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Self-heating food packs for construction workers in remote areas: Influence of nutrition on mental wellbeing of construction workers

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Abstract

Construction workers are exposed to various environmental and occupational stressors, which can significantly impact their mental well-being. Proper nutrition plays a crucial role in maintaining cognitive function, reducing stress, and enhancing overall health. This research examines the This research examines the convenience of self-heating food packages for construction workers working in remote areas by delivering a wide range of nutrition therefore helping to improve mental health. Additionally it evaluates problems associated with poor nutrition in construction workers, the impact of certain food substances on mental health.

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Keywords

Construction worker, Mental wellbeing, Self-heating food packs

Research questions

This study aims to find answer to the following questions:

- What is the need to have self-heating food packages?
- Does having a warm food help maintain a healthy lifestyle for construction workers?
- What chemical element can be used as a self-heating food pack?
- How high can temperature rise?
- How long can it stay at high temperatures?

Introduction

The physically demanding nature of construction work, combined with exposure to environmental stressors such as extreme temperatures and extended working hours, requires adequate nutrition. Unfortunately, fizzy drinks and processed foods often replace balanced meals, leading to nutritional deficiencies and negative effects on mental health [1]. Additionally, factors like prolonged exposure to sunlight and improper food warming methods can further deteriorate workers' health [2]. This paper explores how nutritional choices affect mental well-being and suggests solutions to enhance food quality for construction workers.

To understand the necessity of this research study, it is worthwhile to first identify the problems related to nutrition and mental well-being.

Fizzy Drinks Replacing Proper Nutrition

Many construction workers are unknowingly replacing drinking water and in some cases the whole meal with energy drinks. Energy drinks are commonly consumed on construction sites due to their availability and temporary energizing effects. However, excessive consumption of these beverages leads to dehydration, increased sugar intake, and unstable blood sugar levels. These factors contribute to fatigue, irritability, and decreased concentration, ultimately affecting mental performance and workplace safety [3]. Furthermore, fizzy drinks lead to addictive consumption which can cause diabetes in long term.

Exposure to Sun and the Need for Unique Nutritional Attention

Prolonged exposure to the sun increases the risk of dehydration and electrolyte imbalance, which can lead to heat exhaustion and cognitive decline. Construction workers require diets rich in electrolytes, hydration-supporting foods, and antioxidants to combat oxidative stress caused by UV radiation. Foods rich in vitamin C, omega-3 fatty acids, and potassium can help maintain mental clarity and reduce fatigue [4, 5].

Impact of Microwave Cooking on Food Quality

Most of remote areas are at the absence of electricity. Even if the electricity is available, many construction workers rely on microwaves to reheat meals despite the fact that some studies suggest that microwave cooking can alter the nutritional composition of food, reducing essential vitamins and minerals [6]. This may lead to inadequate nutrient intake, negatively affecting cognitive function and emotional stability. Alternative food warming methods should be considered to maintain food integrity and enhance nutritional benefits.

Importance of Warm Food for a Healthy Lifestyle

Warm meals contribute to improved digestion, increased nutrient absorption, and enhanced mental comfort. For construction workers, consuming warm food helps maintain body temperature, provides comfort in extreme weather conditions, and boosts morale. However, warming food at remote construction sites poses challenges.

Importance of diversified meals to make harsh remote conditions more pleasant

The consumption of warm food has a profound impact on mental well-being, supported by both scientific and psychological principles. Thermoregulatory theory suggests that warmth activates the parasympathetic nervous system (PNS), reducing stress and promoting relaxation [7]. Warm meals also stimulate serotonin production, a neurotransmitter essential for mood regulation, by enhancing tryptophan absorption, which helps reduce anxiety and fosters emotional stability. Psychologically, warm food is associated with nurturing and social bonding, often evoking feelings of comfort and reducing loneliness [8]. Additionally, warm meals aid digestion, ensuring better nutrient absorption, which supports brain function and energy levels. Poor digestion from cold or improperly heated food can negatively affect the gut-brain axis, leading to mood disturbances. Furthermore, research in psychoneuroimmunology suggests that warm food consumption lowers cortisol levels, the body's primary stress hormone, thereby reducing mental fatigue and enhancing cognitive function [9, 10]. For construction workers who endure physically and mentally demanding conditions, access to warm meals can play a vital role in sustaining resilience, emotional well-being, and overall workplace productivity.

Therefore, to provide a range of diversified meals, the following table demonstrates the cooking temperature and time required to prepare 100 grams of following ingredients based on boiling/steaming methods:

Table 1 Cooking time and temperature for a range of food ingredients

Food	Temperature (°C)	Time (min)
Noodle	100	3-5
Egg	100	7-10
Rice	100	15-20
Pork	80-85	35-40
Beef (Mince)	75-80	10-20
Chicken	75-80	15-20
Potato	95-100	15-20

Solutions for Warming Food in Remote Construction Sites

To address the issue of warming food on construction sites, innovative solutions like self-boiling food packages can be employed. These packages use exothermic chemical reactions to generate heat, allowing workers to warm their meals without external heat sources.

Portability: Self-heating food packages bring ease to carry and cook proper meals in remote locations where electricity is not found and long working hours can cause safety issues.

Nutritional Retention: These packages preserve essential nutrients by avoiding microwave exposure and providing diversified food options to help activate parasympathetic nervous system (PNS).

Convenience: Apart from the above mentioned, self heating food packages require minimal effort, making it practical for busy workers.

However, despite all the benefits and for practicality assessment reasons, it is still crucial to study the cooking time and maximum period these food packages can remain above a certain temperature.

Exothermic Reactions in Self-Heating Food Packages

Self-heating food packages rely on exothermic reactions, where chemical substances react with water to release heat energy. Calcium oxide (CaO), commonly known as quicklime, undergoes a highly exothermic reaction when mixed with water, producing **calcium hydroxide ($Ca(OH)_2$)** and releasing significant heat:

$$CaO + H_2O \rightarrow Ca(OH)_2 + \text{heat}(-\Delta H \approx 64.8\ \mathrm{kJ/mol})$$

This reaction is highly exothermic, meaning a large amount of heat is released as the bonds in **calcium hydroxide** form, making it ideal for applications like self-heating food packs. The high temperature generated can efficiently heat food without requiring external energy sources.

$CaO + H_2O$ reaction is preferred for high heat output in self-heating food packs, as it can reach temperatures of **100°C** rapidly [11-14].

Aims and objectives

To address the consumption of warm food in remote construction sites and its positive impact on the wellbeing of remote workers, this study aims to evaluate the feasibility of using calcium oxide as the self-heating element in food packages. Additionally it is important to know what portion of CaO yields a longer and highest heating temperature as it will determine the type of food in the pack.

Methodology

After careful literature review to outline the current knowledge gap, an experimental design has been proposed and conducted aligned with the objectives of this research.

Experimental design

100 grams of water in ambient temperature (25.6 °C) has been mixed with various portions of CaO namely 10%, 20%, 30%, 40%, 50%, and 60%. After proper steering, the mix temperature has been recorded against time. Each experiment stops after 30 min of recording as this period is considered the convenient cooking time in remote sites.

Calcium Oxide was obtained from local suppliers located in Perth, Western Australia with 96% purity and molar mass of 56.08 gr in the form of white powder and density of 3.34 gr/cm^3 .

Data collection

A constant water amount of 100 grams were added to different amounts of Calcium Oxide at ambient 25.6°C with the results outlined in the table 2 (Appendix).

Analysis

Data has been recorded and graphed for 6 different mixes and portions of CaO. In the last mix, 6.5 grams of oil was added in an attempt to sustain the high temperature for a longer period of time as oil does not evaporate at above 90°C. From the graph, it can be observed that as the portion of CaO increases, therefore the maximum temperature increases. In combination with table 1, the minimum temperature required to cook a meal is 75°C. This temperature has been achieved only with CaO percentage of 50% and above.

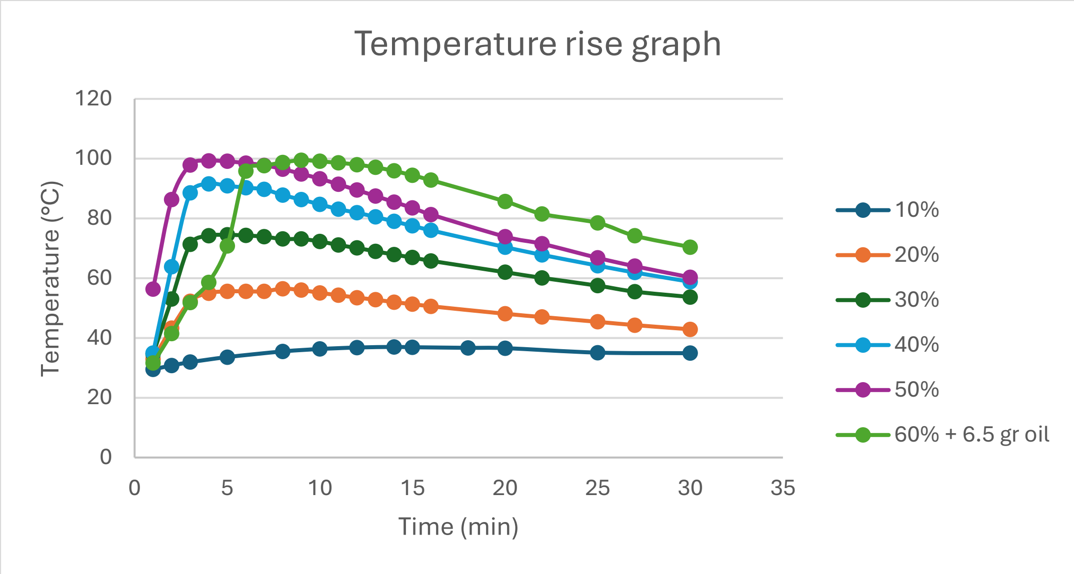

Figure 1 Temperature vs. time for various portions of CaO

The highest temperature recorded belongs to the mix with 60% CaO at 99.8°C. The addition of oil to this mix had slowed down the heating regime perhaps due to having oil acting as a barrier between CaO and water molecules. It has been observed that the temperature could barely rise beyond 99°C perhaps due to the fact that water molecules have all evaporate at this temperature and there is no more water to react.

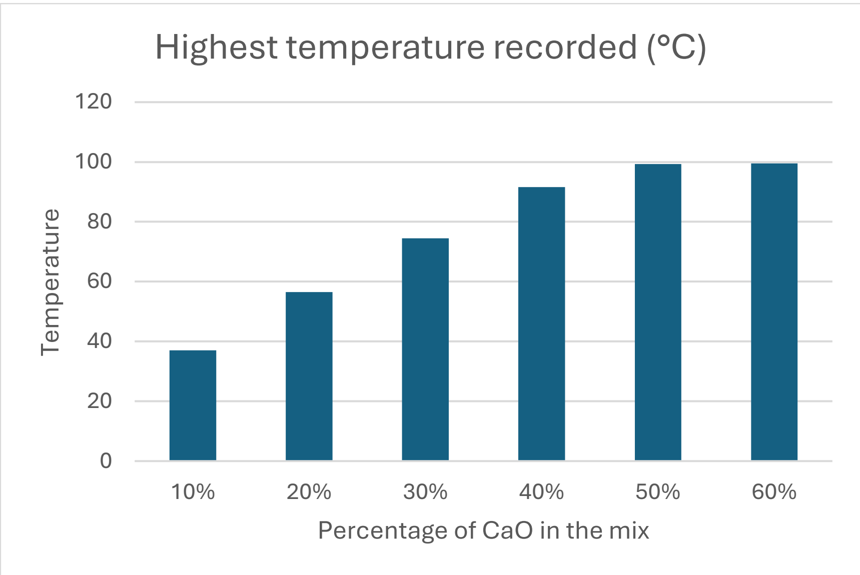

Figure 2 Highest temperature recorded based on the mix portion of CaO

Another key factor in having a feasible self-heating food pack is the duration of heating. Specific meals require certain period of heating at a temperature above a certain limit. Mixes with 40%,50%, and 60% of CaO could hold up temperature above 75°C for more than 10 minutes.

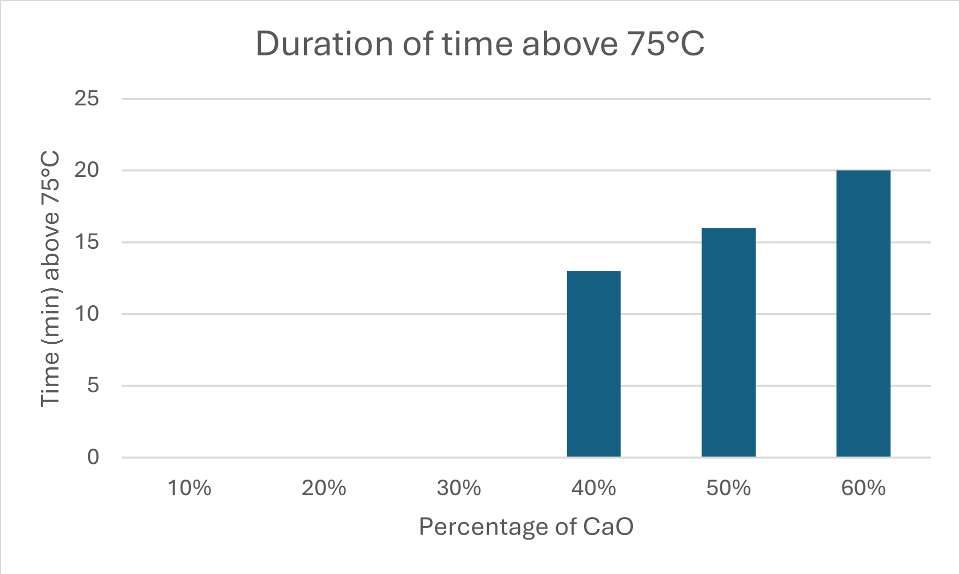

Figure 3 Duration of time each mix remained above 75°C

Recommendations and suggestions

Maintaining the high temperature for a longer period of time is indeed one of the challenges facing this study. In fact, the current chemical reaction could not break above 100°C.

Optimum packaging solution for the highest effective surface area exposed to the reaction between water and calcium oxide.

Conclusion

Proper nutrition is essential for the mental well-being of construction workers, especially in remote areas where food options are limited. Poor dietary choices, such as excessive consumption of fizzy drinks and processed foods, can lead to dehydration, fatigue, and cognitive decline. Warm meals play a crucial role in improving digestion, nutrient absorption, and mood regulation, but the challenge of heating food on-site has led to the exploration of self-heating food packs as a practical solution.

This study found that calcium oxide (CaO)-based self-heating packs can effectively generate the necessary heat for meal warming, with mixes containing 50% or more CaO reaching and sustaining temperatures above 75°C. However, maintaining high temperatures for longer durations remains a challenge. Further research is needed to optimize chemical compositions and packaging efficiency to enhance heat retention. Implementing these solutions can significantly improve the nutrition and mental well-being of construction workers, ultimately boosting their productivity and overall health.

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Appendix

Time (min)	CaO (gr)	Temperature
1	10	29.5
2	10	30.8
3	10	31.9
5	10	33.6
8	10	35.5
10	10	36.3
12	10	36.8
14	10	37
15	10	36.9
18	10	36.7
20	10	36.6
25	10	35.1
30	10	34.9

Time (min)	CaO (gr)	Temperature
1	20	32.9
2	20	43.3
3	20	52.3
4	20	55
5	20	55.6
6	20	55.6
7	20	55.6
8	20	56.5
9	20	56
10	20	55.1
11	20	54.3
12	20	53.5
13	20	52.8
14	20	52
15	20	51.3
16	20	50.6
20	20	48.1
22	20	47
25	20	45.4
27	20	44.3
30	20	42.9

Time (min)	CaO (gr)	Temperature	Time (min)	CaO (gr)	Temperature	Time (min)	CaO (gr)	Temperature
1	30	34.6	1	40	35	1	50	56.4
2	30	53	2	40	63.8	2	50	86.3
3	30	71.3	3	40	88.5	3	50	97.9
4	30	74.2	4	40	91.6	4	50	99.3
5	30	74.5	5	40	90.9	5	50	99.1
6	30	74.3	6	40	90.3	6	50	98.5
7	30	73.9	7	40	89.7	7	50	97.8
8	30	73.1	8	40	87.8	8	50	96.5
9	30	73.1	9	40	86.3	9	50	94.9
10	30	72.3	10	40	84.7	10	50	93.3
11	30	71.1	11	40	83.1	11	50	91.4
12	30	70.1	12	40	81.9	12	50	89.5
13	30	69	13	40	80.5	13	50	87.5
14	30	67.9	14	40	79	14	50	85.5
15	30	66.9	15	40	77.5	15	50	83.5
16	30	65.8	16	40	76	16	50	81.3
20	30	62	20	40	70.4	20	50	73.9
22	30	60.1	22	40	67.8	22	50	71.5
25	30	57.5	25	40	64.2	25	50	66.8
27	30	55.5	27	40	61.9	27	50	64
30	30	53.7	30	40	58.8	30	50	60.3

Time (min)	CaO (gr) +6.5 gr oil	Temperature
1	60	31.6
2	60	41.5
3	60	51.9
4	60	58.6
5	60	70.8
6	60	95.8
7	60	97.6
8	60	98.7
9	60	99.5
10	60	99.1
11	60	98.6
12	60	98
13	60	97.1
14	60	95.9
15	60	94.4
16	60	92.8
20	60	85.7
22	60	81.5
25	60	78.5
27	60	74.2
30	60	70.4