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Evaluation of efficacy of nutrient dense soy product with reference to NDPCal%

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Abstract
Protein is a crucial component of a child's diet, and its significance becomes even more pronounced when considering malnourished children. Malnutrition is a condition characterized by a deficiency or imbalance of essential nutrients, which can lead to stunted growth, impaired development, and weakened immune system. Protein plays a pivotal role in addressing these issues and promoting overall health in malnourished children. Malnourished children often experience stunted growth, and apart from protein-rich diet sufficient kilocalories are required to support their catch-up growth and development. Optimal protein utilization needs sufficient calories in the diet of malnourished children. Without an appropriate calorie intake, the body may utilize protein as an energy source, which can hinder its primary role in tissue repair and growth. NDP Cal% is a way to evaluate the human diet to predict if protein need of an individual would be adequately met based on energy consumed. Dietary protein is expressed as percent of total calories rather than weight. Soybeans are one of the few plant-based protein sources that provide all the essential amino acids needed for human health and is more affordable than animal-based products like meat and dairy. This cost-effectiveness can be crucial for families with limited resources, making it easier to incorporate soy-based foods into the diet of malnourished children. In addition to protein, soybeans are rich in essential nutrients, including vitamins (e.g., B-vitamins) and minerals (e.g., iron, calcium). These nutrients are essential for overall health and can help address nutrient deficiencies common in malnourished children. Present study calculated the NDP Cal% of a nutrient dense soy product (Laddoo) which is developed by CIAE Bhopal. The efficacy of protein estimated by intervening the product to MAM children enrolled in Anganwadi centres of Bhopal District.

Keywords: Net Dietary Protein Calories Percent NDPCal%, Moderate acute malnutrition MAM, Nutrient Dense Soy Product (Laddoo)

Introduction
Malnutrition is one of India's primary challenges, even as it develops as a worldwide giant. It is a complicated issue that is intertwined with poverty, education, ignorance, and food availability. According to the Global Hunger Index for 2016, India ranked 97 among 118 developing nations, with 15.2% of its population being undernourished and 38.7% of children under the age of five being stunted. According to the UNICEF, one million children under the age of five die due to malnutrition related causes in India. These statistics are alarming and far above the emergency threshold for 'acute malnutrition' as per the WHO classification of the severity of malnutrition. Low intake of protein due to poor economic status or the consumption of protein without correspondingly requisite calories intake are two different aspects of this multifaceted problem. There is the need for the development of protein rich products having the recommended protein calorie ratio (NDP Cal%). Because the human body cannot store protein, it must be consumed on a regular basis, and consuming the optimum quantity of Kilocalorie enables proper protein utilisation. This information is extremely beneficial to the low-income population. With the given resources, they can obtain optimal nutrition. Soybean is a miracle bean that contains highest amount of essential amino acids as well as numerous other nutritional benefits. It is one among India's and Madhya Pradesh's most important crops. Soybean is less expensive than animal protein products, but the quality is superior. Being the best source of complete vegetable protein, Soybean has a lot more potential to help combating malnutrition.

As most of Indian families are vegetarian, it could be the best source of protein in Indian diet. Soy product promotion is required in ICDS and other supplementary nutrition programmes. Anganbadi is government-run centre that provide health care and early nutritional care to children, pregnant and lactating women.

Soybean seed has a unique chemical composition that includes a number of nutraceutical compounds such as isoflavones, tocopherol, and lecithin in addition to 20% oil and 40% protein, making it one of the most valuable agronomic crops in the world. Soybean-derived food generally has health benefits and is a less expensive source of high-quality protein. The crop has the potential to eliminate protein malnutrition in the country's poorer sections of society. In India, the use of soybean for food purposes is limited, and more work is needed in terms of blending with other ingredients. (Bhatnagar *et al*, 2004) [1].

The versatility of soybeans will be a major factor in maintaining growth demand, as the soybean market can be segmented into animal feed, food and beverage, personal care, dietary supplements, pharmaceuticals, and biomaterials, including biofuels. (Chatham House, 2016) [3].

Soya milk is a healthy drink due to high protein and low-calorie, especially for those who are lactose intolerant to animal milk, still its use is not popularized in proportion to production and population. The growing consumer acceptance in the country has resulted in the production of many protein-rich food products made from soy protein, such as nutri-nuggets, nutri-soy powder, and so on. (Singh *et al* 2008) [19] Some agencies have also used soybean meal in the production of bread to increase the nutritive value of the product without affecting the flavour or price of the bread, but their appearance is still limited to some hypermarkets or urban areas.

Soybean has many positive effects on various diseases. Many researchers evaluated the effects of Soy Protein on Cardiovascular Disease Risk Factors and suggested that for every 1% reduction in LDL-cholesterol there is a corresponding 1%–2% reduction in cardiovascular events. (Pedersen *et al*, 1998; Charland, *et al*, 2010) [16, 2]. Also, Soybean has positive effects on risk factors of bone health, breast cancer, prostate cancer and kidney functions. Soybean exert positive effects on menopausal symptoms, cognitive function, mental health, skin health, fertility, male fertilization and thyroid function. It has positive results on developmental effects and effects on endometrial tissues (Messina, 2016) [11]. Introducing Soybean in early age will enhance its acceptability in later stage of life and promote healthy adult age.

Madhya Pradesh is the fifth largest producer of Soybean. The present study has proven the efficacy of nutrient dense soy product and discusses the urgency to promote the consumption of Soybean amongst the poor and malnourished population and urge to develop food products made by Soybean for better health index in India.

Table 1: State wise cultivation area for soybean in India

State	2020-21			2021-22		
	Area (Lakh ha)	Area (Lakh acres)	% to total area	Area (Lakh ha)	Area (Lakh acres)	% to total area
Madhya Pradesh	58.54	144.66	48.30	55.84	137.98	45.86
Maharashtra	43.21	106.77	35.65	46.01	113.69	37.79
Rajasthan	11.00	27.18	9.08	10.62	26.24	8.72
Karnataka	3.32	8.20	2.74	3.82	9.44	3.14
Gujarat	1.49	3.68	1.23	2.24	5.54	1.84

Source: www.agricoop.gov.in

Table 2: Production of Soybean in Districts of Madhya Pradesh

State	Districts
Madhya Pradesh (30)	Ujjain, Sehore, Dewas, Dhar, Shajapur, Sagar, Vidisha, Harda, Indore, Rajgarh, Chhindwara, Betul, Mandsaur, Hoshangabad, Guna, Ratlam, Raisen, Bhopal, Narsingpur, Shivpuri, Seoni, Neemuch, Khandwa, Ashoknagar, Damoh, Tikamgarh, Jhabua, Khargone, Satna, Chhatarpur

Source: Transparency Market Research, 2018

Research Methodology

The methods and investigations have been adopted to address the objectives of the study

1. Calculation of NDP Cal% of nutrient dense Soy product.
2. Intervention of nutrient dense Soy product to the malnourished children for three months (90 days).
3. Anthropometric, dietary assessment of malnourished children before and after intervention.
4. Statistical analysis of obtained data

To achieve the above objectives evaluative technique was adopted, with a pre-test-post-test control group design. The study's independent variable was intervention of Nutrient Dense Soy Product (Laddoo), and the study's dependent variable was nutritional status of chosen Anganwadi children for which anthropometric measurements were used. This nutrient dense product is developed by CIAE Bhopal. (Agrahar *et al* 2015) [12].

Table 3: Composition of Nutrient Dense Soy product (Laddoo)

Ingredients	Amount (g)
Whole wheat flour	13
Malted finger millet flour	6
Green gram flour	4
Dairy whitener	9
Roasted peanuts powder	8
Dried papaya powder	6
Roasted sprouted soy flour	54
Jaggery	74
Vegetable oil	20 ml
Water	10 ml

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The study included 77 children enrolled to total 19 Anganwadi of Bhopal District. A non-probability purposive

sampling technique was used for group allocation. The study was conducted from May 2022 to December 2022 at the Bhopal District. Data was collected, collated, and analysed in terms of the study's objective using descriptive and inferential statistics. Data collection tools were structured interview schedule for examining the children's background factors and to assess the nutritional condition anthropometric measurement are taken.

Calculation of the chemical score of soy protein

According to Oxford encyclopaedia, chemical score is a measure of protein quality based on chemical analysis of its amino acid composition. There is an evidence of relationship between the amino acid composition of protein and their nutritional value. Thus if the composition of an ideal protein i.e. the one containing all the essential amino acids in amounts sufficient to meet requirements without any excess, were known, it should then be possible to compute the nutritional quality of a protein in a mixture of a proteins by calculating the deficit of each essential amino acid below the amount in the ideal protein. This approach is the basis of the so called amino acid scoring (chemical score) procedure, by which we can evaluate the capacity of a given protein or mixture of proteins to meet the essential amino acid and nitrogen requirement of an individual.

Chemical score or amino acid score is therefore expressed as the ratio of each essential amino acid in a test protein to the respective amino acid in the reference protein. The reference protein could be a high quality protein like egg or milk or a suggested pattern of amino acid SAAP requirement of preschool children as given by FAO/ WHO 1985. Refer to table which gives the comparison of the suggested pattern of amino acid SAAP requirement in mg/g of protein (and in mg/g N) of preschool children with the composition of high quality animal protein i.e. egg (mg/g N).

The lowest amino acid ratio calculated for any one of the essential amino acids the chemical score of that protein. A protein totally lacking in one of the essential amino acids will have a chemical score of zero.

The chemical score of nutrient dense soy product is 52.643 (Sulphur Containing amino acid) and NDPCal% of the product is

NDPCal% = 10.67

Achieving the NDPCal% 8 for the new product, making it suitable for the growth of vulnerable groups.

Results and Discussion

According to the findings of the current study, nutrient dense soy products considerably improved the nutritional status of malnourished children as compared to the control group. Table 3.1 and 3.2 is depicting the results of intervention. The mean weight score of the control group and the experimental group. It clearly shows that the mean weight score is high in the post test scores of the experimental group with 10.1909,10. 3273, 10.8961 in post-test 1, 2 and 3 respectively when compared to the control group. This shows that provision of supplementation of nutrient dense soy products improved the nutritional status of children.

Table 3.2 describes the association between height of control group and experimental group children. The data shows that the mean height score of the control group is 87.83 in pre-test, 87.85, 87.93 and 87.96 in post 1, post 2, post 3 tests. Whereas in the experimental group, mean height is 87.61, 87.73, 87.87, 87.98 in pre-test, post-test 1, post-test 2, post-test 3, respectively. The t- value is 0.185, 0.106, 0.055, -0.018. The result proves that the mean height score is higher in the experimental group.

Table 3.3 is the calculation of the Chi Square Statistic, which is 5.7824. The p-value is 0.016188 that is significant at $p<0.05$.

Table 4: The mean Weight score in the Control and Experimental group

Weight of child (in KG)	Treatment	Mean	Std. Deviation	T-Value	P-Value
Pre-test	Control	9.7922	0.99601	-0.885	0.000
	Experimental	10.0026	1.83418		
Post-1	Control	9.8312	0.99290	-1.522	0.000
	Experimental	10.1909	1.82109		
Post-2	Control	9.8818	0.98805	-1.882	0.000
	Experimental	10.3273	1.82668		
Post-3	Control	10.4792	8.52097	0.417	0.613
	Experimental	10.8961	1.81524		

Table 5: The mean Height score in the Control and Experimental group

Height of child (in cm)	Treatment	Mean	Std. Deviation	T-Value	P-Value
Pre-test	Control	87.8312	4.96085	0.185	0.000
	Experimental	87.6117	9.15029		
Post-1	Control	87.8584	4.97299	0.106	0.000
	Experimental	87.7325	9.11909		
Post-2	Control	87.9351	4.97453	0.055	0.000
	Experimental	87.8701	9.11309		
Post-3	Control	87.9675	4.97127	-0.018	0.000
	Experimental	87.9883	9.10935		

The statistical analysis revealed that the additional intervention was more successful in the experimental group than in the control group. (Table 3.3)

Table 6: Efficacy of Soy Dense food

Group	Improvement in Nutritional Status	No Improvement	Total	Chi-Square (χ^2)	P Value
Experimental	76 (72.5) [0.17]	1 (4.5) [2.72]	77	5.7824	0.016188
Control	69 (72.5) [0.17]	8 (4.5) [2.72]	77		
Total	145	9	154		

The Chi Square Statistic with Yates correction is 4.2483. The *p*-value is 0.3929 significant at $p<0.05$.

The study proved beneficial in improving children's nutritional status. As a result, the entire health of the young children improves, preparing them for a healthy adult life in the future.

This finding is supported by

Researchers Owolabi *et al*, who did a comparative study on the nutritional status of children in villages of northern Nigeria using and not using soya beans and reported that supplementation of energy dense food has improved the haemoglobin concentration of experimental group.

Another study done by Nazni *et al.* which aimed to study the effect of weaning biscuits supplementation on the nutritional parameters and cognitive performance of the selected children. They chose 150 students from three elementary schools in Salem District, Tamil Nadu, India. The experimental investigation included 80 primary school children with Grade II malnutrition. For three months, Group I (N = 20) followed a home diet with no supplementation, Group II (N = 20) received potato flour biscuits, Group III (N = 20) received wheat biscuits, and Group IV (N = 20) received ragi biscuits for the period of 3 months. Parameters like anthropometric measurements, haemoglobin content clinical picture and cognitive performance were analysed before and after supplementation. After three months on their home diet, Group I (the control group) exhibited no significant difference in height, weight, clinical picture, or cognitive ability. Significant increases in all of the above metrics were observed in Groups II, III, and IV. For a period of three months, Group II children were supplemented with potato flour biscuits. In terms of cognitive ability, Group II outperformed Group III (supplemented with wheat biscuits) and Group IV (supplemented with ragi biscuits).

Bharti Jain (2012) [5] did a study and the results showed that soy and bajra flour could be well supplemented up to the level of 25 per cent with good palatability. This product (Soy-bajra fortified sattu) was more acceptable (74.3%) in comparison to traditional *sattu* (72.4%). Though acceptability of traditional *sattu* laddoo (81.2%) was more as compared to soy-bajra fortified *sattu* laddoo (78.0%), there is no significant difference was observed in all the quality attributes. On 9-point hedonic ranking scale of sensory evaluation the Soy Bajra *sattu* products were tested to find out the consumer acceptability of the ready to eat *sattu* products. Soy-bajra fortified *sattu* products were equally acceptable in in both the sex and rural and urban areas. Soy bajra *sattu* products were high in protein, fat, energy, calcium and iron. The NDP Cal% of soy-bajra fortified *sattu* was 6.32 which is adequate to maintain health for adults and good to promote growth.

Results of a study conducted in Bengaluru on preschool children with protein mix supplementation revealed that the mean difference was high in the post-test scores of the experimental group with14.83, 15.57, and 16.27 in post-test 1(T-Value = 5.366, p-value = 0.000), post- test 2(t108 value = 8.823, *p*-value = 0.000), and post- test 3(T-Value = 12.357, p-value = 0.000), respectively, when compared to the control group. Results clearly show that there was improvement in the nutritional status of the children.

Conclusions

This study on the malnourished children of Bhopal district proved that intervention of nutrient dense soy product improved the nutritional status. This can improve the mortality and morbidity rate of under five children. Soy products should be incorporated in the ICDS program. This recipe can be prepared in home by using locally available dietary articles which is also helpful in cost effectiveness. These references underscore the well-established principle that addressing malnutrition involves not only protein but also a sufficient calorie intake to provide energy for recovery, growth, and overall well-being.

Recommendation

Soybeans are a sustainable source of protein because they require fewer resources and have a lower environmental impact compared to some animal-based proteins. This makes soybeans an environmentally friendly choice, which is increasingly important in today's world. Homemade soy products should be encouraged for their cost effectiveness and freshness. More systematic and coordinated efforts, such as training-cum-demonstration programmes, are required to raise public awareness about the domestic utilisation of soybean production in various Indian states.

Popularization of soybean necessitates a comprehensive approach in which all segments of the population, including women, farmers, educated youth, doctors, field functionaries, shopkeepers, and teachers, are educated about the health benefits and nutritional contribution of soybean, with active participation from state agricultural universities, the Food and Nutrition Board, and various departments such as agriculture, women and child development, health, and education. (Khare *et al* 2023) [13].

Organizations like Central Institute of Agriculture Engineering (CIAE), Indian Institute for Soybean Research, Indore (IISR), Archer Daniels Midland Company (ADM) and Department of Agriculture, Government of Maharashtra, Public Private Partnership for Integrated Agriculture Development Programme (PPPIAD) Soybean Research and Information Network (SRIN), Society for Soybean Research and Development (SSRD) hold seminars, symposia, colloquia and provide forum for interaction of different scientific and educational organizations working in soybean production.

Because soybeans have numerous applications, Agro-Industries can capitalise on their potential. It can be used to make antibiotics, lard, margarine, vegetable oil and ghee, paints, varnishes, linoleum, printing inks, glycerine, explosives, and other products. Furthermore, its products such as Soy flour, Soy milk, Soy oil as a cooking medium, and Soybean cake are high in nitrogen and mineral content and can be used as soil manure and cattle feed to indirectly improve the human nutrition. (Singh *et al* 2006) [20].

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