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ORIGINAL ARTICLE

Evaluating the Immunity-Boosting Efficacy and Safety of Biscuits Enriched with Vitamins, Minerals, and Herbal Extracts in Healthy Individuals: A Randomised, Prospective, Multicentre Clinical Trial

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ABSTRACT

Background: Immunity safeguards against infections and strengthening it through diet can enhance health status. This trial evaluated the immune-boosting efficacy and safety of vitamin-, mineral-, and herb-enriched biscuits in preventing infections and allergies.

Methods: This randomized, double-blind, placebo-controlled, multicenter trial enrolled 664 healthy participants assigned to either Britannia Nutri Choice Herbs biscuits or a placebo. Participants consumed three biscuits twice daily in the morning and evening for 180 days, with compliance (≥80%) monitored. Quality of life (QoL) was assessed using the World Health Organization Quality of Life Brief Version (WHO-QOL BREF). A complete blood count (CBC), C-reactive protein (CRP), and Interleukin 6 (IL-6) and Interleukin 10 (IL-10) assessments were performed for immunity and inflammation. Immunity parameters, energy, stamina, and neurocognitive health were measured by the visual analogue scale (VAS), perceived stress scale (PSS), and Hamilton anxiety rating scale (HAMA). The global assessment scale changes were analysed too.

Results: Of 664 participants, 608 completed the trial (300 in the biscuit group, 308 in placebo). After 150 days, the biscuit group had significantly fewer infections and allergies (136 vs. 208; $p<0.01$). Energy, strength, and stamina improved, particularly in children. No significant differences were observed in Body Mass Index (BMI), neurocognitive health status, immunity markers, QoL, or safety.

Conclusion: Regular consumption of Nutri Choice Herbs biscuits reduced infections and allergies, especially respiratory related in adults. It enhanced energy, stamina, digestion, appetite, and bowel movements; while easing abdominal tightness in children. So these enriched biscuits can be safely recommended to boost immunity and overall health.

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Introduction

Immunity is a fundamental capability of the human body, allowing it to identify and resist potentially harmful microorganisms (1). The immune system acts as a protective barrier, aiding in the elimination of toxic substances through various anatomical structures (lymphatics, bone marrow, thymus gland, spleen) and cellular components (lymphocytes, dendritic cells, macrophages, and natural killer cells). These functions collectively prevent invading pathogens such as viruses, bacteria, fungi, and parasites (1-5). The immune system comprises two main categories: innate immune (natural or nonspecific) and adaptive immune (acquired or specific) systems (6, 7). Both systems work together to bolster the body's immune response (4). However, imbalances in immune responses can lead to hyperactivity, resulting in the destruction of healthy cells, or deficiencies, leading to increased susceptibility to various infections and diseases, including the common cold, flu, respiratory illnesses, and gastrointestinal disorders (3, 8-11).

On average, infants may experience up to 11 respiratory infections per year, preschoolers about eight, and school-aged children around four (12, 13). In the adult population, immunodeficiencies frequently result in an elevated susceptibility to chronic conditions, including autoimmune disorders, cardiovascular ailments, and specific types of malignancies (14, 15). Micronutrients, including vitamins and minerals, play a significant role in supporting a well-functioning immune system and reducing the risk of diseases. Vitamins C, D, E, A, and B complex, along with zinc, selenium, iron, omega fatty acids, and phenolic compounds from herbs, are known for their immune-boosting properties, antioxidant, antistress, and rejuvenating activities (16-19).

Therefore, this study aimed to evaluate the efficacy and safety of Nutri Choice Herbs biscuits developed by Britannia Industries LTD (Figure 1) as described before (20-22). These biscuits are enriched with a blend of vitamins (Vitamins C, E, A, B_6, B_9, and B_{12}), minerals (iron, zinc, and selenium), and immunity-boosting herbs (giloy, tulsi, amla, ashwagandha, and turmeric). This study aimed to assess the impact of these biscuits on general health and immunity over 6 months in healthy individuals. The current study also aimed to evaluate the efficacy of Nutri Choice Herbs biscuits as an immunity booster in preventing infection and allergies through a randomized, prospective, multicentre clinical trial.

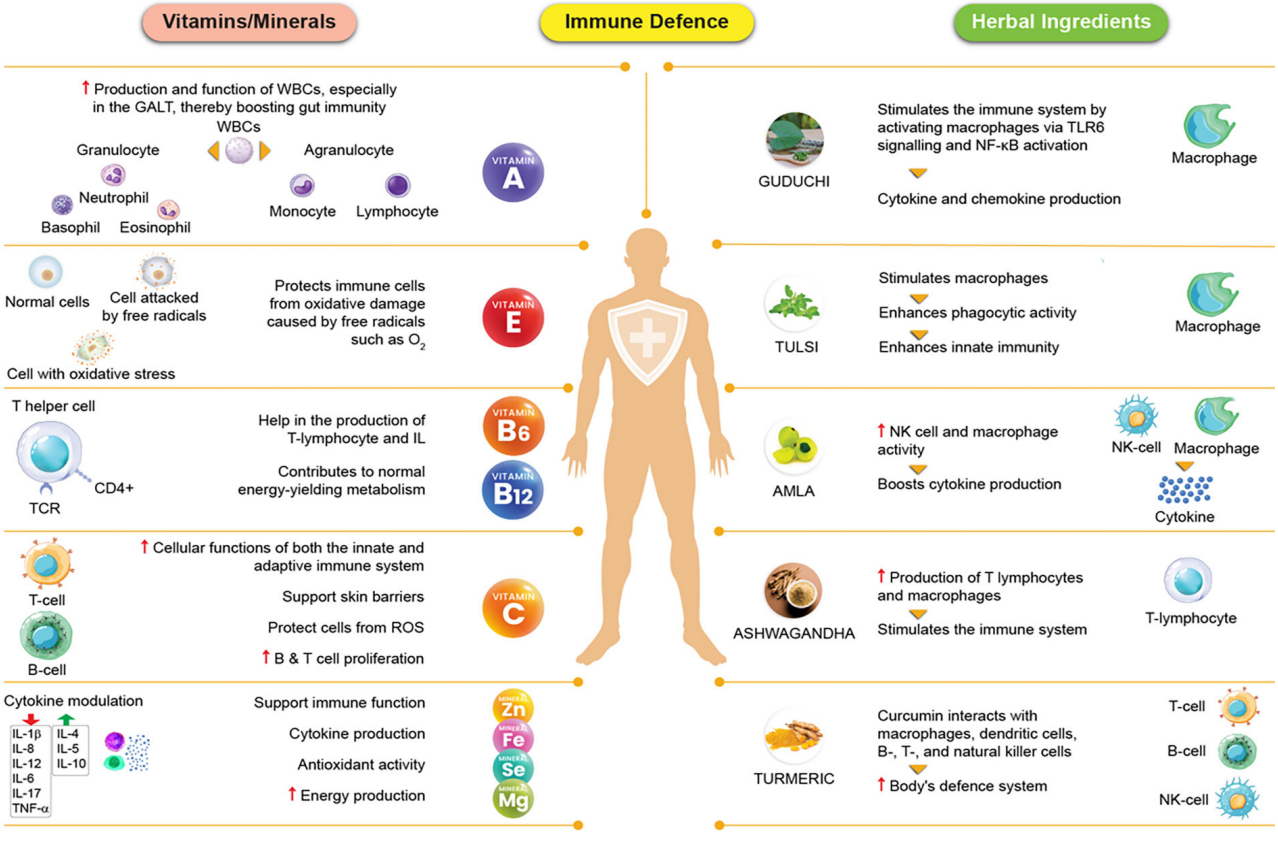


Figure 1: Immunomodulatory mechanisms of vitamins, minerals, and herbal ingredients in Nutri Choice Herbs biscuits (20-22). B Cell: B Lymphocyte; Fe: Iron; GALT: Gut-associated lymphoid tissue; IL: Interleukin; Mg: Magnesium; NF-kB: Nuclear factor kappa-light-chain-enhancer of activated B cells; NK: Natural Killer; ROS: Reactive Oxygen species; Se: Selenium; TCR: T cell receptor; T cell: T lymphocyte; TLR6: Toll-like receptor 6; TNF-α: Tumor necrosis factor alpha; WBC: White blood cell; Zn: Zinc.

Materials and Methods

The study protocol (BISCT/IMMU/BRIT/2021/1, Version 1.0) was ethically approved by Site 01: Institutional Ethics Committee (IEC)-DY Patil University, School of Ayurveda, Nerul, Mumbai (Reference No. DYPUSA/21/534); Site 02: Institutional Ethics Committee (IEC), Ayurved Seva Sangh's Ayurved Mahavidyalaya, Ganeshwadi, Panchvati, Nashik (Reference No. 120); Site 03: Institutional Ethics Committee on Human Research, (PIA-IECHR), Vadodara, Gujarat (Reference No. PU/PIA/IEC/03/2021/043); Site 04: Institutional Review Board for Research, MAMs SS Ayurveda Mahavidyalaya and Sane Guruji Aarogya Kendra, Malwadi, Hadapsar, Pune (Reference No. MAM/SS Ayu/642-A). The study has been performed in accordance with the Declaration of Helsinki. Informed consent was provided to the participants in the language they could read and write. Written informed consent was obtained from the participants prior to the start of the study too (CTRI Registration No: CTRI/2021/11/037971).

This was a randomized, double-blind, placebo-controlled, multicentric, comparative, prospective, interventional clinical study. The methodology was designed to uphold strict controls and comparisons among multiple centres to assess the effectiveness and safety of the intervention over a predetermined period of 6 months (180 days). During this period, participants were asked to consume the study product. Post-recruitment in the study, participants were followed up at monthly intervals (30 days) for 180 days. The sample size was determined based on statistical analysis focusing on the functional benefit area of immunity. Interim analyses were conducted at various predetermined time points to evaluate the progression of improvement in immunity parameters. Among 664 enrolled participants, 608 healthy male and female participants, aged between 12 and 45 years, completed the study. Critical elements of participant recruiting, consenting, and study participation are documented in the Consolidated Standards of Reporting Trials (CONSORT) flow diagram.

The participants were recruited through a computer-generated list to ensure randomisation in a 1:1 ratio between the group consuming the Nutri Choice Herbs biscuits and the placebo group. Inclusion criteria necessitated that the participant to be healthy, willing to consume both the test and reference food products, and free from acute or chronic medical/surgical conditions requiring immediate or continuous medical monitoring and treatment. Moreover, participants aged 18 years and above were mandated to have received at least one dose of the coronavirus disease 2019 (COVID-19) vaccine. Exclusion criteria encompassed individuals with a history of allergy to biscuit-like products, pregnant and lactating women, recent known and recovered cases of COVID-19 within the last 3 months, history of diabetes mellitus or immunocompromised status, individuals under steroids or immunosuppressive therapy, and those who had engaged in any other clinical study within 3 months before the screening process. Participants were required to provide written informed consent and demonstrate a willingness to adhere to the study protocol requirements. Informed consent was provided to the participants in the language they could read and write. The clinical research coordinator documented all the screening and recruitment processes during the informed consent process, which the principal investigator later approved.

Study product details included Nutri Choice Herbs biscuits and placebo biscuits. The Nutri Choice Herbs biscuits were prepared using wheat flour (atta), rolled oats, oilseeds (pumpkin seeds, flaxseeds, and chia seeds), wheat bran, oats fibre, milk solids, iodised salt, vitamins (vitamins A, E, C, B_6, B_9, and B_{12}), minerals (iron, selenium, and zinc), and extracts of herbs (ashwagandha, basil [tulsi], amla, turmeric, and giloy [guduchi]). Placebo biscuits were prepared using wheat flour and contained no active vitamins, minerals, or herbal components. Each biscuit weighed about 9 g. Participants in both groups were instructed to consume three biscuits (approximately 9 g per biscuit) in the morning and three biscuits in the evening for 180 days.

The contract research organization used their database to identify potential subjects, who were screened and enrolled based on predetermined inclusion and exclusion criteria. Before administering the intervention product, participants were provided with detailed information about the study and the informed consent document. The content of the consent form was thoroughly explained before participants signed it. The study protocol, endpoints, and participants diary containing analysis parameters were also explained to ensure participants were fully informed prior to providing consent and commencing the study. Participants or the public were not involved in the study's design, conduct, or the selection of outcome measures. The identities of the participants were not disclosed on any public platform, and all data were anonymized. Additionally, study outcomes were not disclosed to the participants at any stage of the trial.

The study utilized various validated tools to ensure comprehensive and accurate data collection. Initial eligibility confirmation for adult females of childbearing potential was

done by conducting a urine pregnancy test. Furthermore, routine blood assessments, including haemoglobin, a complete blood count (CBC) with erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), immunological parameters (interleukin 6 (IL-6) and 10 (IL-10)), blood sugar, and thyroid-stimulating hormone tests, were carried out to identify underlying conditions. Physical examinations were conducted to measure parameters such as height, weight, body mass index (BMI), pulse, respiratory rate, blood pressure, and temperature. Participants were provided with a subject diary designed to document occurrences of infections or allergy-related disorders, treatments administered, and any hospitalisations. During the baseline visit and follow-up visits and at the end of the study (180 days), the visual analogue scale (VAS), perceived stress scale (PSS), Hamilton anxiety rating scale (HAMA), and the insomnia severity index (ISI) scale were used to assess physical health, neurocognitive health, energy levels, strength, and stamina. The World Health Organization Quality of Life Brief Version (WHO-QOL BREF) was used to evaluate participants' Quality of life (QoL).

The comparative difference in the incidence of infections and allergy-related issues (number of occurrences [episodes], duration, number of participants) over 180 days compared with a placebo group was assessed to determine the product's effectiveness. The secondary efficacy and safety endpoints of the study encompassed various comparative assessments between the Nutri Choice Herbs biscuits group and the placebo group over 6 months. Firstly, the study aimed to evaluate the comparative difference in the severity of infections, categorised as mild, moderate, and severe, during the study period. Additionally, the number of participants requiring hospitalization and the length of hospital stays were monitored and compared between the two groups. The study also evaluated the incidence/frequency and severity of other allergy-related health issues of the Nutri Choice Herbs biscuits group compared with those of the placebo group. Changes in general physical health, neurocognitive health, energy levels, strength, and stamina were monitored throughout the study to identify significant differences between the groups. The participants' QoL was assessed using the WHO-QOL BREF, enabling a comparative analysis of their well-being over 6 months. Upon the study's completion, the investigator's overall assessment of change was compared between the biscuit group and the placebo group to determine the effectiveness of the intervention. Moreover, differences in immunity and inflammatory-related biomarkers, including CBC with ESR, CRP, IL-6, and IL-10, were analyzed in a selected population of 30 subjects from each group. Safety evaluations included monitoring vitals, the incidence of adverse events and serious adverse events, and a global overall safety assessment of the biscuit group was compared with that of the placebo group. This comprehensive approach ensured a thorough evaluation of both efficacy and safety endpoints.

The in-house statistician diligently executed the data analysis using the GraphPad statistical software. Multiple statistical tests were implemented to comprehensively assess efficacy variables in the study. The Chi-square test was utilised to compare the incidence proportions of infections, immunity, and allergy-related disorders across the study groups. To gauge the severity of these cases, both the student's t-test and the analysis of variance (ANOVA) test were employed to elucidate significant differences between the groups. For evaluating within-group changes and between-group differences in variables such as physical health, neurocognitive health, energy levels, strength, stamina, and QoL based on WHO QoL BREF, the Wilcoxon signed-rank test and Mann-Whitney U test were utilized. These nonparametric tests offered a robust analysis of the variations and improvements within and between the study groups. The student's t-test was specifically used to analyze mean changes in immunity and inflammatory-related biomarkers, including CBC, ESR, CRP, IL-6, and IL-10. Finally, the Chi-square test was employed for the global assessment of overall change between the groups, ensuring a thorough evaluation of the study's outcomes. This comprehensive approach to data analysis provided reliable and valid results, contributing to the overall integrity of the study.

Results

There were 213 adults and 87 children in the Nutri Choice Herbs biscuits group, while the placebo group had 222 adults and 86 children. The average age of adults in the Nutri Choice Herbs biscuits group was 29.03±7.94 years compared with 28.05±7.22 years in the placebo group, with no significant difference (p>0.05). The average age of children in the Nutri Choice Herbs biscuits group was 14.20±1.69 years, while it was 14.01±1.61 years in the placebo group. Among the 213 adults in the Nutri Choice Herbs biscuits group, there were 93 males and 120 females. In the placebo group, out of 222 adults, there were 85 males and 137 females. The demographic details are presented in Table 1.

A comparative assessment was conducted to evaluate the difference in the occurrence of infections and allergy-related disorders (number of episodes/durations of episodes/number of subjects) over 180 days between the Nutri Choice Herbs biscuits group and placebo group. In the Nutri Choice Herbs biscuits group, out of 300 participants, a total of 107 cases of infection/allergy were recorded, compared with 110 cases reported by 308 participants in the placebo group. The statistical analysis showed no significant difference ($p>0.05$) in the incidence rate (no. of participants) between the two groups. However, a noticeable decrease in the total number of infection/allergy episodes was observed in the Nutri Choice Herbs biscuits group, with 191 episodes compared with the placebo group with 264 episodes, demonstrating a significantly lower number of episodes ($p<0.001$) for the Nutri Choice Herbs biscuits group (Figure 2).

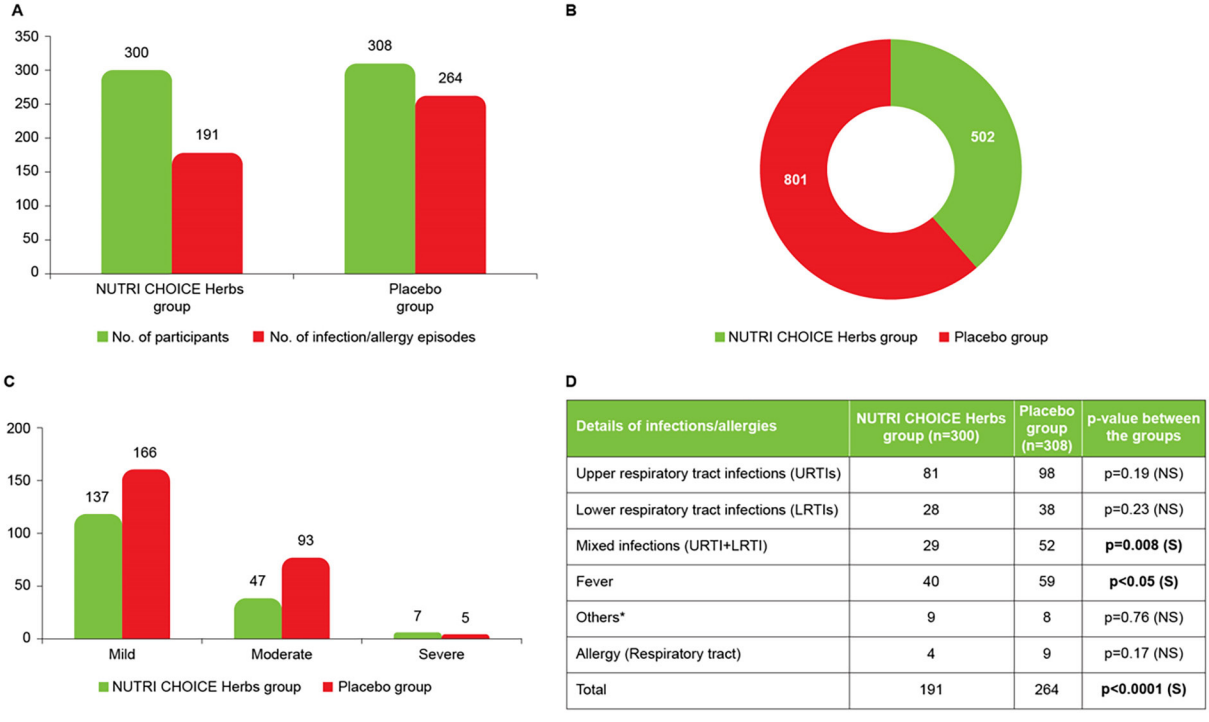
The statistical analysis revealed a significant correlation ($p=0.03$) in the severity of episodes, with the Nutri Choice Herbs biscuits group displaying a significantly milder profile compared with the placebo group. The total duration of infection/allergy episodes in the Nutri Choice Herbs biscuits group was significantly shorter, with 502 days compared with 801 days in the placebo group ($p<0.001$). Additionally, a significant correlation ($p=0.002$) was observed between the reduced number of episodes and the shorter duration in the Nutri Choice Herbs biscuits group, further highlighting the effectiveness of the biscuits in minimizing the impact of infection/allergy episodes (Table 2).

During the comprehensive evaluation of infections and allergic reactions, a total of 191 incidents were observed in the Nutri Choice Herbs biscuits group, while in the placebo group, 264 incidents were reported. Upon conducting an intergroup analysis, it was found that there were significantly fewer occurrences of mixed infections [Upper respiratory tract infections (URTI)+Lower respiratory tract infections (LRTI)] ($p=0.008$) and fever ($p<0.05$) in

Table 1: Demographic characteristics of the study participants.

Group	Sub-group	Male	Female	Age in years	Weight (Kg)	BMI
Nutri Choice Herbs biscuits	Children (n=87)	47	40	14.20±1.69	42.13±11.50	18.65±3.43
group	Adults (n=213)	93	120	29.03±7.94	59.59±12.26	22.93±3.84
Placebo group	Children (n=86)	41	45	14.01±1.61	42.46±11.49	18.88±4.04
	Adults (n=222)	85	137	28.05±7.22	58.65±11.47	22.74±3.66
P value between the groups		>0.05 (NS)	>0.05 (NS)	>0.05 (NS)	>0.05 (NS)	>0.05 (NS)

BMI: Body mass index; NS: Non-significant.



Details of infections/allergies	NUTRI CHOICE Herbs group (n=300)	Placebo group (n=308)	p-value between the groups
Upper respiratory tract infections (URTIs)	81	98	p=0.19 (NS)
Lower respiratory tract infections (LRTIs)	28	38	p=0.23 (NS)
Mixed infections (URTI+LRTI)	29	52	**p=0.008 (S)**
Fever	40	59	**p<0.05 (S)**
Others*	9	8	p=0.76 (NS)
Allergy (Respiratory tract)	4	9	p=0.17 (NS)
Total	191	264	**p<0.0001 (S)**

Figure 2: Comparative assessment of infection/allergy-related disorders among combined populations in the Nutri Choice Herbs biscuits vs. placebo groups. A: Assessment of no. of episodes of infection/allergy-related disorder; B: Assessment of no. of days of infection/allergy-related disorder; C: Assessment of severity of infection/allergy-related disorder; D: Details of infection/allergy-related disorder (Combined population). S: Significant; NS: Non-significant; *Other infections, Nutri Choice Herbs biscuits group: Digestive 8 and urinary tract 1. Placebo group: Digestive 5, skin infections 2, and eye infections 1.

Table 2: Assessment of infection/allergy-related disorder in combined populations.

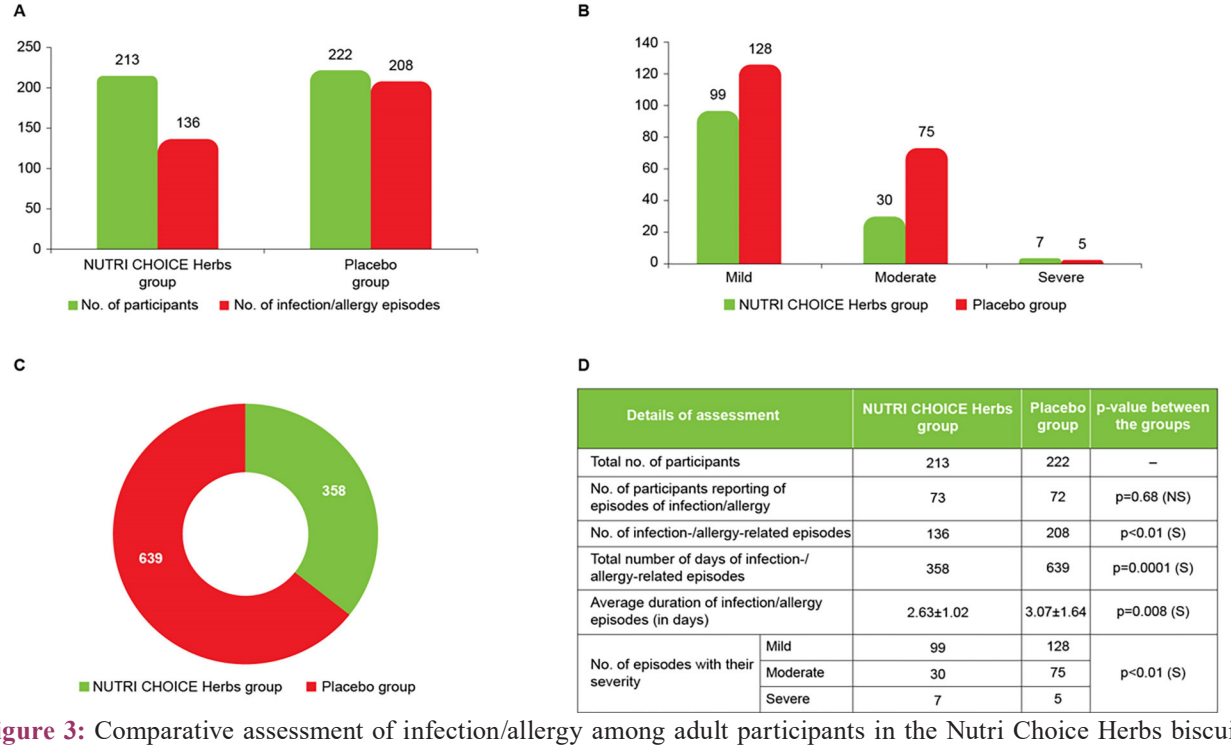
Details of assessment	Nutri Choice Herbs biscuits group	Placebo group	*P* value between the groups
Total no. of participants	300	308	$p>0.05$ (NS)
No. of participants reporting episodes of infection/allergy	107	110	$p=0.99$ (NS)
No. of infection/allergy-related episodes	191	264	$p<0.001$ (S)
Total number of days of infection/allergy-related episodes	502	801	$p<0.001$ (S)
Average duration of infection/allergy episodes (in days)	2.63±0.98	3.03±1.54	$p=0.002$ (S)
No. of episodes with their severity			
Mild	137	166	
Moderate	47	93	
Severe	7	5	$p=0.03$ (S)

NS: Non-significant; S: Significant.

the Nutri Choice Herbs biscuits group than in the placebo group. The detailed findings of infections and allergies are demonstrated in Figure 2D. Furthermore, monthly assessments demonstrated a substantial decrease in infection/allergy occurrences in the Nutri Choice Herbs biscuits group compared to the placebo group after 150 days ($p=0.017$). The Nutri Choice Herbs biscuits group also exhibited fewer infection/allergy disorders after 60 days ($p<0.05$) from the baseline, and this pattern persisted throughout the study.

Among 213 adults in the Nutri Choice Herbs biscuits group, 73 subjects reported incidences of infection/allergy, while of the 222 subjects, 72 subjects in the placebo group reported similar incidences. Notably, the total number of infection/allergy episodes was significantly lower ($p<0.01$) in the Nutri Choice Herbs biscuits group (136 episodes) than in the placebo group (208 episodes). The severity of episodes was significantly milder in the Nutri Choice Herbs biscuits group ($p=0.008$). Furthermore, the total number of days of infection/allergy episodes was significantly lower in the Nutri Choice Herbs biscuits group (358 days) than in the placebo group (639 days), showing a significant difference ($p=0.0001$). The average duration of episodes was also significantly shorter ($p=0.008$) in the Nutri Choice Herbs biscuits group (2.63±1.02 days) compared with that in the placebo group (3.07±1.64 days). Figure 3 presents the comparative assessment of infection/allergy among adult participants in both groups.

A thorough assessment of infections and allergies indicated that out of a total of 136 episodes, there were 61 instances of URTI, 22 instances of LRTI,



Details of assessment		NUTRI CHOICE Herbs group	Placebo group	p-value between the groups
Total no. of participants		213	222	–
No. of participants reporting of episodes of infection/allergy		73	72	p=0.68 (NS)
No. of infection-/allergy-related episodes		136	208	p<0.01 (S)
Total number of days of infection-/allergy-related episodes		358	639	p=0.0001 (S)
Average duration of infection/allergy episodes (in days)		2.63±1.02	3.07±1.64	p=0.008 (S)
No. of episodes with their severity	Mild	99	128	p<0.01 (S)
	Moderate	30	75	
	Severe	7	5	

Figure 3: Comparative assessment of infection/allergy among adult participants in the Nutri Choice Herbs biscuits vs. placebo groups. A: Assessment of no. of episodes of infection/allergy-related disorder; B: Assessment of severity of infection/allergy-related disorder; C: Assessment of no. of days of infection/allergy-related disorder; D: Details of infection/allergy-related disorder. S: Significant; NS: Non-significant

14 cases of mixed infections (URTI and LRTI), 28 cases of fever, 4 cases of allergy, and 7 cases of other infections in the Nutri Choice Herbs biscuits group. Comparatively, in the placebo group, out of 208 episodes, there were 72 cases of URTI, 34 cases of LRTI, 43 cases of mixed infections, 47 cases of fever, 7 cases of allergy, and 5 cases of other infections. Study results revealed that the Nutri Choice Herbs biscuits group had significantly lower numbers of mixed infections (p=0.0001) and fever (p=0.01) compared with the placebo group (Table 3).

Subsequent monthly assessments of no. of infection and allergy-related episodes revealed a significant disparity between the two groups after 150 days from baseline. The Nutri Choice Herbs biscuits group displayed a notably lower number of infections compared with the placebo group. Similarly, an evaluation of the duration of infection and allergy-related disorders demonstrated a significant reduction in the number of days at 60 days (p<0.027) from the baseline in the Nutri Choice Herbs biscuits group vs. the placebo group. These trends persisted throughout the study.

The study examined incidences of infection/allergy among 87 children in the Nutri Choice Herbs biscuits group and 86 children in the placebo group. In the Nutri Choice Herbs biscuits group, 34 subjects reported an incidence of infection/allergy, compared with 38 subjects in the placebo group. The statistical analysis did not reveal a significant difference between the two groups (p=0.49). In terms of the total number of infection/allergy episodes, the Nutri Choice Herbs biscuits group reported 55 cases, while the placebo group reported 56 cases, showing no significant difference between the two groups (p=0.79). The severity of episodes in the Nutri Choice Herbs biscuits group included 38 mild and 17 moderate cases, with no severe episodes. The corresponding numbers for the placebo group were 38 mild, 18 moderate, and 0 severe cases. Statistical analysis indicated no significant difference in the severity of episodes between the two groups (p=0.88). Regarding the duration of infection/allergy episodes, the Nutri Choice Herbs biscuits group reported 144 days, while the placebo group reported 162 days, showing a nonsignificant difference (p>0.05). The average duration of episodes in the Nutri Choice Herbs biscuits group was 2.61±0.87 days, whereas in the placebo group, it was 2.89±1.12 days. The comparative assessment of infection/allergy among children in both groups is recorded.

Upon detailed assessment of infections and allergies, it was observed that the Nutri Choice Herbs biscuits group had 55 episodes with 20 URTI, 6 LRTI, 15 mixed infections (URTI+LRTI), 12 fever episodes, no allergies, and 2 other infections. The placebo group had 56 episodes with 26 URTI, 4 LRTI, 9 mixed infections, 12 fever episodes, 2 allergies, and 3 other infections. Between-group assessments showed no significant differences (p>0.05) in any infections/allergies. Further, monthly assessments of the number of infections/allergy episodes along with their duration showed no significant difference between the two groups (p>0.05).

Information on body weight and BMI from baseline to 90 days and then to 180 days are assessed. The analysis revealed no significant difference between the two groups in terms of changes in body weight at the beginning, at 90 days, and 180 days. A considerable increase in weight was noted from the start to 180 days in the children in both groups. This can be attributed to the normal physiological weight gain associated with growth and development. A detailed information on the changes in digestion-related symptoms over 180 days at monthly intervals, measured on a scale of 0-100 in both groups are recorded. In the paediatric group, notable enhancements in appetite, reduction of abdominal tightness, and improved bowel movements were observed from the baseline to 180 days. The enhancement in appetite and bowel habits in the paediatric group began to manifest on day 90 from the baseline and persisted throughout the study. A substantial reduction in abdominal tightness was observed after 120 days from the baseline. Similarly, in the adult group, there was a significant

Table 3: Detailed assessment of infection/allergy-related disorder (adult population).

Details of infections/allergies	Nutri Choice Herbs biscuits group (n=213)	Placebo group (n=222)	*p* value between the groups
Upper respiratory tract infections (URTI)	61	72	p=0.39 (NS)
Lower respiratory tract infections (LRTI)	22	34	p=0.12 (NS)
Mixed (URTI + LRTI)	14	43	p<0.0001 (S)
Fever	28	47	p=0.01 (S)
Others*	7	5	p=0.51 (NS)
Allergy (respiratory tract)	4	7	p=0.39 (NS)
Total	136	208	p<0.0001 (S)

NS: Non-significant; S: Significant. *Other infections, Nutri Choice Herbs biscuits group: Digestive 6, Urinary tract 1. Placebo group: Digestive 2, Skin infections 2, Eye infections 1.

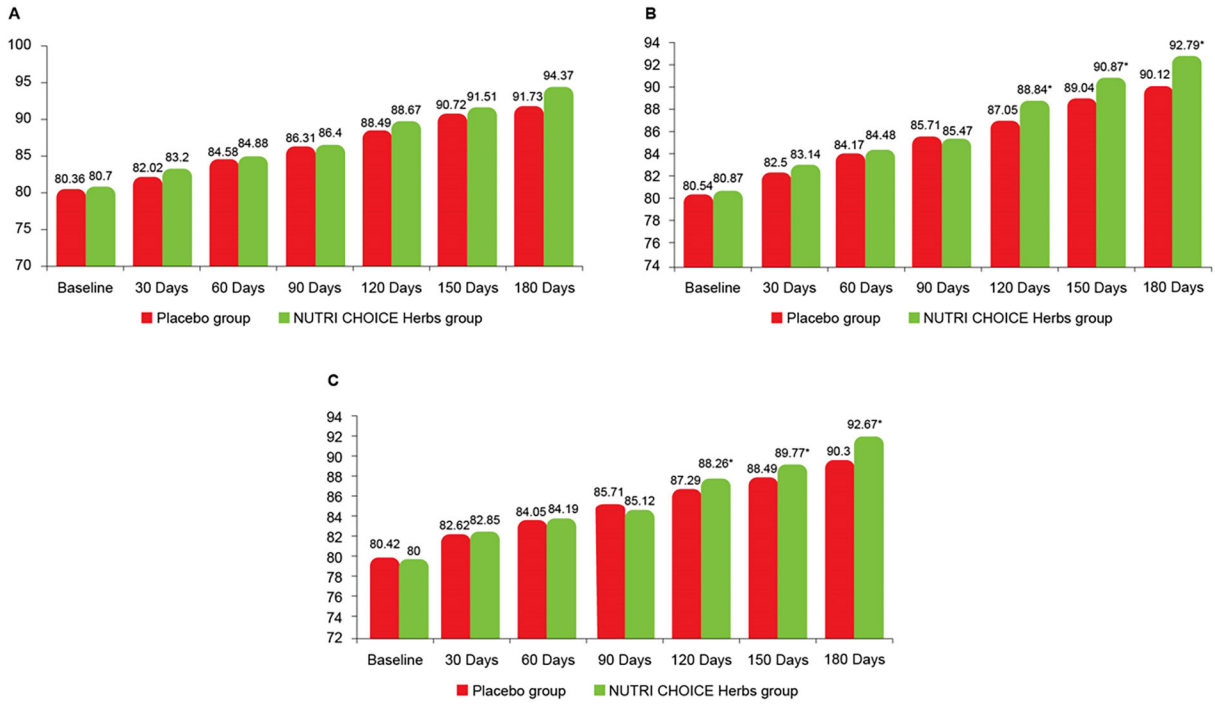


Figure 4: Comparative assessment of the effect on energy, strength, and stamina levels among children in both groups. A: Assessment of energy score in children; B: Assessment of strength core in children; C: Assessment of stamina core in children. *p<0.05: Within-group from baseline.

improvement in appetite scores from the beginning to the end of the study. However, other parameters of the digestive system did not exhibit noteworthy changes from the baseline to the end of the study.

The impact of the intervention on neurocognitive health parameters, such as stress, anxiety, sleep, and mood, was assessed in both groups over 180 days from baseline. The results showed no significant differences in these parameters between the groups for either adults or children. The energy, strength, and stamina levels over 180 days were assessed between the two groups. A significant improvement in these parameters was observed among children in the Nutri Choice Herbs biscuits group compared with those in the placebo group (Figure 4). Specifically, the increase in strength and stamina was noted from day 120, and in energy from day 150, continuing until the study's conclusion. However, no significant changes were observed in the adult population.

Laboratory-related parameters, including CRP, IL-6, and IL-10, were measured in a selected population to evaluate changes in immunological parameters. It was observed that there was a significant reduction in IL-6 and IL-10 levels from baseline to 180 days in both study groups. However, CRP level did not significantly change from baseline to 180 days in either group. When comparing the groups, no significant differences were noted. An assessment of CBC parameters revealed no significant differences between the two groups. The levels remained within the normal range at both baseline and the end of the study (180 days).

QoL was assessed in adults and children for 180 days across four domains (physical, mental, social, and environmental health). The study showed no significant differences between the two groups. The global assessment of overall efficacy of the product showed improvement in the Nutri Choice Herbs biscuits group both for children and adults compared to placebo group, as per both the investigator and the subject assessment.

Discussion

The current clinical trial was conducted to evaluate the impact of regular consumption of Nutri Choice Herbs biscuits on the immune system and digestive health, as well as other health-related factors such as neurocognitive health and overall QoL of healthy participants over 180 days. The study evaluated the occurrences and severity of infections and allergies, particularly those related to the respiratory system, along with their duration. It also involved a comparative analysis with a matched placebo. A total of 308 healthy individuals aged 12-45 years participated in the study, with all the baseline demographic factors, including age, gender, and body weight, being matched.

The results revealed that participants who consumed Nutri Choice Herbs biscuits experienced significantly fewer infections/allergies compared with those who had taken a placebo. The episodes were also shorter and less severe in the Nutri Choice

Herbs biscuits group tracking infection and allergy episodes revealed a significant difference between the groups from day one to 120, persisting until the study's end. Furthermore, the observation of these benefits was particularly significant in the adult population (18-45 years) compared with children aged 12-17 years. Additionally, the study revealed an improvement in digestive/gut health-related parameters, including appetite and bowel movements. These improvements were noted from baseline to 90-120 days. The beneficial outcomes can be attributed to the high fiber content of Nutri Choice Herbs biscuits, sourced from wheat flour (atta), rolled oats, oilseeds (pumpkin seeds, flaxseeds, and chia seeds), wheat bran, and oat fibre.

In children, a significant improvement in energy levels, strength, and stamina was observed with the consumption of Nutri Choice Herbs biscuits from baseline to day 120, continuing to the study's conclusion. Notably, no adverse reactions were reported with the use of Nutri Choice Herbs biscuits. Recurrent respiratory infections, commonly caused by viruses and bacteria, are often associated with weakened immunity (23, 24). Recent comprehensive reviews have highlighted the impact of various food components, such as specific vitamins, minerals, proteins, flavonoids, nondigestible polysaccharides, probiotics, and short-chain fatty acids, on the immune system (16, 25, 26). These effects are pertinent to enhancing antiviral immunity (27). While some infections resolve independently, others may necessitate antimicrobial treatment. Improving immunity can reduce the frequency, duration, and severity of these infections (28, 29).

Herbs like ashwagandha, giloy, tulsi, amla and turmeric, along with essential minerals, are known to boost immunity and prevent infections/allergies. Improved digestion is associated with enhanced immunity and reduced infection risk (30). The ayurvedic concept of rasayana, which includes herbs like amla, tulsi, ashwagandha, giloy and haridra, aligns with the contemporary understanding of immunity by enhancing the body's disease-fighting capacity (31). Essential vitamins support the immune system and provide crucial nutritional benefits, while dietary fibres aid digestion and bowel movements (32-35). This study found that regular consumption of Nutri Choice Herbs biscuits significantly reduced respiratory infections' incidence, duration, and severity. Improved immunity, enhanced digestion, appetite and bowel movement benefits stem from ingredients like ashwagandha, tulsi, amla, giloy, and turmeric, alongside vitamins and minerals. highlighting the biscuits' nutritional and immunomodulatory properties.

Conclusion

The present study concluded that regular consumption of Nutri Choice Herbs biscuits significantly reduced the incidence, duration, and severity of infections and allergies as they contain ingredients like ashwagandha, tulsi, amla, giloy, and turmeric, as well as nutrients such as vitamins, zinc, iron, and selenium, known for their immunomodulatory and antioxidant properties. Episodes of infection and immunity specifically associated with the respiratory tract were notably lower in frequency, duration, and severity with the consistent consumption of Nutri Choice Herbs biscuits. This effect was more pronounced among adult participants compared with that in children. Furthermore, the study indicated that consuming Nutri Choice Herbs biscuits contributed to improving digestive/gut health. Essential digestive functions such as appetite and bowel movements exhibited substantial enhancement, accompanied by reduced abdominal discomfort. Additionally, notable improvements in energy levels, physical strength, and stamina were observed, particularly among paediatric participants. Therefore, it is indicated that Nutri Choice Herbs biscuits may be recommended to support overall health, boost immunity, aid in digestive and bowel health, improve appetite, and promote increased energy, strength, and stamina.

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Authors' Contribution

SN: Conceptualization, Funding acquisition, Methodology, Project administration, Writing review and editing; MPS: Data Curation, Formal Analysis, Project administration, Writing – original draft, Writing review and editing; ML: Conceptualization, Writing review and editing; BB: Conceptualization,

Writing review and editing; VKS: Formal Analysis, Investigation, Supervision, Validation, Writing review and editing; SD: Data Curation, Formal Analysis, Software, Validation, Visualization, Writing review and editing; MH: Data Curation, Formal Analysis, Software, Validation, Visualization, Writing review and editing; AK: Data Curation, Formal Analysis, Software, Validation, Visualization, Writing review and editing; PJD: Data Curation, Formal Analysis, Validation, Visualization, Writing review and editing; ST: Data Curation, Formal Analysis, Resources, Supervision, Validation, Writing review and editing. All authors gave final approval of the version to be published. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of Interest

The authors SN, MPS, ML, and BB are employees of Britannia Industries Limited. The authors VKS, SD, MH, AK, PJD, and ST received honorarium from Britannia Industries Limited for the conduct of this trial.

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