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# High Energy Foods: Review with Food Technological Perspective

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**ABSTRACT**

Energy foods have gained a special interest all around the globe due to enhanced consumer awareness about activity-based calorie requirements. Energy-specific foods can be prepared in the form of bars/ fluids by using a combination of various types of ingredients such as cereals, pulses, nuts, and seeds. Energy foods provide concentrated calories specifically required for athletes and military personnel, those involved in high-endurance physical activities. The latter group was deployed in challenging terrains associated with harsh climatic conditions (high altitudes, hot and cold environments). In addition to the harsh climate, the situation worsens with limited accessibility and availability of regular food. Therefore, food and fluid intake will be considerably less, which ultimately disturbs the energy metabolism and health of an individual. The research poses challenges in the development of energy foods for specialised requirements and incorporating the highest energy in the lowest volume of foods. This is because of raw material selections, economics, product palatability and stability (shelf life) in adverse conditions. The high energy content, volume, and stability are suitable factors for using certain products as survival or emergency rations. Indeed, there was a necessity to understand the fate of energy metabolism and its medical implications in different harsh climatic conditions. The present review is a brief discussion about the influence of a challenging environment on nutritional and energy requirements and the significance of different energy foods.

**Keywords:** Energy bars & Beverages; Energy balance; Thermoregulation; Ergogenic aid

**NOMENCLATURE**

| | |
|---|---|
| MRDA | : Military recommended dietary allowance |
| HAPH | : High altitude pulmonary hypertension |
| RH | : Relative humidity |
| MJ | : Mega joule |
| Kcal | : Kilocalories |
| TDEE | : Total daily energy expenditure |
| HIF | : Hypoxia inducing factor |
| ROS | : Reactive oxygen species |
| NO | : Nitric oxide |
| BAT | : Brown adipose tissue |
| BCAA | : Branched chain amino acids |
| ATP | : Adenosine triphosphate |
| BMR | : Basal metabolic rate |
| HNDS | : High nutritious dense spread |
| WHO | : World health organisation |
| MRS | : Magnetic resonance spectroscopy |

## 1. INTRODUCTION

Adequate nutrition is an essential aspect of the long-term sustainability of human beings. Food delivers basic nutrition requirements to the body and serves as the first and foremost choice for survival and well-being. The macromolecules in food, such as carbohydrates, proteins, and fats, serve as principal energy sources, undergo a stepwise oxidation process, and produce energy[1]. The energy balance is termed as the balance between energy intakes versus energy expenditure. Energy metabolic homeostasis is a vital aspect of any living system; any deviation in energy balance causes adverse consequences such as energy malnutrition, muscle wasting, impaired growth, etc. Military personnel nutritional requirements are very specific and more attention has to be paid to delivering quality and balanced nutrition. They are usually involved in heavy strenuous physical activities to maintain fitness and readiness for field combat[2,3]. Military personnel experience different physiological challenges in typical harsh environments, which lead to consequences such as hypoxia (insufficient oxygen supply to the tissue), particularly at high altitudes, severe hypothermia is caused by exposure to cold conditions, severe dehydration and electrolyte loss in hot environments. All these factors affect the energy metabolism and, therefore, energy balance in the system[3-7]. The Energy expenditure of different terrains was varied, i.e., in cold terrains 4549±1221 kcal/day, hot environments (desserts) 4664±1399 kcal/day and in jungle (hot & humid) 3937±159kcal/day[8,9]. To meet the high calorie demands at harsh climatic conditions, a special category of foods formulated with lesser volume with denser calories are essential. Energy

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foods are special foods that are developed with versatile ingredients and also added with some specific ergogenic aids, etc[10-19]. These convenience foods are processed in the form of ready-to-eat bars and ready-to-serve energy drinks, where hydration of the body is one of the key objectives apart from the energy concern**.** This critical review discussed the aspect that impacts energy metabolism in harsh conditions and the significance of energy foods in energy metabolism and nutrition.

## 2. ENERGY REQUIREMENTS IN EXTREME ENVIRONMENTS AND TERRAINS

### 2.1 Energy Requirements at High Altitude

High altitudes or flying can lead to a variety of disturbances in metabolic homeostasis and increased oxidative stress. The major physiological concerns at high altitudes are hypoxia, weight reduction and dehydration. Generally, defence forces were deployed at high altitudes, ranging from 2,500 to 3,000 meters above sea level. It is essential to know the metabolic changes that take place at high altitudes to assess the nutritional and health status of troops. The average energy expenditure of Indian troops of different regiments deployed at altitudes of 2300 meters and above was 3769 kcal/day, and the average energy from the food ratio was 3963 kcal/day[2]. Several factors influence energy metabolism at moderate and higher altitudes, such as hypoxic-hypobaric environment, physical training, and diet[7]. High-carbohydrate foods are preferred as an energy source at high altitudes and in-flight. At altitude, carbohydrate utilisation increases due to metabolic shifts, higher glycogen turnover, and hypoxia-induced stress. Elevated intake of carbohydrates supports endurance by replenishing glycogen, optimising training intensity, and enhancing mitochondrial adaptations. Carbohydrate oxidation varies, but increased dietary intake is generally recommended to counteract energy deficits and sustain performance[7,20]. Besides, beta-oxidation of fat helps in the pooling up of ATP molecules and thus aids in maintaining the energy balance. However, the role of fat in endurance is moderate, owing to the lesser oxidative capacity of mitochondria in muscles[21]. In addition, the increase in physical activity negatively influences the formation of acylcarnitine from long-chain fatty acids, which is essential for entering into the mitochondria for oxidation[22]. The role of protein in energy homeostasis is relatively less compared to other macromolecules. However, in the case of endurance, the oxidation of BCAA (Branched-Chain Amino Acids) especially plays an essential role and is converted into keto-acids, which are considered essential precursors in the tri-carboxylic acid cycle[23].

Hypoxia is a physiological condition of the body that generally occurs during the acclimatisation process to the altered environment (high altitude). During this, several physiological alterations are observed such as a decrease in the partial pressure of oxygen in the body tissues, therefore resulting in the elevation of hyperventilation and cardiac output[24]. Hypoxia is also induced by pathological conditions, i.e., oncogenesis and inflammation. Hypoxia-Inducing Factor (HIF), a central gene transcription mechanism, shifts the aerobic phosphorylation by inhibiting the conversion of pyruvate to acetyl Co-A, in the case of low oxygen levels in the tissues. In addition to this, HIF up-regulates the glycolytic process and thereby activates the lactate dehydrogenase enzyme, which is involved in the regeneration of NAD+ required for the recycling or reprocessing of glycolytic pathways[25]. This process reduces the oxygen consumption load in mitochondria and thereby reduces the probability of the release of Reactive Oxygen Species (ROS). The dominance of aerobic glycolysis over anaerobic takes place, which produces more ATP molecules, i.e., 8, than the latter, which produces only 2[25-26]. At high altitudes, armed forces usually experience an energy-deficient condition (the total energy expenditure is more than that of energy intake). Eventually, this leads to a disturbance in the energy homeostasis of the body. Physical exercise, which is an integral part of military activities, requires much more energy to perform intense physical exercise. Often, the physical activity at particularly challenging deployment terrains, i.e., high altitude, hot and cold environments, makes it more difficult[27].

### 2.2 Energy Requirements at Low-Temperature Terrains

The human body is very sensitive; it gets severely harmed by exposure to a low temperature or a cold environment. Prolonged exposure to cold conditions can cause severe hypothermia. In the case of military personnel, the following factors such as elevated excretion, heavy weight loads (protective clothing and artillery), and intense exercise can raise calorie requirements[28]. In cold-exposed adult humans, a considerable drop in body temperature is delayed by slowing heat loss through peripheral vasoconstriction and enhancing heat liberation through shivering and non-shivering thermogenesis, this phenomenon is also termed as fuel for heat production in cold conditions[29].To maintain body temperature in the case of increasing heat loss, the major response to cold is a rise in energy expenditure. In non-shivering thermogenesis, oxidation of adipose fat, especially Brown Adipose Tissue (BAT), occurs[30]. Prolonged exposure to the cold upregulated the thermogenic uncoupling protein (UCP-1), present in the mitochondria of brown adipose tissue, thereby increasing the rate of fat oxidation in tissue which is attributed to the elevated circulatory free fatty body. Besides, the oxidation of BAT, cold exposure also influences insulin sensitivity, thereby elevating the uptake of glucose[31,32]. The energy expended in this process is replenished by an increase in calorie intake that is directly proportional to the energy expended. Energy expenditure for war fighters during periods of physical exertion in the cold might range from 4,281 to 4,919 calories per day. In some cases, requirements are raised to nearly 6,000 calories per day[33]. A high-carbohydrate diet is required for cold settings; excess carbohydrates are required to replace glycogen stores and to maintain core temperature. In cold conditions, fluid intake is raised because of the cold-induced increase in urine production, fluid loss through breathing, and a voluntary reduction in fluid intake. It can also be challenging to meet the high-calorie requirements of cold weather operations. Therefore, both fat and carbohydrates are important sources of energy[34,35].

In cold conditions, military personnel's calorie requirements should be raised; nevertheless, estimates vary widely, for males in cold climate conditions cooler than 57 °F (14 °C), the current U.S. Military Recommended Dietary Allowance (MRDA) is 4,500kcal/day[34]. The basal metabolic rate, physical activity, thermoregulation of the body, and thermic effect of food are the main factors for calculating total energy expenditure in cold settings[36-37]. Basal Metabolic Rate (BMR) is greatly influenced by climate; BMR is higher in cold climates than in temperate and hot climatic conditions. The basal metabolic rate was experimentally found as a mean of 2,176 ± 550 kcal/day for temperate climates, 2,251± 460 kcal/day for hot climates, and 2,898 ± 855 kcal per day on the 21st day for cold climates[38]. The findings imply that heat generated by physical activity can be an effective way to sustaining core body temperature in cold environments, lowering the metabolic cost of thermoregulation.

### 2.3 Energy Requirements at High Temperatures Terrains

Hot environments can be either extremely hot, such as in sandy deserts, or both extremely hot and humid, as seen in tropical rainy wet forests and coastal areas. Fluid and electrolyte balance are key aspects during operations in a warm or hot climate. Several factors facilitate fluid loss in hot settings, i.e., environmental temperature, humidity, work intensity, fitness status, acclimatisation, and genetics[5,35,38].

Chronic exposure to hot climatic conditions causes severe heat stress. The physiological strain caused by heat stress is due to some factors, i.e., body size, physiology, acclimatisation, radiation, wind currents, intensity of work and relative humidity[39]. The possible effects of heat stress include decreased gastrointestinal functionality, reduced gastric emptying, hypohydration, heatstroke, flatulence, and vomiting[40]. Heat stress negatively affects gastrointestinal health due to the compromised permeability of intestinal epithelium (damage of tight junction proteins and release of cathepsin-B), thus allowing digestive enzymes to cross the barrier and produce inflammation[41]. To sustain and maintain a thermostatic system, the majority of the heat generated by this process must be eliminated from the body to maintain core body temperature. There are two processes through which possible heat can be dissipated into the environment; those are sensitive and insensible mechanisms. Here both sensible (radiative and convective) and insensible (evaporative, i.e., sweating) processes are used by the body to lose excess heat[42]. Heavy exertion at higher ambient temperatures lowers the skin-to-ambient-temperature gradient, reducing sensible heat loss significantly. The majority of heat loss by the body will occur as a result of an evaporative process in these settings (i.e., sweating)[6]. Physical activity in a hot environment and hypo-hydration leads to an increase in core body temperature, therefore impacting on reduction in physical performance and exercise strength[38]. In a random study with soldiers the calculated energy expenditure was 4,281 ± 170 and 3,937 ± 159 kcal/day for the cold and hot environments, respectively[8].

### 2.4 Energy Requirements at Plain Terrains

Topographic relief (i.e., variations in relative elevation), whether exceedingly homogeneous (e.g., a salt flat) or extremely diversified (e.g., a boulder field), or abrupt, are all characteristics of terrain (e.g., a cliff face). When compared to equivalent manoeuvres executed on a solid grassy plot, associated operations through harsh terrain may raise energy needs by about 25 %[43]. The energy requirements of military personnel differ with the type of environment and terrain in which they were deployed and climatic conditions (cold, hot, and high-altitude environments)[5,20,33]. Energy requirements at plain terrains are considerably low as compared with the other extreme condition-oriented terrains. Thairon[44], *et al.* 2005 concluded that personnel who participated in combat activities at mountain warfare showed an elevated total daily energy expenditure of approximately 29.8 MJ (7,122 kcal) than at the base (3,441-4,158 kcal/day) probably this lower energy expenditure is due to low environmental stress, fewer working hours, good sleep, and the availability of freshly cooked food. The type of terrain and vegetative cover is another predictor of total daily work output, as it affects the energy cost of mobility. For example, patrolling in a tropical jungle on steep terrain will require more energy than troops patrolling on level grassland at the same tempo and for the same duration[43]. The soldiers consumed average energy of 3,632 ± 92 kcal/day on the plane and those who deployed at high altitudes of 3,906 ± 42.3 kcal/day[45]. The energy expenditure is linearly increased with an increase in foot depth in snow-lined terrain[46].

### 2.5 Energy Requirements in Hot and Humid Environments

Numerous thermoregulation systems in the body produces metabolic heat (endogenous heat load) can be released into the environment. The effectiveness of such processes is determined by relative air humidity (RH %) and air velocity (m/s) in the environment[47]. The environmental factors such as temperature, humidity, and wind speed directly influence performance, endurance, and physical activity[48]. The ambient temperature of 20-30 °C with a relative humidity of 45-50 % is considered hot and dry or warm environments, and temperatures above 30-40°C and relative humidity of higher than 60 % are considered to be hot and wet or humid environments causing discomfort[49,50]. In a warm environment, the majority of body heat is dissipated through evaporation. The efficiency of this process is determined by the water vapor pressure in the air, which is influenced by temperature. Fatigue and exhaustion time are reduced with an increase in humidity. The core temperature increases to 39 °C at 80 % humidity, and the mean skin temperature is also increases[51]. The effect of humid conditions on energy metabolism, there were some studies and only a few pieces of evidence are available. From the earlier studies, it was observed that there was no significant effect of relative humidity on resting metabolic rate in both men and women with increases in relative humidity from 32 %-66 %[52]. Because of the additional load of evacuation and elevated sweat gland activity, energy expenditure in hot and humid conditions increases slightly and considerably. At very high temperatures, i.e., 40 °C i.e., the energy needs are increased by around 56-60 kcal/kg body weight[53]. The energy expenditure is reported to be 3937±159 kcal/day in humid jungle conditions and 4664±1399 kcal/day for hot desert conditions[7-9].

## 3. TRENDS IN ENERGY FOODS FOR EXTREME ENVIRONMENTAL CONDITIONS

### 3.1 Energy-Rich Bars and Foods

Energy bars are prepared with a combination of versatile ingredients such as cereals, pulses, nuts, etc. These ingredients are nutritionally rich and can be suitable for the formulation of specific energy foods. The high-calorie cereal bars are types of ready-to-eat foods and can be classified as functional foods because these foods contain high energy per low volume, useful for a special group of people such as athletes, astronauts, and the armed forces. Replacing energy with this low-volume energy food is quite feasible and convenient rather than whole bulky meals[54-57]. Granola bars are a type of nutrient-rich cereal bars formulated with diversified ingredients such as cereals (rice, wheat, maize, millet, barley, and oats), legumes, and nuts can be added with other ingredients such as dates, raisins, and sugar syrups. Syrups act as a binder helpful in holding the texture and also intensifying the nutritive and calorific value[56,57]. Cereal or granola bars are generally prepared in compressed forms, and sugar or date syrups are used as agglutinates. Cereal or granola bars were considered to be a potential energy food as they contained 200-300 kcal of energy per 100 g of composition[54-57]. The processing ingredients and feasibility inferred cereal bars are considered as potential convenient energy-rich snacks. Cereal energy bar preparation and some of the processing technologies used are depicted in Fig. 1**.**

Apart from the energy concern, cereal bars are also added with other nutrient-dense ingredients to improve the minerals, vitamins, and antioxidant profile of foods; these foods are generally marketed as nutri bars. Energy bars deliver instant energy within a lesser volume and influence energy balance, thereby improving the endurance and physical performance of individuals involved in high-strenuous activities such as soldiers and athletes[56-57]. Jabeen[57], S. *et al.* 2020 reported that the energy protein bar prepared from ingredients such as dates, apricots, protein isolate, and sugar improved stamina and running performance in young male athletes. In some instances, energy bars are incorporated with ergogenic aid substances to improve performance[10]**.** Ergogenic aids are substances that primarily enhance the performance of individuals with high strenuous activity by regulating energy metabolism, energy control, or energy production. Some of the ergogeinc aids are creatine, beta-alanine, ginseng, caffeine, isotonic drinks, carbohydrates, and proteins[10-19] Table 1. A food ration energy bar formulated with beta-alanine and L-arginine was used as a supplement to reduce muscle fatigue and

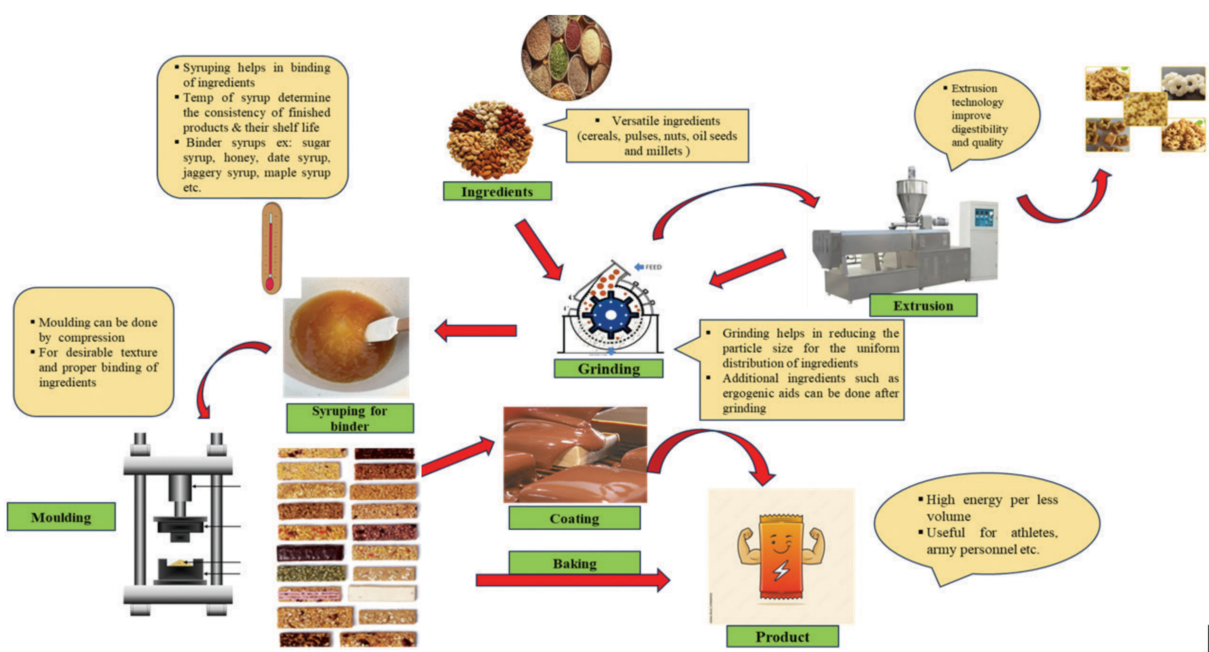


**Figure 1. Processing technologies of different types of energy bars.**

improve vasodilation along with nigella sativa leaves powder, which was found to significantly improve the anaerobic performance and reduced the inflammation of post-exercise military personnel[11]. A high protein and energy bar formulated with ingredients such as oats, inulin, whey protein, and soy protein isolate showed serum reduction in aspartate, deaminase, and lactate dehydrogenase (muscle damage markers), were significantly reduced and therefore reduction in post-exercise muscle damage was observed[58]. Supplementation of Branched Chain Amino Acids as an ergogenic aid was found to improve cognitive performance and relieve fatigue in military personnel[59]. Curcumin is added as an ergogenic aid to the high-calorie bar and significantly improves human performance in adults[12]. The ergogenic aids such as sodium bicarbonate and citrate have considerably improved the running performance of runners competing in 400 m to 40 km marathons[13]. L-carnitine, which is a quaternary amine utilised as an ergogenic aid, carnitine is the essential component in the beta-oxidation of fatty acids, where it helps in the transportation of beta-oxidation intermediate compounds Acetyl Co-A, across the membrane for further degradation. The L-carnitine and other supplemented antioxidants as ingredients in ergogenic foods improved the lipid profiles and exercise performance[14].

### 3.2 Energy-Rich Beverages

Energy-rich beverages come under the category of non-alcoholic beverages, which include both sports and energy drinks. Normally, sports drinks contain 6-8 % carbohydrates, whereas energy drinks contain higher amounts of carbohydrates (9-10 %). Sports drinks are generally non-caffeinated and contain added minerals (sodium, potassium, and magnesium) for the rehydration and maintenance of fluid balance in the body. In the case of energy drinks contain higher quantities of carbohydrates, caffeine, and other macro and micronutrients (vitamins and minerals). Green coffee, green tea, guarana, and ginseng are some of the most popular components (stimulants) of energy drinks[60]. Depending on the purpose, one or a blend of these substances in combination is useful in developing energy-rich beverages. Energy drinks deliver instant energy due to higher free sugars in the formula (Glucose, fructose, and sucrose), although sugar-free versions are also available. Small quantities of minerals and B vitamins help in coping with dehydration during or post exercise and recovery stages, and also aid in energy metabolism (B vitamins). The stimulants in energy drinks for improving endurance such as caffeine and Guarana (herb with high caffeine content) and others, whereas these ingredients are sometimes considered

**Table 1. Ergogenic aids and their mechanism of influencing energy metabolism and endurance**

| Ergogenic aid | Mechanism | Clinical trails | References |
|---|---|---|---|
| Caffeine | Caffeine and methylates (metabolites) can bind the adenosine receptors for adenosine present in the different tissues of the brain, heart, and smooth muscles | Administration of acute amounts of 6 mg/kg improved the performance and cardioprotective activity in cyclists | 74 |
| L-carnitine | Plays a crucial role in the shuttling of Acetyl Co-A and long-chain fatty into mitochondria for beta-oxidation | Oral Administration of 2g of L-carnitine to young athletes significantly improved oxygen uptake and endurance and reduced the lactate content | 75 |
| Arginine | Precursor for Nitric oxide (NO), which functions as a cell signalling molecule that helps in increasing vasodilation, blood flow and reducing muscle fatigue | A supplemented level of 6 gm/day for 14 days to 24 footballers found that the treated group had a lower level of lactate and reduced muscle fatigue | 19 |
| Ginseng | Ginseng is an herbal plant; typically, the root part extract is used predominantly as an ergogenic aid. Ginseng has several functions of improving performance endurance such as influencing cognitive performance, vasodilation, and increase in haemoglobin levels. | A 200 mg dose of Panax ginseng one hour before exercise improved the endurance and performance of heat-adapted male recreational runners. | 66 |
| Beta-alanine | A potential precursor for the carnosine (dipeptide) in muscle, which helps buffer the H+ ions produced during the rapid activity of muscles. | Oral administration of beta-alanine to 15 male athletes has found to significant increase in the muscle carnosine level was quantified noninvasively using proton MRS | 18 |
| Curcumin | A polyphenol compound has the potential to act as an antioxidant, reduce inflammatory activity and also oxidative stress caused by strenuous exercise. | The intervention of 500 mg/day of curcumin has to reduce the muscle damage in the experimental group (65 no) compared to the placebo. | 76 |

substances of concern because higher doses disturb the normal functioning of the body[61]. Physical endurance is important in athletics and military activities, which can impact performance. Endurance is influenced by the carbohydrate metabolism in the body and the quantity of carbohydrates in the diet[62]. The carbohydrates such as amylose, fructose, and galactose are oxidised at low rates, while amylopectin, sucrose, and maltodextrins are oxidised at higher rates (approximately 25 % - 50 %). Therefore, the type of individual sugar as a mixture in energy foods greatly influences the exogenous oxidation[63]. The consumption of energy drinks before exercise increases endurance and performance by maintaining blood glucose levels and carbohydrate oxidation rate, thereby reducing skeletal muscle loss and glycogen stores[60]. Energy drinks are caffeinated drinks with higher carbohydrate content, and their usage is more in military forces[61]. Caffeine is a psychoactive chemical substance involved in cognitive performance and attention, which helps relieve fatigue. It is absorbed in the gastrointestinal tract into the blood and metabolised in the liver into 3 major metabolic by-products, namely paraxanthine (1,7-Dimethyl-xanthine), Theophylline (1,3-Dimethyl-xanthine), and Theobromine (3,7-Dimethyl-xanthine). Caffeine is also a fat-soluble compound and can easily cross the blood-brain barrier and affect the central nervous system[15]. In the case of military applications, caffeinated energy drinks are often used as a countermeasure for adverse effects of sleep loss at night and fatigue during combat operations[16,64]. Caffeine also involves the maintenance of energy balance by increasing energy expenditure through stimulating the central nervous system. The activated Sympathetic Nervous System (SNS) shows the indirect effect on reduction in hunger and influence on energy expenditure[64]. Acheson et al 2004[16] experiments concluded that the thermogenic effect of caffeine elevated the resting energy expenditure by increasing fat oxidation. Marko[65], *et al*. studied a pre-workout energy drink, which contains 6,000 mg of carbohydrates, 2,000 mg L-carnitine, and 1,500 mg of amino acids showed positive results; administration of 40 min before the exercise significantly increased performance and reduced fatigue. Ginseng is also another common ingredient in high-energy drinks. It is a medicinal plant consisting of bioactive glucosides called ginsenosides. The consumption of energy drinks supplemented with ginseng and other natural herbs is common in the U.S. army, as they help improve physical performance and relieve fatigue[17]. Ginseng extract administration effectively raised the blood glucose levels, reducing the lactate, pyruvate, and free fatty acids in plasma and thereby improving performance and reducing fatigue[66].

### 3.3 Energy-Dense Semi-Solid Foods

Energy density is known as the amount of energy per prescribed volume of food portion. Energy-dense foods deliver high energy, thereby restricting the bulk food intake volumes. This can be beneficial in the case of military ratios, where a low volume of high-energy foods reduces the weight of food rations. Generally, liquid foods have less energy density than solid foods due to the water percentage in the composition. The textural characteristics of food can greatly influence satiety; a meta-analysis of data revealed that hunger was effectively reduced by solid and viscous foods when compared with liquid foods[67-69]. Semi-solid foods have more advantages as they are easy to carry and consume. Therefore, individuals can intake more quantities, thereby replenishing all essential nutrients quickly. Semi-solid foods play a vital role during combat operations and injury-oriented circumstances[70]. Nut pastes were excellent sources of energy, protein, and other phytochemical compounds. The nut and cheese spreads are integral parts of several rations of different Military rations. High-energy food paste used in the US Army is prepared by using different ingredients and has an energy content of around 253 kcal/50g[71]. Zhang[70], *et al.* developed a high-energy semi-solid energy food with enzymatically treated protein hydrolysates having an energy content of 3.33-3.38 kcal/g with essential amino acid profiles. High-energy, nutrient-rich therapeutic food paste developed with peanut paste and other legume flours as a major ingredient, having a shelf life of around 90 days[72]. High nutrient-rich energy spread prepared from groundnut butter, oil, skimmed milk powder, and powdered lacto serum, and administered to severely malnourished children and compared with WHO F-100 liquid food, it was observed that the HNDS (High Nutritious Dense Spread) contains the highest energy density 2280 KJ/100g, whereas WHO F-100 liquid food has 418 KJ/100g liquid foods[73].

## 4. CONCLUSION

Research evidence has shown the broad spectrum of the impact of different environments on body physiology and energy metabolism. Human energy needs differ with the type of environment in addition to several factors that influence the body's energy balance such as appetite, thermoregulation, the energy value of food, availability of foods, etc. In these circumstances, the concept of energy foods came up as a solution wherein the energy-dense ingredients composed of essential macro and micronutrients are used. These energy foods are available in the form of bars, drinks, and semi-solid slurries. Apart from the positive benefits of energy foods as major energy suppliers, it is necessary understand the impact of energy-dense foods on health, especially energy food supplemented with stimulants. Therefore, future research should consider factors such as the impact of energy foods on different age groups, intake levels and further biochemical interactions.

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