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ANTI-OXIDANT ENRICHED NUTRIENT BAR SUPPLEMENTATION ON THE SERUM ANTIOXIDANT STATUS OF ATHLETES

SUPRIYA V[*], LALITHA RAMASWAMY[**]

*- *PhD Scholar, Bharathiyar University, Coimbatore (Part-time) Lecturer, Department of Clinical Nutrition, Sri Ramachandra University, Porur, Chennai.* Email: priiyas@gmail.com

**- *Associate Professor and Head, Department of Nutrition and Dietetics, PSG College of Arts and Science, Coimbatore, India*
Email: lalitharam58@gmail.com.

ABSTRACT

Background: Antioxidants supplementation may provide protection against negative health consequences of oxygen free radicals caused by aerobic and re-sustained exercise .**Objective**: is to find out the efficacy of anti- oxidant rich nutri bar supplementation on the anti-oxidant status of athletes. **Methods**: This study is a single- blind randomized prospective intervention design with control group. Sample size calculation suggested statistical power of 0.80, with significance ($p<0.001$) which gave rise to 20 athletes. The Experimental group (n=20) was supplemented with the formulated nutri bars emphasizing on carotene, vitamins A, C, E daily for a period of 3 months(two bars/day wt=50gms/bar) and control group with a placebo. Bio-chemical parameters namely Glutathione, glutathione peroxidase, superoxide dismutase, Vitamin C and serum Lipid peroxides were assessed at baseline and after 90 days. Subjects belonging to the experimental and control group were requested to preserve a three-day food documentation so as to determine the modifications in the nutrient intake. Statistical analysis was performed using SPSS (version 15). **Results:** The mean age was 18 ±3.2 yrs. 60 % of the selected athletes were males and 40% females. The athletes of the experimental group showed a significant increase in serum levels of Superoxide dismutase ($p=0.000$), Lipid peroxides ($p=0.005$) and gluathione ($p=0.000$) than control group. The mean levels of vitamin C and glutathione peroxidase decreased in the experimental group (NS) but the same was significant in the control group ($p=0.000$, $p=0.02$, $p=0.000$).

Conclusion: Antioxidant effects of the formulated food were useful in improving the endurance of athletes. Supplementation of antioxidant rich nutri bars has beneficial effects on reducing the oxidative stress of the athletes.

Key words: Nutri- bar, anti-oxidants, SOD, LPO, oxidative stress, GSH.

Introduction

Sports and nutrition are directly related to each other. Taking into consideration the fact that sportspersons need more energy to carry out their sporting activity effectively, it becomes of prime importance to take care of the nutrition for sports performance. Careful planning and implementation is required, when it comes to athlete's sports nutrition (Prochaska *et al*., 2005). As far as the nutritious diet of sportsperson is concerned, there are lot many things that deserve proper attention like selection of foods, timing of food intake, selection of nutrition supplement and many more.It is well recognized that athletic performance is enhanced by optimal nutrition (American College of Sports Medicine, American Dietetic Association, and Dietitians of Canada, 2000).

An active body consumes significantly more oxygen than a less active body, so it follows that regular physical activity may result in a persistent state of oxidative stress and, therefore, greater antioxidant needs. Exercise induces free radical formation in muscle, liver and oxidative damage and as lipid peroxidation. To overcome this oxidative stress, the body has to produce anti-oxidants to defend by itself. An anti-oxidant is a molecule that disposes, scavenges and suppresses the formation of reactive oxygen species (ROS) and lipid peroxidation. Among the well known biological anti-oxidants- glutathione (GSH), glutathione per- oxidase (GSH-Px) and superoxide dismutase (SOD) have a significant role as a suppressor on scavenging free radicals (Hengstermann, 2008 and Sikka, 1996). Diets high in vegetables and fruits, which are good sources of antioxidants, have been found to be healthy; however, researches have not been conclusive in antioxidant supplementation to be beneficial for athletic population.

Atalay et al, 2006 evaluated the importance of dietary anti-oxidants and exercise. Physical exercise induces oxidative stress and tissue damage; antioxidant nutrients may be helpful in that regard. The following three recommendations are made: 1) it is important to determine the individual antioxidant need of each athlete performing a specific sport; 2) multi-nutrient preparations, as opposed to mega doses of any single form of nutrient, seem to be a more prudent path to choose; and 3) for outcomes of antioxidant supplementation, performance should not be the only criteria. Overall well being of the athlete, faster recovery, and minimization of injury time could all be affected by antioxidant therapy.

The nutrient intake of the athletes in terms of calories, protein, carbohydrates, fats and vitamin A when compared against RDA of athletes were found to be significantly lower than the recommendations. More than 50 percent of athletes in certain sports consume vitamin-mineral supplements on a regular basis. 100 mg of anti- oxidants/ day have been

studied to minimize the stress involved in different sports. Many athletes use dietary supplements as part of their regular training or competition routine, including about 85% of elite track and field athletes. Supplements commonly used include vitamins, minerals, protein, creatine, and various "ergogenic" compounds. Sports drinks, energy bars, and protein-carbohydrate shakes may all be useful and convenient at specific times (Maughan, *et al.,* 2009)

The novel way of incorporating the anti-oxidants into their diet is by involving indigenous, underutilized ingredients which are abundantly rich in anti- oxidants. The requirements vary at different sport level and they can provide wonders in athletes' performance. The ingredients such as rolled oats, pumpkin seeds, dehydrated carrots, flaxseeds, peanuts, almonds, honey and dates syrup were selected based on their anti- oxidant properties.

Nigam et al (2008) oats studied a compound called avenanthramides or phenolic compounds present in oats at approximately 300 parts per million (ppm) and have been reported to exhibit anti-oxidant activity in various cell-types.The major carotenoid in pumpkin (> 80%) is beta-carotene, thus possessing anti- oxidant activity. (Potter and Hotchkiss, 2002). **Peanuts** have ample amounts of protein and fiber. Peanuts are one of the great energy foods, no matter an athlete or a desk-jockey trying to maintain focus through a long work day. They are high in protein, dietary fiber, and antioxidants (King *et al.,* 2008). Almond rank top among the highest-protein nuts, high in manganese and vitamin E as well, are vital defenders against oxidative sms damage (Clark , 2012) According to Iyer and Brown (2011) Avemar, a product of industrial fermentation of wheat germ with a standardized content of benzoquinone and plant flavonoids, has been tested as an anti-cancer and immune-modulatory dietary supplement. Proposed mechanisms include anti-oxidant and anti-inflammatory actions. Date fruit which usually supplies only calories, can thus be turned into a product such as dates bar having significant amounts of other valuable nutrients. (Al hooti et al., 1997)

These ingredients were selected since they are underutilized, easily available, economical and ready- made foods and easily consumable.

Keeping the above mentioned importance of antioxidants, the purpose of the present study is to test an antioxidant rich nutri bar prepared from underutilized ingredients, which would be of great help in order to ensure the athletic performance. Nutri bars are mostly preferred by athletes as they are ready to eat foods and could be easily picked up by them before, during and after the event. Therefore, the study has been designed with the following objectives:

- To formulate and supplement an antioxidant rich nutri bar to the athletes and
- To find out the impact on the antioxidant status such as superoxide dismutase (SOD), lipid peroxides (LPO), Vitamin C, Gluathione (GSH) and Glutathione Peroxidase (GSH-px) of the athletes.

Materials and methods

Study design and participants

This study is a single- blind randomized prospective intervention design with control al

group. Sample size calculation suggested statistical power of 0.80, with significance ($p<0.001$) which gave rise to 20 athletes and in order to take care of probable attrition, 40 subjects were recruited for the study.

The study was conducted between March 2014 and May 2014. Inclusion criteria were athletic men and women aged between 18 and 22 years, who have a minimum of 3 years of experience with track and field events and who are willing to participate and who filled in the printed informed approval. These athletes were recruited from sport academies in Chennai, India. Exclusion criteria included having any chronic diseases, who were < 18 and > 22 years of age and those who are on other nutrient supplements were excluded from the study. Voluntary participation was emphasized and a printed informed approval was acquired from them to be integrated in the study. The study was officially declared by the institutional Ethical board of Human Research Ethics Committee of PSG College of Arts and Science Coimbatore, India for Nutrition departments. (REF: REC/NCND/K14 003).

3-day record

Subjects belonging to the experimental and control group were requested to preserve a three-day food documentation so as to determine the modifications in the nutrient intake. It was collected at baseline, and at twelve weeks of the supplementation. Nutritional ingestion through 3 day record was evaluated via DIETCAL software.

Formulation

Initially a pilot study was conducted to arrive at the acceptable formulation. The Acceptability test was conducted for the prepared bars in three variants by evaluating the different sensory attributes like appearance colour, flavour, texture, taste and overall acceptability by ten semi- trained members. **Five point hedonic scales** were used to evaluate the nutri-bars.

The nutri- bars were made up into 50 gm (each bar weight) and two bars were provided for the athletes as per the anti-oxidant content of the bars. 110 mg of anti-oxidants as per standardization is incorporated into 100 gm of the nutri- bars. This was divided into two bars weighing 50 gm each.

Estimation of nutrient analysis

The prepared bars using antioxidant rich ingredients were subjected to nutrient analysis. The nutrients namely total carotene, vitamin A, C, E, energy, proteins, carbohydrates and fats were analysed.

NUTRIENT ANALYSIS OF THE BAR

Nutrients	Composition/100gm
Energy	524.5 kcals
Protein	24.48gms
Carbohydrates	39.14gms
Fats	30.87gms
Vitamin A	15.6 mcg
Vitamin E	20.2 mg
Vitamin C	50.6 mg
TOTAL ANTI-OXIDANTS	115.8 mg

Microbial Analysis

Microbial analysis was carried out by total plate count (TPC). The total microbial load (TPC) of nutri bars were determined in nutrient agar media on day Zero and then again after 7 days and 14 days.

Supplementation

Those subjects in the study group who were assessed were supplemented with the formulated nutri bars daily for a period of 3 months (12 weeks). Two bars per day were given to the subjects during the day (morning and evening sessions) and it was monitored personally by the investigator that athletes consumed the nutri-bar supplement. Those subjects in the control group were provided with appropriate nutritional counseling about the importance of anti- oxidant rich foods and a placebo was given. The nutritional intake and the blood reports were collected at 12 weeks of the supplementation from both the study and control groups to check for any improvement in the anti- oxidant status.

Blood analysis

The bio-chemical parameters, namely Glutathione peroxidase, Glutathione concentration, superoxide dismutase, Vitamin C concentrations lipid peroxides in plasma serum, were estimated before and after supplementation of anti- oxidant rich nutri- bars to find out the impact on these blood parameters.

Statistical Analysis

Paired 't' tests were used to assess the difference between the groups (treatment and control groups). A significant *P* value ($P \leq 0.05$) for the interaction term was considered a demonstration of a treatment effect. Significance was found between the placebo and the treatment group at either time interval. Statistical analysis were performed using SPSS (version 15).

RESULTS AND DISCUSSION

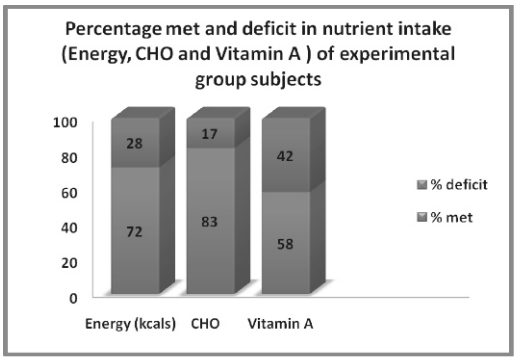
The mean age of participants were 18 ±3.2 yrs with a range of 18 to 21 yrs. 60 % of the selected athletes were males and 40% females. According to a report by a Statistical Review of Australia (2012) on sports and physical recreation, in organized sport, the participation rate was similar for men and women in organized sport.

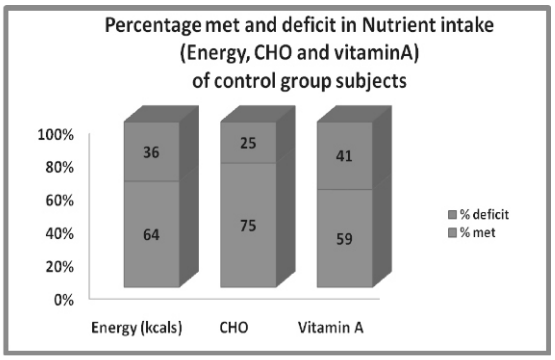
TABLE- I Dietary intake of the athletes

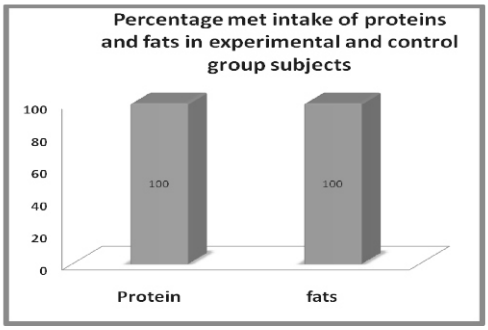
Nutritional parameters	Exp grp	Control gp	t test (p value)
Energy (kcals)	2171.20±267.42	1915.00 ±240.83	20.14(0.000*)
Protein (gm)	79.05±17.74	61.40 ± 8.04	20.51(0.000*)
Carbohydrates (gm)	323.45±32.40	291.65±25.51	14.26(0.000*)
Fats (gm)	41.50±2.50	41.40±3.48	13.51 (0.000*)
Vitamin A (mcg)	521.75±87.51	534.75± 85.35	19.13(0.000*)

*-Significant at (p<0.001)

FIG 1- DIETARY INTAKE OF ATHLETES BELONGING TO EXPERIMENTAL AND CONTROL GROUPS







Young athletes in their quest for victory by recognizing that children and adolescents generally need more calories and protein per kilogram of body weight than adults. Nutrient needs further elevate and reach their peak during adolescence.

The results reveal that nutrition counseling is important for athletes to consume the nutrients as per the RDA as well as pertaining to their specific sport activity. Shriver et al (2013) has also echoed that nutrition counseling is essential for the volleyball players to increase carbohydrates while decreasing the fat content of their diets. Effective nutrition intervention is needed to improve dietary intakes and eating habits of female college athletes.

TABLE II Mean Organoleptic Scores of Nutri- Bars

ATTRIBUTES	MAX SCORE	A1	A2	A3
Appearance	30	19	20	21
Colour	30	19	19	22
Flavour	30	19	20	24
Texture	30	20	20	23
Taste	30	20	22	24
Overall acceptability	30	20	19	24
Total score	180	117	120	138

TABLE III Microbial Count of the Variant A3

Duration(days)	Microbial Colonies(CFU/ml)
Soon after Preparation	0.04×10^3
7 days (At room temp)	0.08×10^3
14 days(At room temp)	0.14×10^3

Scientific literature clearly documents athletes' need to consume adequate calories, protein, carbohydrates, as well as appropriate timing to fuel muscles during training and competition for maximal performance (American Dietetic Association, 2009; Zinn et al., 2010).

The three variants (A1, A2, and A3) were made different with varying proportions of rolled oats, dehydrated carrots, groundnuts and almonds to achieve a highly acceptable product. It was thus observed from table III that variant A3 had scored highest in attributes of appearance, colour, flavor, texture, taste and overall acceptability. The variant A3 was accepted well with a total score of 24. **Overall, the sample was acceptable and tasted good.**

FINDING: The objective 1 was achieved with regard to the supplement developed so as to suit the needs of the athletic population.

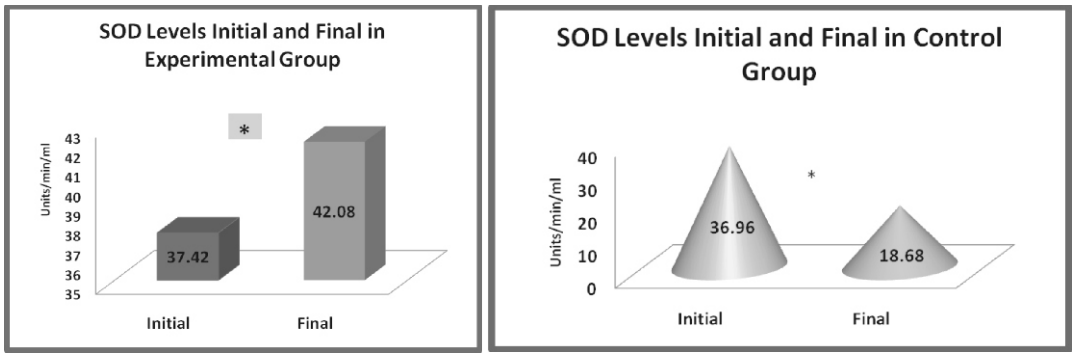
Microbial analysis was performed for the developed product A3. It is presented in tableIII. It is clear from the table that there was no microbial growth soon after preparation, at 7 days and 14 days of storage period. There was

TABLE IV Mean Levels of SOD, LPO and Vitamin C Levels Of Experimental and Control Groups.

Parameters	Experimental MEAN ± SD	Control MEAN ± SD	't' test (P value)
SOD(Units/min/ml) Initial	37.42±12.01	36.96± 10.79	0.12(0.90 ^{NS})
Final	42.08±13.16	18.68 ± 21.15	4.20(0.000*)
Change	-4.66	18.28	
't' test (P value)	3.89(0.001*)	3.88(0.001*)	
LPO (µg/ml) Initial	2.89±0.82	3.44 ± 1.59	1.36(0.18 ^{NS})
Final	3.80±1.37	3.85 ± 1.87	0.08(0.93 ^{NS})
Change	-0.91	-0.41	
't' test (P value)	3.18(0.005**)	2.53(0.02***)	
Vitamin C (mg/dl) Initial	4.14±1.38	5.43 ± 1.97	2.38(0.02***)
Final	3.62±1.28	3.32 ± 0.94	0.841(0.40 ^{NS})
Change	0.52	2.11	
't' test (P value)	1.21(0.23 ^{NS})	5.02(0.000*)	

***- Significant at p<0.001, **- Significant at p<0.01, ***- Significant at p<0.05 ,NS- Not Significant**

FIG- 2 SOD Levels Initial and Final in Experimental and Control Group



*- Significant at p<0.001

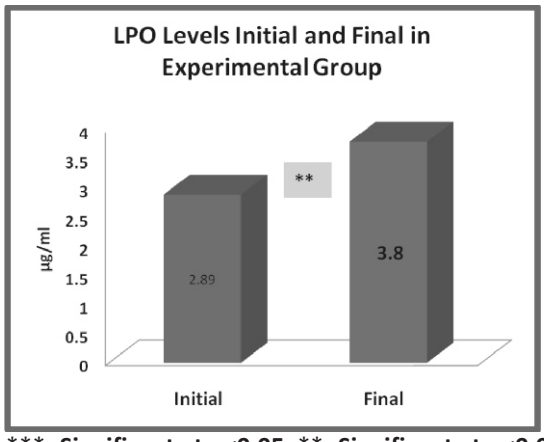
negligible growth and therefore safe for consumption. Minimum bacterial count (L.Plantarum) count was found soon after preparation and very negligible increase in microbial growth was seen over different storage periods. At day 14, the microbial count had increased from 0.04 x 10^3 to 0.14x10^3. Since the developed product was nutri bar, their keeping quality was good. Hence ideally the bars could be consumed till 14 days of preparation kept at room temperature and in cold storage up to one month after preparation.

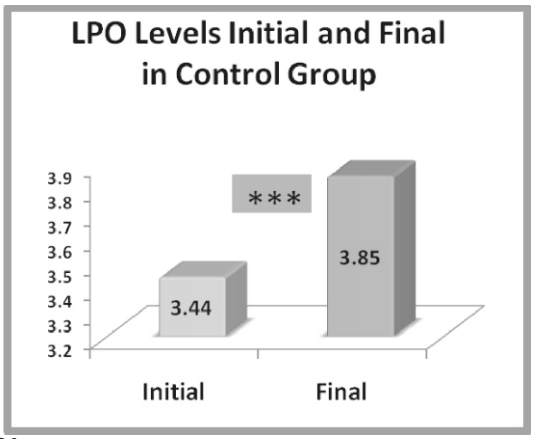
The mean initial levels of SOD and LPO between experimental and control groups showed no significant difference {SOD t value-0.12(0.90 ^{NS}) LPO t value-1.36(0.18 ^{NS})}indicating no difference in the levels at baseline, whereas mean initial levels of vitamin C{t value-**2.38(0.02***)}** alone showed a difference (p<0.05) between the groups. At the end of 90 days of supplementation, the mean final levels of SOD alone showed a significant difference (p<0.001) between the groups. However, LPO and vitamin C levels between experimental and control groups showed no significant difference {LPO t value-**0.08(0.93 ^{NS}))}** and vitamin C {t value-**0.841(0.40^{NS}).**

In experimental group, the mean initial levels of SOD was found to be 37.424±12.01 Units/min/ml which rose significantly to 42.08±13.16 Units/min/ml after supplementing for a period of 90 days (p<0.001). Whereas in control group, the mean initial level was 36.96± 10.79 Units/min/ml decreased to18.68 ± 21.15 Units/min/ml at the end of 90 days (p<0.001). Since the athletes of the control group were not supplemented with anti-oxidants, the SOD values were decreased (p<0.001).The present study results are on par with the study conducted by Skarpanska-Stejnborn A, (2011) who investigated the effect of plant superoxide dismutase extract (GliSODin) supplementation on the balance of oxidants and antioxidants in the serum and erythrocytes of competitive rowers. The supplementation group (n = 10) received 2 capsules (500 mg) of GliSODin extract once daily for 6 weeks than the placebo group (n=9). After supplementation, SOD activity was significantly higher (p = .0037) in the supplemented group than the placebo group.

In experimental group, the mean initial levels of LPO which was 2.89 ±0.82 µg/ml increased to 3.80±1.37 µg/ml post intervention (p<0.01) for a period of 90 days as seen in figure 3.In the

FIG-3 LPO levels initial and final in experimental and control group





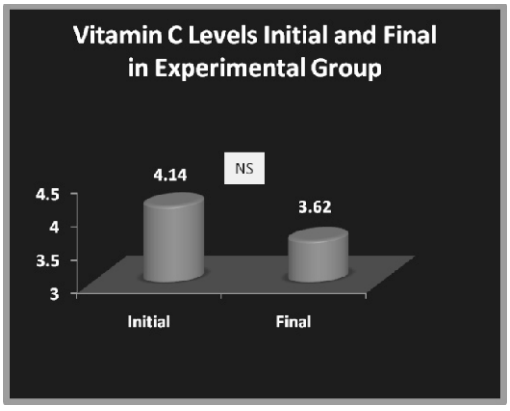
***- **Significant at p<0.05**, **- **Significant at p<0.01**

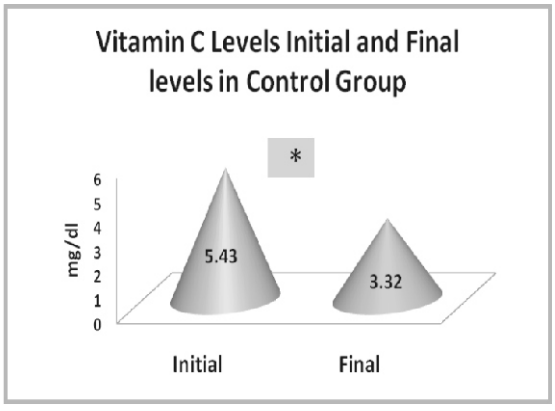
control group, there was a significant increase from 3.44 ± 1.59 µg/ml to 3.85 ± 1.87 µg/ml (p<0.05). This significant increase could be due to the effect that the athletes of the control group were also well trained**.**

It is inferred that vitamin C levels of experimental group subjects decreased after 90 days of supplementation from 4.14 mg/dl to 3.62 mg/dl in the experimental group with statistically not- significant results

In the control group the mean final level showed a significant decrease from 5.14 mg/dl to 3.32 mg/dl (p<0.001) Similar observation by Schröder et al. (2000) **on the three compound antioxidant supplement including** 600mg α-tocopherol, 1000mg vitamin C and 32mg β-carotene, or a placebo over 32 days during and plasma α-tocopherol, vitamin C, β-carotene, retinol, lipoperoxides (LPO), and the total antioxidant status (TAS) were analysed before and after treatment. The results suggest that supplementation with α-tocopherol, β-

FIG- 4 Vitamin C levels initial and final in experimental and control group





***- Significant at p<0.001, NS- Not Significant**

TABLE V Level of Significance of Glutathione (GSH) and GSH px (Glutathione peroxidase- GSH px) between experimental and control groups

Parameters	Experimental MEAN ± SD	Control MEAN ± SD	't' test (P value)
GSH (µg/ml)Initial	209.76 ± 8.17	214.12 ± 7.4	1.76 (0.08 NS)
Final	244.58±33.36	188.88±38.3	4.90 (0.00*)
Change	-34.82	25.24	
't' test (P value)	4.42(0.000*)	2.80(0.011**)	
GSH Px (µg/ml) Initial	17.15± 15.25	15.30±12.13	0.42(0.67 NS)
Final	18.65 ± 8.9	9.20±6.32	3.84(0.000*)
Change	-1.5	6.1	
't' test (P value)	0.45(0.65 NS)	2.48(0.02***)	

***- Significant at p<0.001, **- Significant at p<0.01, ***- Significant at p<0.05,NS- Not Significant**

carotene and ascorbic acid might partially account for the hormonal and enzymatic stress marker profile of professional basketball players.

The mean initial glutathione levels were found to be 209.76 ± 8.17µg/ml and 214.120 ± 7.42 µg/ml in the experimental and control groups respectively and statistically not significant (NS), whereas the final levels showed a significant difference (p<0.001) between both the groups as evident from the table. Similarly, the mean initial glutathione peroxidase (GSH-px) levels were found to be **17.15± 15.25** µg/ml and **15.30±12.13** µg/ml in experimental and control groups respectively which was statistically not significant (NS), but at the end of 90 days period, the mean final level of glutathione peroxidase (GSH-px) levels was **18.65 ± 8.9** µg/ml in the experimental group and **9.20±6.32** µg/ml in the control group and the difference was statistically significant at p<0.001.

Studies have shown that glutathione and reduced glutathione levels are enhanced with anti-oxidant supplementation. Kara, (2010) proved the effect of zinc supplementation on free-radical formation and antioxidant system in individuals who are actively engaged in wrestling as a sport. Measurements performed at the end of the study (zinc-supplemented groups) showed the highest GSH level, GPx, and zinc level ($p < 0.01$) and were not different in the groups without supplementation (control group).

FINDING: The formulated supplement was found to have an impact in the biochemical parameters assessed. Hence the objective 2 was also fulfilled.

SUMMARY AND CONCLUSION

The use of conventional anti-oxidant supplements have shown some attenuation of oxidative stress indications but has not reduced these indicators levels to baseline value. Yet they have shown to be partially successful in alleviating the condition. Moreover, the concepts of antioxidants in aiding their performance levels are unaware by the athletes. The novel way of incorporating the anti-oxidants into their diet is by involving indigenous, underutilized ingredients which are abundantly rich in anti- oxidants.

Keeping the above mentioned importance of antioxidants, the purpose of the present study was to test an antioxidant rich nutri bar prepared from underutilized ingredients, which would be of great help in order to ensure the athletic performance. Nutri bars were mostly preferred by athletes as they are ready to eat foods and could be easily picked up by them before, during and after the event.

The subjects were selected by purposive sampling techniques. Ethical clearance was obtained from the Human Research Ethics Committee, PSG College of Arts and Science, Coimbatore. An informed consent was obtained from the subjects. The subjects were selected from Sports Academies in Chennai. 40 subjects were selected for the supplementation phase. In both, experimental and control groups, there were equal number of samples, each with 10 male and 10 female athletes. Subjects belonging to the experimental and control groups were asked to maintain a three-day food record in order to find out the changes in the nutrient intake and was collected at baseline of data collection. The selected ingredients namely carotene, vitamins A, C, E, proximate principles such as energy, proteins, carbohydrates and fats were analyzed. Shelf life studies by total plate count were also conducted.

Single blind study was employed for supplementation. Those subjects in the study group who were assessed were supplemented with the formulated nutri bars daily for a period of 3 months (12 weeks).The nutri- bars were made up into 50 gm (each bar weight) and two bars were provided for the athletes as per the anti-oxidant content of the bars. 110 mg of anti-oxidants as per standardization was incorporated into 100 gm of the nutri- bars, while those in the control group were given a placebo. The bio-chemical parameters, namely Glutathione peroxidase, Glutathione concentration, Superoxide dismutase, Vitamin C concentrations, lipid profile and LPO in plasma serum, were estimated on the 0^{th} day and 90^{th} day on the sub sample of 40 subjects of both groups by standardized procedures.

MAIN FINDINGS OF THE STUDY

- The energy intake expressed in calories was found to be 2171.20±267.422 kcals in experimental group and 1915.00 ±240.837 kcals in control group against the recommendations of 3000 kcals and was statistically significant ($p<0.001$). Proteins, carbohydrates, fats and vitamin A (mcg) were all found to be significantly different from the RDA ($p<0.001$).
- The significant improvement in the SOD levels($p<0.001$) of the experimental group (initial 37.42 ± 12.01 Units/min/ml, final-42.08±13.16 Units/min/ml) is due to the daily consumption of anti-oxidant rich nutri bars formulated by the investigator and effective nutritional counseling provided. The mean initial level of SOD was 36.96± 10.79 Units/min/ml which decreased to18.68 ± 21.15 Units/min/ml at the end of 90 days ($p<0.001$) in the control group. Since the athletes of this group were not supplemented with anti-oxidants, the SOD values were decreased.
- In experimental group, the mean initial levels of LPO was 2.89 ±0.82 µg/ml which

increased to 3.80±1.37 µg/ml post intervention ($p<0.01$) in view of daily consumption of anti- oxidant rich nutri bars. In the control group, there was a significant increase from 3.44 ± 1.59 µg/ml to 3.85 ± 1.87 µg/ml ($p<0.05$).

- Vitamin C levels decreased after 90 days of supplementation from 4.14 mg/dl to 3.62 mg/dl in the experimental group with statistically not- significant results. However, in the control group there was a significant decrease from 5.14 mg/dl to 3.32 mg/dl ($p<0.001$).
- At baseline, the mean GSH levels were 209.76 ± 8.17µg/ml and after supplementation of anti-oxidant rich nutri bars for a duration of 90 days, the mean final glutathione levels showed a steep increase to 244.58±33.36 µg/ml and the increase of 34.82 µg/ml in response to supplementation was significant ($p<0.001$), thus the hypothesis 6d is rejected. The Control group showed a decreased GSH level (214.120 ± 7.42 µg/ml to 188.88±38.3 µg/ml significant at ($p<0.01$).
- The mean initial GSH-Px level of the experimental group was 17.15± 15.25 µg/ml and marginally increased to 18.65± 8.9µg/ml statistically not significant. In the control group, GSH-Px level decreased from15.30±12.13 µg/ml to 9.20±6.32 µg/ml in control group ($p<0.05$).

CONCLUSION

Antioxidant effects of the formulated food were useful in improving the bio- markers and physical fitness of athletes. Supplementation of antioxidant rich nutri bars has beneficial effects on the oxidative stress and physical fitness of the Future research may explore the effect of other nutritional antioxidants that can benefit the athletes. The anti-oxidant requirements for athletes have to be computed for recommendations.

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