

ANTIOXIDANT VITAMINS IN BENIN BRONZE CASTERS AND THEIR ENVIRONMENTAL COHORTS: A PRELIMINARY NUTRITIONAL ASSESSMENT

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ABSTRACT

The process of bronze casting often leads to prolonged exposure to air pollutants, heavy metals, and potentially hazardous working conditions. Understanding the levels of antioxidant vitamins among the Benin bronze casters is vital because their exposure to environmental pollutants and potential occupational hazards may increase their oxidative stress levels. Therefore, this study aimed to evaluate the levels of antioxidant vitamins; A, C, and E in Benin bronze casters. A total of ninety (90) consenting participants were recruited for this study; They included foundry workers (bronze casters), randomly selected individuals around the foundry site (environmental), and healthy unexposed individuals (control). Vitamins A, C, and E levels were determined using spectrophotometry. Data obtained was analyzed using Statistical Package for Social Science (SPSS) software. The findings revealed that vitamin A levels were significantly lower in bronze casters (36.06 ± 9.15) when compared to environmental (58.57 ± 41.05) and control groups (62.61 ± 51.12) ($p < 0.05$). Vitamin C levels were significantly lower in bronze casters (0.53 ± 0.14) when compared to the environmental group (1.02 ± 0.53) and the control group (1.55 ± 0.37) ($p < 0.05$). Also, there was a significant reduction in vitamin C levels in the environmental group when compared to the control group ($p < 0.05$). Vitamin E levels were significantly lower in bronze casters (5.14 ± 1.92) and environmental (6.28 ± 3.32) groups when compared to the control group (11.49 ± 3.75) ($p < 0.05$). There was a strong positive correlation between vitamin A and vitamin C ($r = -0.589$, $p = 0.001$). Vitamin C showed a strong positive correlation with vitamin E levels ($r = 0.562$, $p = 0.001$). In conclusion, the lower vitamin levels suggest an increased vulnerability to oxidative stress, which occupational hazards and environmental factors, such as exposure to metal toxins and pollutants may exacerbate.

Keyword: Vitamins, Antioxidants, Bronze Casting, Environmental Pollutants

INTRODUCTION

The bronze casting tradition, originating in the 14th century under Oba Oguola's

patronage and hereditary control of the IneN'igunEronmwon, stands as a distinctive hallmark of the former kingdom of Benin,

now situated in Edo State Nwachukwu (2012). This enduring tradition, characterized by indigenous technology, has given rise to many cultural artifacts, including bronze heads, free-standing figures, plaques, and expressive masks, enriching the Benin population's cultural, religious, and socioeconomic fabric. The Oba plays a pivotal role in overseeing the cultural resources and their multifaceted significance Nwachukwu (2012).

Bronze casting, a fundamental aspect of preserving this tradition, involves intricate processes such as molding, core creation, melting and pouring, shakeout, and dressing/cleaning Hoshuyama et al. (2006). While well-suited for iron and steel, casting also extends to non-ferrous metals like bronze, brass, and aluminum Sütöová and Grzinčič, (2013). However, the occupational landscape, particularly in the bronze casting industry, exposes workers to various risks, including chemical exposure, physical hazards, and unfavorable ergonomic conditions, potentially leading to diverse health repercussions Fabius et al. (2013). Pro-oxidant/antioxidant imbalance and oxidative stress further compound health concerns, arising from harmful compounds inherent in the materials used in bronze foundries Erel (2004).

Antioxidants play a pivotal role in cellular protection against damage induced by oxidation processes. Free radicals, produced during oxidation, may lead to oxidative damage, but antioxidants counteract this by neutralizing free radicals and suppressing subsequent oxidation processes Hamid et al. (2010). This delicate balance is crucial for maintaining cellular health, and the complex system of antioxidants in plants and animals includes vitamins A, C, and E, as well as enzymes such as catalase and superoxide dismutase Hamid et al. (2010).

Vitamins, intricate compounds essential for a healthy metabolism, have unique organic origins and are crucial for growth, development, health, and reproduction

Orssaud et al. (2007). While vitamin A is not a major antioxidant, recent studies indicate its potential role in protecting against oxidative stress damage Malivindi et al. (2018). Vitamin C, a potent antioxidant, reduces DNA damage and inhibits the formation of reactive nitrogen species Padayatty et al. (2003). Vitamin E, comprising tocopherols and tocotrienols, scavenges lipid peroxyl radicals, mitigating potential damage to cellular membranes Jiang (2014).

Given the substantial impact of workplace risks on society's health and economic well-being, understanding occupational exposure, especially in the context of bronze casting, becomes imperative Rongen et al. (2013). The exposure to harmful substances in bronze casting, including metal fumes and toxic gases, poses significant health risks, potentially leading to oxidative stress-related conditions. This study aims to evaluate the levels of antioxidant vitamins (A, C, and E) among Benin bronze casters in Edo state, Nigeria, shedding light on their protective mechanisms against oxidative damage and identifying potential health risks associated with their occupation.

MATERIALS AND METHODS

Study Design

A cross-sectional design was used for the investigation, and participants were recruited into the study groups. The participants were divided into three groups: occupationally exposed (bronze casters), randomly chosen foundry workers (environmental participants), and unaffected, healthy controls.

Study Area

The research was conducted in Igun, Oguola, and St. Saviourareas in Benin City, Edo State, South-South Nigeria. Edo State is in Nigeria's South-South geopolitical zone, with a projected population of 3,233,366 residents, comprising 1,633,946 males and 1,599,420 females. The area is situated within the tropical rainforest, covering a total land area of 19,281.93 square kilometers, between

longitudes 50E and 6042" N and 7045" N and 7035" N of the Equator. The city of Benin is the largest in the state, with a population of 1,086,882 residents, and is composed of Egor, Oredo, and Ikpoba-Okha Local Government Areas.

Sample Size

The sample size for the study was determined based on the formula below (Jaykaranet al. 2011)

$$N = \frac{Z^2 \times P (1 - P)}{C^2}$$

Where:

N=Required sample size

Z=Confidence level interval at 95% (Standard value of 1.96)

P=Estimated prevalence

C = margin of error at 5% (Standard value of 0.05).

$$N = \frac{1.96 \times 1.96 \times 0.55 (1 - 0.55)}{0.05 \times 0.05}$$

$$N = \frac{3.816 \times 0.55 \times 0.95}{0.025}$$

N=80

A total of 90 participants will be used for this study to ensure validity and cover dropouts.

Study Participants

A total of eighty (90) subjects were recruited for this study. The subjects included fifty (50) bronze casters (occupationally exposed), twenty (20) randomly selected individuals around the site but not occupationally exposed serving as environmental, and twenty (20) unexposed healthy participants serving as control. Informed consent was obtained from each participant after proper notification and information on the nature of the research, risk involved, benefits as well as confidentiality, alongside the administration of a questionnaire.

Bronze Casters (Exposed Participants)

In Benin City, Edo State, Nigeria, fifty male bronze casters from Igun Street were involved in the daily tasks of molding, waxing, coating, firing, and casting. These tasks were all part of the process of creating bronze objects. The bronze casters with a minimum of five years of experience working with toxic substances gave their consent to participate in the study and were registered.

Environmental Group

Randomly selected sex-matched individuals not occupationally exposed from the area formed the environmental group. This included twenty (20) participants enlisted from around the bronze casting environment.

Control Group (Unexposed Participants)

Unexposed, healthy age- and sex-matched participants formed the unexposed or control group. These included twenty (20) participants enlisted from another Community far from the bronze casting environment.

Inclusion Criteria

- Workers who were occupationally exposed to bronze casting for five years and above at the time of sample collection were registered.
- Control subjects were healthy male individuals with no similar occupational exposure.

Exclusion Criteria

1. Participants with demographic or medical history of any form of disease, smoking, and alcohol consumption were excluded from the study.

Informed Consent

Informed consent was obtained from all participants before sample collection.

Data Collection

The participants of the study were provided with a structured questionnaire to gather

information on various aspects related to their work. The questionnaire included questions about their age, gender, alcohol and tobacco use, basic health information, duration of exposure to certain factors, awareness level among participants, use of personal protective equipment among bronze casters, method of disposal of waste, daily tasks performed, and injuries encountered.

Sample Collection and Preservation

Approximately five milliliters (5 mL) of venous blood were collected from the test participants (bronze casters), environmental subjects, and control subjects using standard phlebotomy techniques. The blood samples were allowed to clot and retract and were then centrifuged at 3000 revolutions per minute for 5 minutes. The plasma from each sample was collected and stored in Eppendorf tubes. The plasma samples were kept frozen (-4°C to 0°C) before analysis. Frozen samples were thawed, brought to room temperature, and analyzed.

Determination of Antioxidant Vitamins

Vitamin A was determined by the method of Rutkowski *et al.*, (2006), Vitamin C was determined using Rutkowski and Grzegorzczuk's approach (2007), and Vitamin E was determined according to the method of Rutkowski *et al.*, (2005).

Statistical Analysis

The Statistical Package for Social Scientists (SPSS) version 25.0 (IBM, USA) was used for statistical analysis, including descriptive statistics. For both the test and the control, data were presented as mean standard deviation. One-way analysis of variance (ANOVA) was used to compare the data at 95% confidence intervals, and a p-value of less than 0.05 (< 0.05) was regarded as significant.

Ethical Approval

The Ethical Clearance Committee approved the protocol for this study, Edo State Ministry of Health, with reference number HM.1208/7467.

RESULTS

Table 1: Social Demography and Anthropometric Indices of Bronze Casters and Controls.

Variable	Bronze casters (n=50)	E. Cohorts (n=20)	Unexposed control (n=20)
Age (Years)	47.12±15.75	42.58±1.73	46.29±15.74
Sex	Males	Males	Males
Mean Weight	44.31±22.27	79.92±1.67	67.20±125.06
Body mass index (Kg/m^2)	25.20±3.93	24.87±0.69	24.33± 4.27

Key: Sex, mean weight, and Body mass index are expressed in Mean±SEM

Table 2: Risk Awareness and Occupational Exposure Pattern of the Study Participants

Observation	Bronze Casters	Environmental cohorts	Control
Level of awareness of bronze-borne toxic substances	Basic (64%)	Basic (65.4%)	Basic (15%)
	No basic (46%)	No basic (34.6%)	No basic (75%)

Nature of exposure	Occupational and Environmental	Environmental	No occupational exposure
Duration of exposure to bronze casting material	≥ 5.0 years	≥ 5.0 years	Nil
% Using PPE while working (Apron, hand gloves, and face masks)	Users (38.5%) Nonusers (61.5%)	Not applicable	Not applicable
Willingness to participate in bronze casting toxicological study (By granting informed consent)	Willing (YES)=100% Not willing (No)=0%	Willing (YES)=98.2% Not willing (NO)=1.8%	Willing (YES)=90% Not willing (NO)=8%

Keys: PPE: personal protective equipment

Table 3: Levels of Antioxidant Vitamins in Bronze Casters, Environmental and Control Groups

Parameters	Bronze casters	Environmental	Control	F value	p-value
Vit A (µg/dl)	36.06±9.15 ^a	58.57±41.05 ^b	62.61±51.12 ^b	6.86	0.002
Vit. C (µg/dl)	0.53±0.14 ^a	1.02±0.53 ^b	1.55±0.37 ^c	75.11	0.001
Vit. E (µg/ml)	5.14±1.92 ^a	6.28±3.32 ^a	11.49±3.75 ^b	38.49	0.001

Values are shown in Mean±SD. Values with different superscripts are significantly different from each other, p<0.05 is considered significant.

Table 4: Correlation of Antioxidant Vitamins in Bronze Casters.

Parameters		Vitamin A (µg/dl)	Vitamin C (µg/dl)	Vitamin E (µg/ml)
Vitamin A (µg/dl)	r value	1	0.589	0.132
	p-value		0.001	0.213
Vitamin C (µg/dl)	r value	0.589	1	0.562
	p-value	0.001		0.001
Vitamin E (µg/ml)	r value	0.132	0.562	1
	p-value	0.213	0.001	

p<0.05 is considered significant.

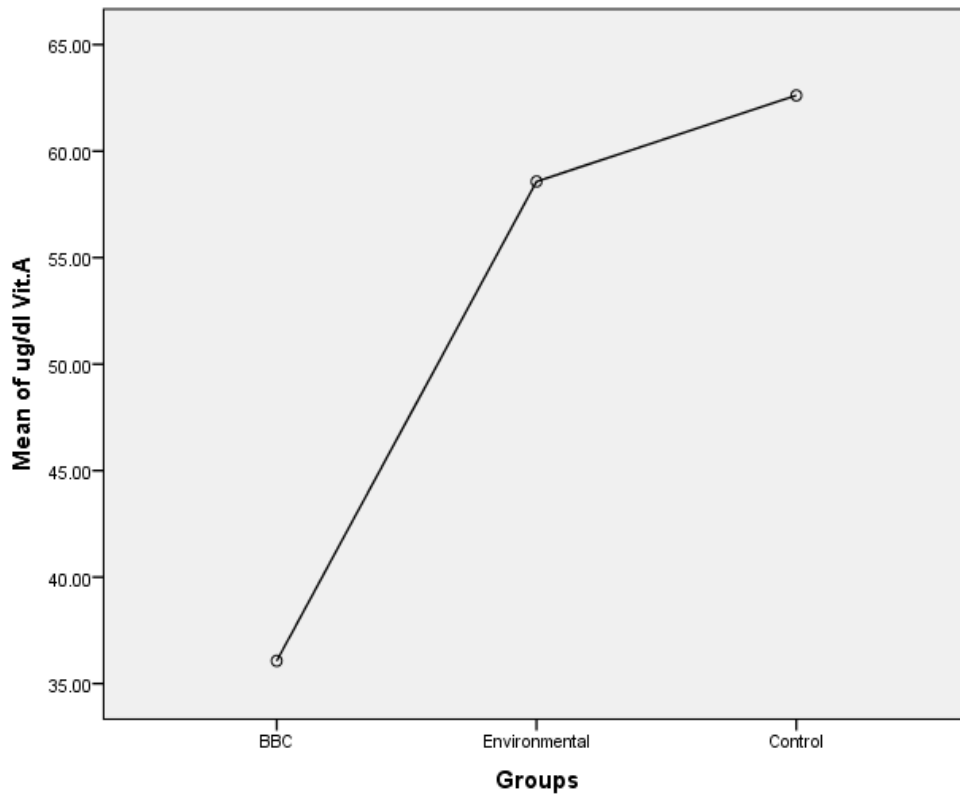


Figure 1: Chart showing Vitamin A levels across all studied groups. Benin bronze casters had the lowest vitamin A levels when compared to environmental and control groups ($p < 0.05$).

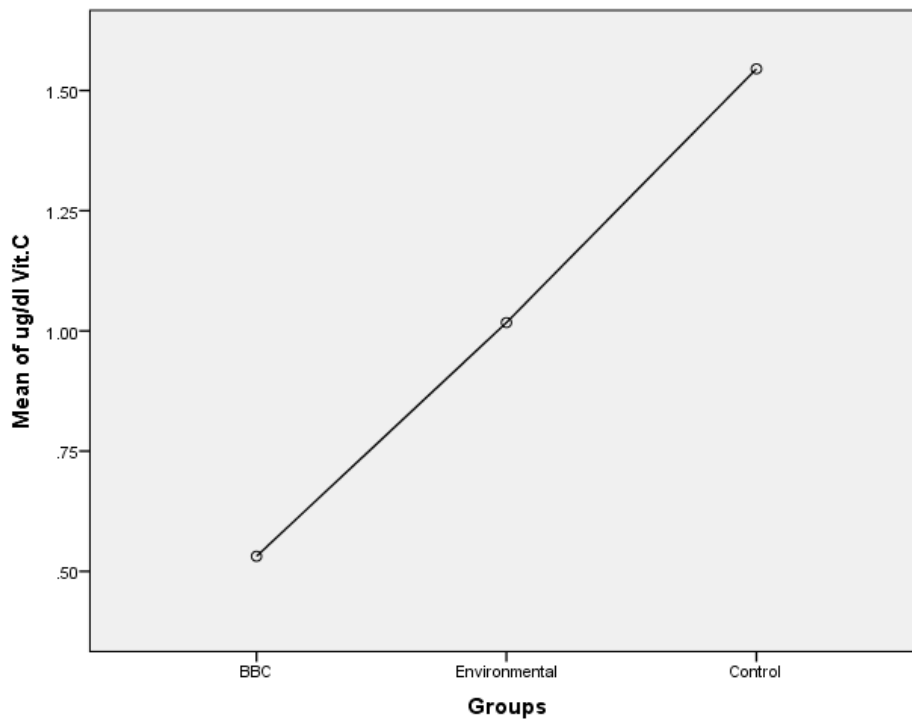


Figure 2: Chart showing Vitamin C levels across all studied groups. Benin bronze casters had the lowest vitamin C levels when compared to environmental and control groups ($p < 0.05$).

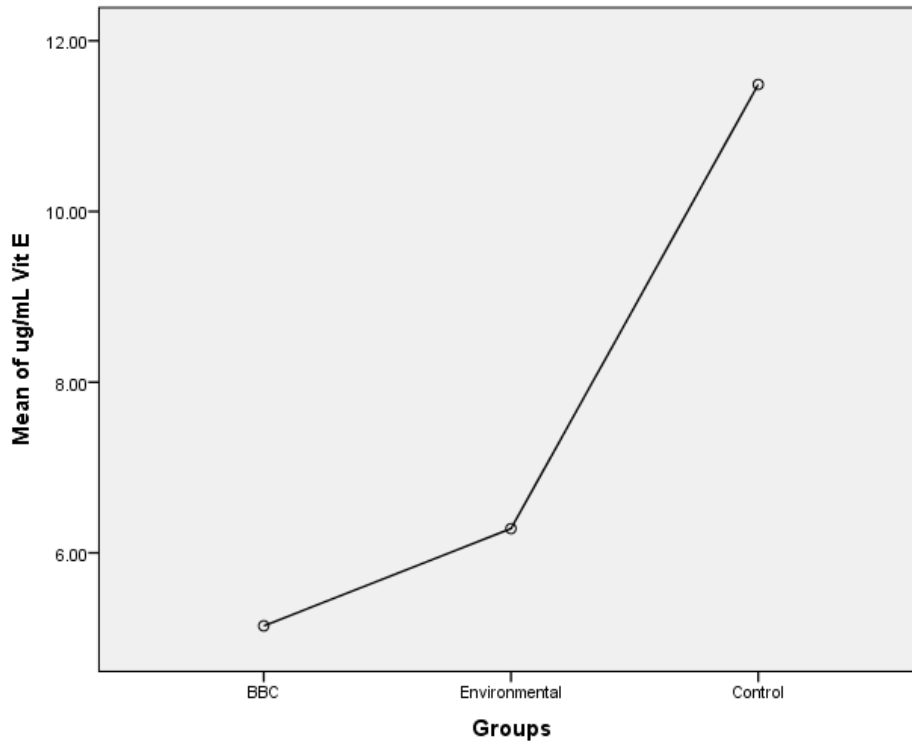


Figure 3: Chart showing Vitamin E levels across all studied groups. Benin bronze casters had the lowest vitamin E levels when compared to environmental and control groups ($p < 0.05$).

DISCUSSION

The art of bronze casting involves heating metals to extremely high temperatures, which can produce dangerous fumes and particles. People who work in this field are often exposed to air pollution, heavy metals, and other hazardous conditions. These environmental factors can have a significant impact on the health of bronze casters, making it essential to consider their nutritional status, with a particular focus on antioxidant vitamins Scholz et al. (2008).

Antioxidants like vitamins A, C, and E are critical for preventing oxidative stress in the body. When there is an imbalance between the body's ability to neutralize harmful free radicals and their production, oxidative stress can occur. This imbalance has been linked to many health problems, including chronic conditions like cancer, cardiovascular disease, and neurological disorders, and it can cause damage to cells. According to Valko et al.

(2006), antioxidants can protect against damage caused by metals through free radical attacks. However, research suggests that antioxidants may be less effective in the presence of high levels of free radicals (Lalhminghlu and Ganesh, 2018). Antioxidants are reducing agents that provide free radicals with electrons, which neutralize them and prevent oxidative damage to biological structures Herling et al. (2008).

It is crucial to understand the levels of antioxidant vitamins among the Benin bronze casters for various reasons. Firstly, their exposure to environmental pollutants and occupational hazards may increase their oxidative stress levels, making it imperative to have a robust antioxidant defense system. Secondly, inadequate intake of antioxidant-rich foods due to socioeconomic factors or cultural practices may further impact their nutritional status. Therefore, a comprehensive evaluation of the antioxidant vitamin levels in

this community can shed light on potential health risks and inform interventions to improve their well-being.

During our evaluation of the Benin bronze casters' community, we noted that only 38.5% of participants utilized Personal Protective Equipment (PPE). This discovery contrasts with a study by Efegoma (2022), which found a higher percentage of PPE users. This finding underscores the potential occupational health risks faced by the majority of individuals within this community who are not adequately protecting themselves from the harmful effects of their work environment.

Our evaluation also revealed that bronze casters had significantly lower levels of Vitamin A compared to other groups. This finding is consistent with a study by Azize (2018), which reported reduced levels of antioxidant vitamins after exposure to toxic metals. Vitamin A is essential in maintaining vision, skin health, and the immune system. Its deficiency can lead to night blindness, impaired immunity, and various health issues Wiseman et al. (2017).

When compared to the other groups, bronze casters had much lower levels of vitamin A. This result is consistent with a study by Azize (2018), which found that antioxidant vitamin levels were lower following exposure to hazardous metals. The immune system, eyesight, and skin all benefit from vitamin A. Night blindness, weakened immunity, and a variety of medical conditions can result from its absence Wiseman et al. (2017).

Compared to the other groups, bronze casters showed significantly lower levels of vitamin A. According to a study by Azize (2018), antioxidant vitamin levels were shown to be lower following exposure to hazardous metals. This result is consistent with their findings. The immune system, the vision, and the health of the skin all depend on vitamin A. According to Wiseman et al. (2017), its absence can result in night blindness, weakened immunity, and several other health

problems. The reduced levels of Vitamin A among bronze casters might be attributed to their occupational exposure to environmental toxins and a potential imbalance in their dietary intake.

This study also revealed significantly lower Vitamin C levels in bronze casters compared to both the environmental group and the control group. Vitamin C is a strong antioxidant that protects cells from oxidative stress and boosts the immune system. Its deficiency can lead to scurvy, a condition characterized by weakness, fatigue, and gum bleeding Barrita and Sanchez (2013). The lower levels of Vitamin C among bronze casters may be linked to increased oxidative stress due to occupational factors.

Another significant observation is the low Vitamin E levels in both the bronze casters and the environmental group when compared to the control group. Vitamin E is an antioxidant that protects cell membranes from oxidative damage. Its deficiency can lead to neurological problems and muscle weakness Rizvi et al. (2014). The findings suggest that both the bronze casters and those living in proximity to the bronze casting environment may be experiencing higher oxidative stress compared to the control group, which could be associated with their exposure to environmental toxins Franco et al. (2009).

Bronze casting is a labor-intensive process that involves the manipulation and melting of various metals, including copper, tin, and zinc. During this intricate craft, exposure to metal toxins and hazardous substances is virtually inevitable. Exposure to these metal toxins without adequate protection can have profound health implications. Metal toxins, especially heavy metals, are known to generate reactive oxygen species (ROS) within the body when they interact with cellular components. These ROS are highly reactive molecules that can cause oxidative stress Ercal et al. (2001).

The low utilization of PPE observed in our study may indirectly impact the antioxidant

vitamin status of the bronze casters. Inadequate protection against metal toxins could lead to higher levels of oxidative stress, which in turn may result in the increased utilization of antioxidant vitamins to counteract the effects of free radicals Valko et al. (2006). This heightened demand for antioxidants could potentially deplete the body's stores of Vitamins A, C, and E over time, potentially compromising the casters' overall health.

CONCLUSION

The evaluation of antioxidant vitamin levels (Vitamins A, C, and E) among the Benin bronze casters and the environmental group, in comparison to the control group, reveals significant deficiencies in these essential nutrients. Vitamin A, Vitamin C, and Vitamin E were consistently lower in the bronze casters and, to some extent, in the environmental group. These findings highlight the critical need for targeted interventions to address these nutritional deficiencies in these communities. The lower vitamin levels suggest an increased vulnerability to oxidative stress, which occupational hazards and environmental factors, such as exposure to metal toxins and pollutants may exacerbate.

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