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Nutritional contribution of Trans-Himalayan Cabbage and Cauliflower in Consumers' Diet

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Abstract

The research investigates the nutritional contribution of Trans-Himalayan cabbage and cauliflower to the diet of residents in Ladakh, an Indian region with extreme climatic conditions. Given the region's limited arable land and harsh environment, local vegetable production is vital for meeting the nutritional needs of its population, including a significant number of army personnel and tourists. The study analyzed cabbage and cauliflower from Suru, Nubra and Indus valleys of Ladakh situated at varying altitudes. Proximate and mineral analyses were performed on samples to assess their nutritional profiles. Results revealed that cabbage and cauliflower from Suru Valley had significantly higher ($p<0.05$) carbohydrate levels (50.6±0.8 and 47.3±2.6 g/100g dry weight respectively). Cabbage and cauliflower from Indus Valley had higher protein content (19.7±0.4 and 19.8±0.7 g/100g dry weight respectively). As per EDI, cauliflower contribution to dietary fiber content is higher than cabbage ($p<0.001$). It was also found that the cauliflowers were rich in Fe as compared to cabbage and cabbage were richer in Ni concentration. Both crops were estimated to be rich in minerals as per nutrition contribution%, especially manganese (cabbage - 36.3±0.6% and cauliflower - 24.7±7.3%), potassium (cabbage - 22.3±3.0% and cauliflower - 22.7±3.5%) and nickel (cabbage - 139.3±18.0% and cauliflower - 68.9±1.2%) as contribution was >19%. Hence, it can be stated that Ladakh grown crops are nutritionally enriched. This study underscores the potential of locally grown Brassicaceae crops to enhance dietary quality and reduce reliance on imported vegetables, thus supporting both nutritional health and local agriculture in Ladakh.

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Abbreviation: masl- meter above sea level, RACC-Reference amount customarily consumed, RDI-Recommended dietary intake, RDA- Recommended Dietary Allowance, EDI- Estimated Dietary Intake, NC- Nutrient contribution

Introduction

Ladakh is an Indian Trans-Himalayan region with arid geology experiencing low humidity, extreme temperature and high UV radiations. Of the 23,612 hectares of arable land, just 0.4% is actively cultivated.[1] The cultivation is confined to mono-cropping for 5 months.[2] During the snowy winter months, the region becomes cut off, causing road imports to either stop or slow significantly, which leads to spoilage of perishable goods. Importing via air becomes very costly under these conditions.[3] According to Ladakh Autonomous Hill Development Council (LAHDC), the total population of Ladakh is 274,289 individuals. Additionally, it holds a large population of army personnel deployed in the region as well as a rapidly growing number of tourists. The high-altitude environment presents various physiological challenges, yet nutrition has not been sufficiently prioritized.[4] The households have increased vegetable production for domestic use as well as to meet the demand of army and tourism industry.[5] Defence Institute of High-Altitude Research (DIHAR), formerly FRL and State Agriculture Department conducted trainings and extension activities for the army and residents to promote vegetable cultivation in the region so as to maintain the demand and supply ratio.[6]

Vegetables are great source of nutritional components such as minerals, fibres, vitamins, carbohydrates and proteins, that are essential for balanced diet. Adequate nutrition is essential for building and maintaining nutritional reserves. Around the world, specialized ration scales are being developed for armed forces ensuring they receive food that meets these standards. Similarly, populations follow diet plans crafted by nutritionists to align with their dietary habits, environment, climate, daily activities, and economic constraints. According to ICMR-NIN 2024 and studies conducted on army ration scale; 200g of fresh or 20g (dehydrated) vegetables per day should be consumed at high altitude respectively.[7] India is one of the largest producers of Brassicaceae crops[8] and in Ladakh, cabbage and cauliflower are among the majorly cultivated crops.[9] Additionally, to extend the growing season in Ladakh's harsh climatic conditions, local farmers utilize greenhouse environments for cultivating these Brassicaceae crops. Due to which these are in locals' diet for longer period as these are also stored in dried form to consume during winters. These are the prominently consumed crops, with numerous traditional dishes incorporating them as key ingredients. Traditionally, these were used as a medicine[10] and according to epidemiological studies, Brassicaceae crops lowers the risk of developing cancers, hepatic steatosis and heart disease.[11]

Ladakh's diverse agro-climatic, geographical, and seasonal conditions result in varying environmental influences on crop quality.[12] The attributes of primary interest to the consumers are the nutritional aspects of any vegetables.[13] Although many studies have been conducted in plains but Ladakh's unique topography and extreme climate necessitate specific research into the proximate and mineral content of crops grown there. Mainly Brassicaceae crops as these locally grown crops are grown and consumed for extended period even after growing season in green house conditions. This will give an insight about the overall nutritional quality of cabbage and cauliflower grown in the region required to fulfil the nutritional needs of the residents consuming these vegetables. It will also reduce the dependency of vegetables imported from other regions of the country and will add on farmer's income.

Materials and Methods

Sample Collection

Cabbage and Cauliflower were collected from majorly populated areas of Ladakh; Suru, Nubra and Indus valleys. These are situated at an altitude range from 2500-2700, 3000-3200 and 3250- 3560 meter above sea level (masl) respectively. Three villages from each valley were selected based on the population that covers more consumers. Systematic and composite sampling were followed to collect mature and disease- free crops.[14] These samples were kept in sterile plastic bags and taken to laboratory for further analysis. Samples were cleaned with double distilled water then dried at 65 °C in oven until constant weight was observed and later grinded into fine powder.

Determination of Proximate and Minerals Content

Micro- Kjeldahl method was followed to determine crude protein content. Total carbohydrate was determined by anthrone method.[16] Moisture content (%), Crude ash, fat and fibre was determined by following the method described by Aletan and Kwazo[15] Calculation of these parameters was done using the following formulae:

Moisture content (%)=(Fresh weight-Dried weight)/(Fresh weight)*100 ...(1)

Crude fat (%)=(Weight of ether soluble material)/(Weight of sample)*100 ...(2)

Crude fibe (g/100g)=(100-(We-Wa))/Ws*100 ...(3)

Where, W_s is the weight of acid and base digested dried sample,

W_e is weight of dried sample + weight of crucible

W_a is weight of dried ash fiber + weight of crucible

Ash (%)=((crucible weight + sample) - (crucible weight + ash))/(Sample weight)*100 ...(4)

Mineral content was determined by atomic absorption spectriophotometer.[14] with slight modifications. 0.2 g of powdered samples were acid digested in 2 ml conc. HCl and 6 ml conc. HNO_3 using high-pressure microwave digester unit (TOP wave Analytik Jena, AG Germany). Acid digests were adjusted upto 50 ml with deionised water and later filtered through ashless Whatman filter paper no. 42. Minerals such as Fe, Zn, Cu, Mn, Ni, K, Na and Mg was determined by Atomic Absorption Spectrophotometer (ZEE nit 700P Flame Analytik Jena).

Estimated Dietary Intake (EDI) and Nutrient Contribution (NC)

EDI was calculated using the nutrient content evaluated for vegetable's Reference amount customarily consumed (RACC). NC % was then calculated based on the Recommended dietary intake (RDI) or Recommended Dietary Allowance (RDA).[17] These are calculated as follows:

EDI=(Nutrient content)/100×RACC(g) ...(5)

Nutrient contribution(%)=EDI/RDI×100 ...(6)

Where, RACC for vegetables is 20g (dehydrated)[7]

To calculate NC%; EDI for carbohydrate, protein, fats and dietary fiber is expressed in g/day and for minerals, it is expressed in mg/day, based on RDI units of g/100g for proximate components and mg/100g for minerals.

Statistical Analysis

All analysis were done in triplicate and expressed as Mean ± SD (standard deviation) using MS Excel. Statistical software IBM SPSS Statistics 22 was used for further analysis. One-way ANNOVA was performed on the data acquired to determine the statistically significant differences between the means. Independent t-Test was applied between the cabbage and cauliflower within same valley. 95% ($p<0.05$) of confidence level was set in all statistical analyses.

Results

Determination of Proximate Content

Carbohydrates, proteins and fats are the major energy source that contributes to the daily calorific intake. Carbohydrate, protein, fats, dietary fiber and ash is represented in Table 1.

Table 1: Proximate content in cabbage and cauliflower and their EDI and NC in consumer's diet

Nutritional parameter	Crops	Suru valley	Nubra valley	Indus valley	EDI (g/day)	NC (%)
Carbohydrate (g/100g)	Cabbage	50.6 ± 0.^{8a}	44.2 ± 2.9^{b*}	42.6 ± 4.1^{b}	9.2 ± 0.9*	7.0 ± 0.7
	Cauliflower	47.3 ± 2.6^{8a}	38.3 ± 1.6^{b}	33.5 ± 4.8^{b}	7.9 ± 1.3	6.1 ±1.0
Protein (g/100g)	Cabbage	17.2 ± 0.2^{b*}	14.7 ± 1.8^{c}	19.7 ± 0.4^{8a}	3.4 ± 0.5	6.9 ± 0.9
	Cauliflower	16.2 ± 0.3^{b}	17.0 ± 1.7^{b}	19.8 ± 0.7^{8a}	3.5 ± 0.4	7.1 ± 0.7
Fats (g/100g)	Cabbage	5.5 ± 1.1^{b}	9.7 ± 0.3^{8a}	9.5 ± 1.0^{8a}	1.6 ± 0.4	2.5 ± 0.8
	Cauliflower	6.9 ± 2.6^{8a}	10.0 ± 1.6^{8a}	11.4 ± 4.8^{8a}	1.9 ± 0.6	2.8 ± 0.9

Dietary fiber (g/100g)	Cabbage	10.7 ± 0.1^{8a}	11.6 ± 0.9^{8a}	9.1 ± 0.4^{b}	2.1 ± 0.01	6.0 ± 0.04
	Cauliflower	11.9 ± 0.6^{b}*	14.7 ± 1.7^{8a}*	14.1 ± 0.8^{a,b}*	2.7 ± 0.3***	7.8 ± 0.9
Moisture content (%)	Cabbage	91.3 ± 3.4^{8a}	92.1 ± 1.2^{8a}	90.9 ± 1.9^{8a}		
	Cauliflower	90.9 ± 2.4^{8a}	92.5 ± 1.8^{8a}	90.2 ± 1.3^{8a}		
Ash (%)	Cabbage	9.1 ± 2.8^{8a}	9.1 ± 0.9^{8a}	7.6 ± 1.6^{b}		
	Cauliflower	9.0 ± 0.9^{8a}	9.9 ± 1.6^{8a}	8.1 ± 0.6^{8a}		

Mean ± Standard deviation; One-way ANOVA; different superscript (a, b and c) designated within valleys describes the significant different data with $p<0.05$ at different sites.
Independent t test: within crops with respect to nutritional parameter within same valley is represented by *($p<0.05$), **($p<0.01$) and ***($p<0.001$)

The carbohydrate content in cabbage and cauliflower grown in Ladakh ranges from 39.2 - 51.6 g/100g and 28.0 - 49.0 g/100g, respectively, on a dry weight basis. There is a negative correlation ($p<0.05$) between carbohydrate content and altitude, indicating that crops from the lower altitude Suru valleys have higher carbohydrate levels compared to those from other valleys. Specifically, cabbage from the Suru valley contains 50.6 ± 0.8 g/100g dry weight, and cauliflower contains 47.3 ± 2.6 g/100g dry weight of total carbohydrates. The Indian Council of Medical Research - National Institute of Nutrition (ICMR-NIN) recommends a daily intake of 130g of carbohydrates. The EDI for carbohydrates in cabbage and cauliflower were 9.2 ± 0.9 g/day and 7.9 ± 1.3 g/day respectively which makes up the nutritional contribution of 7.0 ± 0.7% and 6.1 ±1.0 % respectively.

Protein content in Ladakh grown cabbage and cauliflower range from 13.0- 19.5 and 15.9-20.4 g/100g dw. The RDA for protein is 54g/day and 46g/day for women. The EDI for protein was estimated out to be 3.4 ± 0.5 and 3.5 ± 0.4 g/day from cabbage and cauliflower respectively. Hence, protein content of cabbage and cauliflower nutritionally contribute up to 6.9 ± 0.9% and 7.1 ± 0.7% respectively.

Crude fat content in Ladakh grown cabbage and cauliflower range from 4.4-10.3 and 4.1-14.9 g/100g dry weight basis (dwb) respectively. Cabbage from the high-altitude Indus region has higher crude fat content, while there is no significant variation in the fat content of cauliflower from different Ladakh valleys. The RDA for fats is 67g/day for an individual. EDI of fats from cabbage and cauliflower were 1.6 ± 0.4 g/day and 1.9 ± 0.6 g/day respectively. The NC% for fats from cabbage and cauliflower detected were 2.5 ± 0.8% and 2.8 ± 0.9%.

Crude fiber content in Ladakh grown cabbage and cauliflower range from 8.7-12.6 and 11.3-15.8 g/100g db respectively. Cabbage from mid and low-altitude regions shows significantly higher fiber content, while cauliflower from mid-altitude areas also exhibits higher fiber levels compared to other valleys. RDA for dietary fiber is 40g/day for men and 30g/day for women. The EDI of crude fiber from cabbage and cauliflower were detected as 2.1 ± 0.01 and 2.7 ± 0.3 g/day respectively, with NC% of 6.0 ± 0.04% and 7.8 ± 0.9% respectively.

As per independent t- test, cabbage significantly contributes more to total carbohydrate content, whereas cauliflower provides more dietary fiber. These vegetables can help meet caloric needs, with 100g of cabbage and cauliflower providing approximately 25.4-30.5 and 23.5-30.9 Kcal of energy, respectively, as calculated by Aletan and Kwazo.[15]

Moisture content in cabbage and cauliflower ranges from 87.5-94.3 and 88.1-94.6% respectively. Total ash content in cabbage and cauliflower ranges from 4.0-12.4 and 7.4-11.6 mg/100g respectively. The ash content reflects the mineral content of the samples, which will be detailed in further studies.

Determination of Mineral Content

Trace minerals content in cabbage and cauliflower from different valleys of Ladakh is represented in Table 2. Fe and Mn content was found significantly higher in Indus valley grown cabbage compared to other valley cabbage. Whereas Fe and Mn was higher in mid altitude Nubra grown cauliflower. Statistically, cauliflower was found to have a higher Fe content than cabbage. However, cabbage from the Suru and Nubra regions contained more Mn compared to cauliflower from the same areas. Cu and Ni concentration in cabbage were in the range 0.3-0.5 and 2.4-3.7 mg/100g dwb, respectively; cauliflower contained 0.4-0.6 mg/100g dwb of Cu and 1.7-1.8 mg/100g dwb of Ni. Statistically, it was observed that Ni content in cabbage was higher than cauliflower. Cabbage and cauliflower from Nubra region were richer in Zn compared to other two valleys as presented in Table 2. RDA for Fe is 19 mg/day for men and 29 mg/day for women; Mn is 4 mg/day for an individual; Cu is 1.7 mg/day; Ni is 0.5 mg/day; Zn for men is 17 mg/day and for women is 13.2 mg/day. If a person consumes 20 g of cabbage in dried form, then the EDI of Fe, Cu, Zn, Mn and Ni EDI is 2.2 ± 0.3 mg/day, 0.1 ± 0.0 mg/day, 0.5 ± 0.2 mg/day, 1.5 ± 0.3 mg/day and 0.6 ± 0.1 mg/day respectively. It makes a nutritional contribution % of 9.2 ± 1.4 %, 4.5 ± 0.6 %, 3.4 ± 1.4 %, 36.3 ± 0.6 % and 139.3 ± 18.0 % for Fe, Cu, Zn, Mn and Ni respectively.

Table 2: Trace minerals in cabbage and cauliflower and their EDI and NC in consumer's diet

Mineral		Suru (mg/100g)	Nubra (mg/100g)	Indus (mg/100g)	EDI (mg/day)	NC (%)
Fe	Cabbage	10.6 ± 0.3[b]	9.6 ± 1.2[b]	12.8 ± 1.1[a]	2.2 ± 0.3	9.2 ± 1.4
	Cauliflower	26.9 ± 1.5[a]***	18.1 ±2.3[b]*	24.6 ± 2.8[a]*	4.6 ± 0.9	19.3 ± 3.7
Cu	Cabbage	0.4 ± 0.05[a]	0.4 ± 0.005[a]	0.4 ± 0.003[a]	0.1 ± 0.0	4.5 ± 0.6
	Cauliflower	0.4 ± 0.03[a]	0.4 ± 0.03[a]	0.5 ± 0.05[a]	0.1 ± 0.0	5.6 ± 0.7
Zn	Cabbage	1.3 ± 0.1[c]	3.7 ± 0.5[a]	2.6 ± 0.1[b]**	0.5 ± 0.2	3.4 ± 1.4
	Cauliflower	1.5 ± 0.2[b]	2.0 ± 0.1[a]	1.5 ± 0.2[b]	0.3 ± 0.1	2.2 ± 0.4
Mn	Cabbage	7.2 ± 0.3[b]***	5.9 ± 0.8[c]	8.6 ± 0.4[a]*	1.5 ± 0.3	36.3 ± 0.6
	Cauliflower	3.1 ± 0.4[a]	5.5 ± 0.3[b]	6.3 ± 0.4[a]	1.0 ± 0.3	24.7 ± 7.3
Ni	Cabbage	2.8 ± 0.3[a]**	3.4 ± 0.4[a]**	3.2 ± 0.3[a]**	0.6 ± 0.1	139.3 ± 18.0
	Cauliflower	1.7 ± 0.03[a]	1.7 ±0.03[a]	1.7 ± 0.02[a]	0.3 ± 0.0	68.9 ± 1.2

Mean ± Standard deviation; One-way ANOVA; different superscript (a, b and c) designated within valleys describes the significant different data with p<0.05 at different sites.
Independent t test: within crops with respect to nutritional parameter within same valley is represented by *(p<0.05),**(p<0.01) and ***(p<0.001)

EDI of Fe, Cu, Zn, Mn and Ni from cauliflower was 4.6 ± 0.9 mg/day, 0.1 ± 0.0 mg/day, 0.3 ± 0.1 mg/day, 1.0 ± 0.3 mg/day and 0.3 ± 0.0 mg/day which makes a nutritional contribution of 19.3 ± 3.7 %, 5.6 ± 0.7 %, 2.2 ± 0.4 %, 24.7 ± 7.3 % and 68.9 ± 1.2 % respectively.

Macrominerals in cabbage and cauliflower are presented in table 3. Na and Mg content in Indus valley grown cabbage was significantly higher than Nubra and Suru valley. However, Na and Mg content in cauliflower and K content in both cabbage and cauliflower were higher in Nubra and Indus valley grown ones. According to independent t-Test, between crops and within valleys, Suru valley grown cabbage contained higher sodium content compared to cauliflower; Nubra valley grown cauliflower was richer in K content compared to cabbage grown in the same region. Cabbage from Indus region had higher Mg content than cauliflower from same region. RDA for Na and K is 2000 mg/day and 3500 mg/day for an individual; Mg is 440 mg/day for men and 370 mg/day for women. The EDI of sodium was 67.8 ± 9.5 and 47.0 ± 24.3 mg/day from cabbage and cauliflower respectively. The NC% of cabbage and cauliflower for Na was 3.4 ± 0.5% and 2.3 ± 1.2% respectively. The EDI and NC% of K with the consumption of cabbage was 779.3 ± 103.8 mg/day and 22.3 ± 3.0% respectively. While the EDI and NC% of K with the consumption of cauliflower was 795.2 ± 122.5 mg/day and 22.7 ± 3.5 % respectively. The EDI of Mg was 50.2 ± 21.5 and 35.8 ± 6.1 mg/day from cabbage and cauliflower respectively. The NC% of cabbage and cauliflower for Mg was 12.4 ± 5.3 % and 8.8 ± 1.5 % respectively.

Table 3: Macro- minerals in cabbage and cauliflower and their EDI and NC in consumer's diet

Minerals	Crops	Suru	Nubra	Indus	EDI (mg/day)	NC (%)
Na	Cabbage	328.5 ± 0.9^{b***}	299.5 ± 18.5^{b}	389.1 ± 49.1^{a}	67.8 ± 9.5	3.4 ± 0.5
(mg/100g)	Cauliflower	92.3 ± 13.7^{b}	318.4 ± 45.2^{a}	294.1 ± 103.5^{a}	47.0 ± 24.3	2.3 ± 1.2
K	Cabbage	3250.0 ± 126.7^{b}	4080.6 ± 201.2^{a}	4358.4 ± 152.7^{a}	779.3 ± 103.8	22.3 ± 3.0
(mg/100g)	Cauliflower	3219.6 ± 322.7^{b}	4507.8 ± 98.6^{a*}	4200.2 ± 170.8^{a}	795.2 ± 122.5	22.7 ± 3.5
Mg	Cabbage	143.3 ± 21.2^{b}	240.2 ± 40.3^{b}	368.9 ± 76.0a*	50.2 ± 21.5	12.4 ± 5.3
(mg/100g)	Cauliflower	144.4 ± 14.8^{b}	196.4 ± 21.4^{a}	196.8 ± 16.7^{a}	35.8 ± 6.1	8.8 ± 1.5

Mean ± Standard deviation; One-way ANOVA; different superscript (a, b and c) designated within valleys describes the significant different data with $p<0.05$ at different sites.
Independent t test: within crops with respect to nutritional parameter within same valley is represented by *($p<0.05$),**($p<0.01$) and ***($p<0.001$)

Discussion

Nutrition scientists across the world are working to maintain and optimize the health and performance of people through identifying nutritional deficits in different food crops.[18]

The negative correlation ($p<0.05$) between carbohydrate content and altitude was estimated. The reason might be that at higher altitude, the light intensity is higher than optimal with thin air layer that might lead to the drop-in photosynthetic rate resulting in lesser carbohydrate content. The EDI and NC are useful for making dietary recommendations based on nutritional composition. As per US FDA nutrient content claims, that if a food meets 10-19 % NC% then it is categorised as a good source for that nutrient.[19] Carbohydrates are involved in blood glucose, insulin, cholesterol and triglyceride metabolism. Carbohydrates breaks down into glucose that is used for energy or stored in muscle and liver tissue for further requirement.[20]

Crops from the higher-altitude Indus valley exhibited higher protein levels, likely due to increased cold or environmental stress that stimulates amino acid production.[21] Vegetables or plants are considered as a moderate source of protein. Hence, additional protein-rich sources must be added to these vegetables to fulfil the requirement of this macronutrient.[22] Proteins comprise major structural elements of cells and form major constituents of muscle. It also regulates gene expression and immune system. Monomers of proteins are known as amino acids that are known to serve as hormones, neurotransmitters in neurons, and acts as modulators in various physiological processes.[18] Vegetables are not considered the primary source of fats or lipids. One of the aspect of vegetables is that it doesn't contain traces of trans fats or cholesterol.[23] However, fats are essential for providing essential fatty acids and absorbing fat-soluble vitamins. They are highly effective in the diet as they are efficiently absorbed by the body.[24]

The variation in fiber content in crops may be due to different environmental adaptations of the crops during growth.[25, 26]

Dietary fiber helps in enhancing digestibility, lowers serum cholesterol level, reduces risks of heart disease, hypertension, diabetes and cancers. According to the provisions of Codex Alimentarius (CAC 2009), food with fiber content greater than 6 g 100 g^{-1} are considered to be rich in dietary fiber.[27] Hence, according to dwb cabbage and cauliflowers can be considered a good source of dietary fiber.

The carbohydrate, protein, crude fat, and dry matter percentages in cabbage grown in Ladakh were similar while the dietary fiber content was lower to the data reported in previous studies.[28] Carbohydrate content, dry matter%, protein content of cauliflower was similar and dietary fiber was less as compared to the previous reports.[29] Vegetables consumed in appropriate combination provide almost all the essential nutrients for proper body functions. Despite being low in calories, vegetables provide a feeling of satiety. Thus, it can be ensured that the

Trans- Himalayan crops can replace the imported vegetables from plains with respect to proximate composition.

The lower dry matter content and higher moisture levels signifies lower shelf life of fresh plant which makes a crop more susceptible to microbial attack. Consequently, people in the Trans-Himalayan region store these crops in dried form and use preservation methods like pickling and fermentation to keep them for winter months.[30,31]

Minerals are important for vital body functions. Cu, Zn and Mg concentration in cabbage and cauliflower was similar whereas Fe and Mn were comparatively higher than previously reported studies.[32] According to the average NC% differences, cabbage provides more Zn, Ni, and Mn than cauliflower, while cauliflower better meets the Fe and Cu requirements compared to cabbage. Minerals such as iron is involved in respiration and also acts as a cofactor for many vital proteins and enzymes.[33] Copper helps in the synthesis of haemoglobin and iron metabolism.[34] Zn helps in healing wounds, cell development, and division. Sufficient intake of Mn is necessary for metabolism, thyroid function and blood sugar regulation. It activates numerous essential enzymes.[35] Vegetables fulfil the need of minerals intake and enhance availability in daily life. Vegetables are substantial contributor of minerals to the daily diet. Based on the differences in average NC%, it can be concluded that cabbage better meets the Na and Mg requirements compared to cauliflower. Na regulates blood pressure, extracellular fluid volume and is essential for muscular and nervous system. K content improves water retention, prevent kidney stones, osteoporosis, decrease cardiovascular risk and is also a cofactor for many enzymes. Na and K acts as an electron carrier in body and together participate in blood pressure regulation, nerve impulse transmission and muscle contraction. High Na and low K intakes may alleviate hypertension.[36] In cabbage and cauliflower, it is found that the potassium concentration is high and sodium is low. Hence, it is suitable to maintain Na:K ionic balance in the body. Magnesium helps in maintaining osmotic equilibrium, improve T cell activity against infections and cancers. It is involved in cardiac excitability, neuromuscular conduction and is a cofactor in more than 300 metabolic reactions.[37] These observations assure that minerals requirement from vegetables can be fulfilled by cabbage and cauliflower grown in Trans- Himalayas.

Conclusion

It was concluded that NC of cabbage for carbohydrate, protein, fats and dietary fiber was 7.0 ± 0.7%, 6.9 ± 0.9%, 2.5 ± 0.8% and 6.0 ± 0.04 % respectively whereas NC% of cauliflower for carbohydrate, protein, fats and dietary fiber was 6.1 ±1.0%, 7.1 ± 0.7%, 2.8 ± 0.9% and 7.8 ± 0.9% respectively. Moisture content of cabbage and cauliflower was >90%. Both the crops were rich in mineral content and NC for Mn, Ni and K was estimated to be >19%. Hence, the crops cultivated in higher altitudes ensures to fulfil the nutritional requirement. The consumer population can rely on these crops which will also add on to the farmer's income and reduce the cost of imports via road or by air. Additionally, comprehensive nutritional profiling of other prominently produced crops should also be undertaken to identify a wide variety of vegetables to meet daily nutritional requirements. According to the available data, nickel (Ni) levels in these crops exceed 50%, highlighting the need for a detailed investigation into heavy metal concentrations.

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The manuscript incorporates all datasets produced or examined throughout this research study.

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This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Clinical Trial Registration

This research does not involve any clinical trials.

Permission to Reproduce Material from other Sources

Not Applicable.

Author Contributions

- **Avantika Avantika:** Visualization, Methodology, Data Collection, Analysis, Writing – Original Draft
- **Narendra Singh:** Conceptualization, Supervision, Review & Editing.

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