cd	4.75±0.21c	1.13±0.00d	7.34±0.04	56.73±0.19b	413.82 ±0.98a

20	18.06±0.04c	13.50±0.02bc	5.46 ±0.39c	1.29±0.03c	7.44 ±0.03	54.26±0.34c	410.72±1.45b
30	19.80±0.15b	13.55 ±0.00b	7.90 ±0.25b	1.70 ±0.03b	7.24±0.10	49.80±0.36d	400.37 ±1.11c
40	20.58±0.05a	13.80±0.07a	8.91±0.16a	1.98±0.01a	7.26±0.07	47.49±0.11e	396.39±0.89d
$LSD_{0.05}$	0.13	0.08	0.41	0.08	0.17_{ns}	0.91	0.99
Pr>F	<0.0001	<0.0003	<0.0001	<0.0001	0.4617	<0.0001	<0.0001
CV%	1.08	0.9	9.16	3.97	3.36	0.78	0.63

Data were expressed as mean±SD. Different letters in the same column indicate significant different at p<0.05.

3.3 Sensory Evaluation

Table 3 shows that sensory score of nutri bars including color, texture, taste, flavor and overall acceptability. The evaluated score showed that combining of 20% PSCF was a significant difference in all of sensory attributes. In color appearance, 0% PSCF and 20% PSCF were significantly higher than 30% PSCF and 40% PSCF. Therefore, it can be said that the darker in color due to the combining of more PSCF was not preferred by the panelists. In case of texture, 0% PSCF was the lowest score with 4.76 and 20% PSCF was the highest with 6.32. In the table, the maximum score for taste can be seen in 20% PSCF (7.38) followed by 0% PSCF, 10% PSCF and 30% PSCF, respectively. The lowest score for taste was 40% PSCF with 4.85. For flavor assessment, it can be found that the score was in ascending order, 0% PSCF (5.82), 10% PSCF (5.84) and 20% PSCF (7.02) but it was decreased as increasing levels of PSCF more than 20%. Among five formulations, combining of 20% PSCF had the highest average score (7.44) when compared to the others. Koukoumaki et al., (2022) also reported that pulses affect the properties of crackers but their sensory profiles were not universal for all species or all levels of substitution.

Table: 4. Sensory Characteristics of Nutri Bars with Different Levels of PSCF

Formulations (PSCF %)	Color (Appearance)	Texture	Taste	Flavor	Overall Acceptability
0	6.71±0.17a	4.76±0.20d	6.29±0.19b	5.82±0.22b	6.2±0.20b
10	6.15±0.20b	5.78±0.21ab	6.11±0.23bc	5.84±0.23b	6.38±0.20b
20	6.87±0.15a	6.32±0.25a	7.38±0.19a	7.02±0.20a	7.44±0.16a
30	5.74±0.17b	5.41±0.24bc	5.56±0.22c	5.58±0.22bc	5.67±0.18c
40	5.19±0.20c	5.05±0.23cd	4.85±0.23d	5.16±0.20c	5.04±0.23d

Data were expressed as mean±SD. Different letters in the same column indicate significant different at p<0.05.

4. Conclusion:

Cereal-based nutri bars combining different levels of partially sprouted chickpeas flour was successfully produced to develop new formulations using food legume that is widely grown in Myanmar. It can be concluded that nutri bars formulated by the addition of 40% partially sprouted chickpea flour gave the highest protein content of 20.58 %, fat content of 13.80 %, and the highest fiber content but acceptance by the panelists was negative. The highest overall acceptability by the panelists was addition of 20% partially sprouted chickpeas flour. Therefore, it can be recommended that partially sprouted chickpea flour can be successfully combined up to 20% to improve the nutrient quality of nutri bar.

5. Conflict of Interest:

The authors declare no conflict of interest.

6. Acknowledgements:

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