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Nutrient-Dense, Functional Foods Enhance Hair, Skin, and Nail Appearance

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ABSTRACT

Objective

The American diet is nutrient-poor and rich in unhealthy compounds like sodium, sugar, and saturated fats. Whether food has an effect on appearance has not been fully elucidated. The purpose of this prospective, single-armed study was to evaluate the impact of consuming two nutrient-dense functional foods, which are low in salt, sugar, and saturated fats, on hair, skin, and fingernail health.

Methods

Both subjective (self-reported questionnaires and photographs) and objective (i.e., salivary pH and skin hydration) tests were used to evaluate appearance. Weekly compliance with nutrient-dense foods, body weight, and quality of life assessment were also recorded.

Results

Participants(n=28) consumed most of the nutrient-dense foods and remained weight stable, which was the goal of the study to exclude the effect of changes in body weight on appearance. Neither objective measurement of appearance showed significant improvements. Subjective measurements using questionnaires specific to hair, skin, and fingernails improved significantly over the 8-week study. Rating of photographs that the participants took of themselves improved significantly over the 8-weeks. These included reduced redness, decreased pore size, and better skin color. Using an acne-rating scale, a significant improvement was observed at week 8 compared to baseline. The quality of life parameters improved significantly including feeling of well-being, feeling full, having more energy, sleeping better, having less stress, and being more focused.

Conclusion

Inclusion of two nutrient-rich, functional foods in the diet improved the appearance of hair, skin, and fingernails. These foods were well-received and easy-to-prepare, leading to excellent compliance with the dietary protocol.

Keywords

Appearance; Diet; Functional foods; Nutrient-dense foods; Hair; Skin; Nails.

INTRODUCTION

Margaret Wolfe Hungerford is credited with coining the exact phrase "beauty is in the eye of the beholder" in her novel Molly Bawn, published in 1878 (grammarist.com/phrase/beauty-is-in-the-eye-of-the/).[1] The phrase means that beauty is mostly subjective. The urge to feel more attractive is evidenced by the estimated sales of beauty-enhancing products $17.7 billion in 2017.[2] In addition, interest in beauty and nutrition is extensive; more than 27 million hits appeared as a result of a Google search.

Sadly, many of the claims accompanying both topical and ingestible products targeted at enhancing beauty are not supported by evidence-based science. It makes more sense to focus on consuming a diet that contains all the essential nutrients needed by the body because nutrient deficiencies are common and may adversely affect appearance. The nutrient triage theory, proposed by Bruce Ames, avers that natural selection is known to favor short-term survival at the expense of long-term health when they are in conflict.[3] Ames hypothesized that as the scarcity of a micronutrient increases, a triage mechanism for allocating scarce micronutrients

is activated that favors short-term survival at the expense of long-term health. This suggests that scarce micronutrients get shunted to vital organs leaving lesser body parts like hair, skin, and nails with shortages.

Dietary Guidelines for Americans 2015-2020 showed that the population consumes a nutrient-poor diet, notably lacking in fruits and vegetables.[4] Others suggest that fruits and vegetables may help with facial appearance and provide essential nutrients needed to enhance skin integrity.[5,6]

Some have proposed functional foods as a vehicle to deliver essential nutrients missing from the typical diet.[7] The purpose of this study is to assess the effect of nutrient-dense, functional foods on appearance using both subjective and objective measurements.

METHODS

This was a prospective, single-armed, 8-week study where individuals served as their own controls for hair, skin, and nails. At baseline, before the nutrient-dense foods were consumed, subjective and objective measurements were made of hair, skin, and nails. In addition, prospective information was obtained weekly about compliance with the nutrient-dense functional foods, quality of life, and changes in body weight. Individuals took photos of themselves at baseline, week 4, and week 8 from various poses.

Subjects

Participants were recruited through social media (e.g., Facebook, Instagram). Each gave informed consent that abided by the Helsinki Declaration. Entry criteria were: aged 25-40-years, had a body mass index (BMI) of 20-40 kg/m^2, never consumed the nutrient-dense functional foods before, not pregnant, breastfeeding, or trying to get pregnant, and had no poorly controlled chronic condition.

Dietary Intervention

Subjects were provided two nutrient-dense, portion-controlled functional foods daily over two months. These were provided at no charge and were easy-to-prepare; most required just the addition of hot or cold water or milk. Participants received one shake and could choose between chocolate and vanilla. The second, nutrient-dense food consisted of oatmeal, cereal, or rice cereal (nutrient-foods.com).[8] Each functional food contained at least 25% of the daily value (DV) for every vitamin and mineral, except sodium and chloride. At least 25% adequate intakes (AI) for omega-3s were also included in each offering. Free nutrition coaching was provided to assist with questions about the dietary intervention and aid compliance. Each week, the participants reported how many of the two functional foods they consumed and how much of each they ate. In addition, subjects logged average weekly water consumption.

Objective Measurements the Skin

Provided at no charge to the participants were a salivary pH test (pHion Balance, Apex Wellness Group, LLC, Scottsdale, Arizona), and a skin hydration device (Luna FOFO, Las Vegas, NV, USA).

According to the manufacturer, normal salivary pH is 6.75 to 7.25. Skin issues, including acne, dryness, wrinkles, and oiliness occur when the skin is either excessively acid or basic.[9] Salivary pH acts as a surrogate marker for skin pH.

Skin hydration is measured using a three-tier scoring system: (1) Overall score: 0-100; (2) Moisture: low, normal, high; and (3) Age: -2 through +2. Appearance improved with a higher score, increased moisture compared to baseline, and "reverse" aging (e.g., going from +2 to -2-years). Raw data were presented as improved, stayed the same, or worsened.

Subjective Assessments of Hair, Skin, and Nails

Questionnaires: At baseline, week 4, and week 8, participants completed inquiries related to hair, skin, and nails.[10-12] The questionnaires used in this study were adapted from previously published information but were not validated.[10-12] The survey that referred to hair probed hair loss, brittleness, dryness, fizziness, and appearances like shininess. The skin questionnaire asked information about color, smoothness, pore size, and hydration. The nail-specific questioned related to smoothness, color, red areas around the nails, and perceived speed of growth. Each question used a rating system of 1 to 5, where 1 was the worst and 5 was the best.

Self photos: At baseline, week 4, and week 8, participants took close-up photographs of their face using their cell phones from these different positions: facing left cheek, nose, and chin; facing right check, nose, and jawbone; and up close to the forehead. The subjects were told to wear no make, not to use filters, and be sure there was adequate lighting.

Assessments were made for skin characteristics: redness, pore size, skin color, and acne at baseline, week 4, and week 8. Acne was objectively measured using a rating scale.[13] All photos were rated using a scale of 1 to 5, with 1 being the best and 5 being the worst.

Quality of Life Questions

At baseline and weekly, subjects answered nine questions about their quality of life. Each was rated using a scale of one to five, with 5 being the best and 1 being the worst. The questions asked related to: general feeling, fullness, mood, energy level, any gastrointestinal symptoms (GI), sleep quality, stress, focus, and passion. Data were compared at baseline, week 4, and week 8. The percentage change between the mean at baseline and week 8 was calculated.

Statistics

All data were expressed as means±standard deviations. All the parameters were compared by Student *t*-test and significance was defined at $p \leq 0.05$. If there were equal numbers of participants between baseline and week 4 or week 8, the paired Student *t*-test was used, otherwise, unpaired Student *t*-test was used for the comparisons.

RESULTS

Thirty-six individuals enrolled in the study and eight withdrew (78% retention) related to one person not liking the nutrient-dense food provided, five not responding to the coach, one had a medical issue not related to the study, and one did not tolerate the foods.

The 28-participant study included mostly females (n=24; 78%) and the average age was 27±4-years. At baseline, about half were a healthy body weight, and one-third were obese (Table 1). Most participants thought that they were consuming a healthy diet (86%). Participants remained weight stable throughout the study (baseline weight 73±14 kg; week 6 weight 72.1±14.0) (data not shown). The goal of the study was to remain weight stable to exclude the effect of weight change on appearance.

Table 1. *Baseline Body Weight and Diet History*

Attributes	Findings
Height (cm)	164±8*
Weight (kg)	73±14*
Body Mass Index (BMI)	27±6*
20 to≤25	15 (54 %)
26≤30	5 (18 %)
31≤35	7 (25 %)
More than 35	1 (4 %)
Diet	
Believed to be eating a healthy diet	
Yes	24 (86%)
No	4 (14 %)
Doctor recommended a special diet	
Yes	5 (18 %)
No	23 (82 %)
* Mean±SD.	

The participants consumed more than six of the seven nutrient-rich shakes and more than six of the seven meals that were provided weekly. Daily water consumption remained stable throughout the study (baseline, 6.2±1.7 cups; week 8, 6.5±1.5 cups); the recommended number was seven cups per day. Of those who exercised, the mean duration of minutes over the 8-week study increased from 192±112 minutes at baseline to 335±537 minutes at week 8. The length of exercise bouts varied widely from 20-minutes to 8-hours weekly.

Objective Measurements

The two objective measures of appearance did not show significant improvements. Salivary pH remained stable over the 8-week study and was considered acidic according to the manufacture's recommendation of normal salivary pH (i.e., 6.75 to 7.25). Mean salivary pH was 6.30±0.76 at baseline; 6.44±0.64 at week 4, and 6.36±0.63 at week 8. The skin hydration objective measurements showed mixed results. A number of participants showed improvements: skin score (6; 21%), skin moisture (7; 25%), and skin aging (10; 36%). However, others had worsening effects for skin score (15; 54%), skin moisture (6; 21%), and skin aging (9; 32%). No changes were observed for the remaining subjects for skin score (7; 25%), skin moisture (15; 54%), and skin aging (9; 32%).

Subjective Measurements

Questionnaires: Questionnaires specific to hair, skin, and nails over the 8-week study are presented in Tables 2, 3, and 4. The measurement scale used was 1-5, with 1 being the worst and 5 being the best. The hair-specific questions all showed improvements (Table 2). Significant benefits ($p \leq 0.05$) at week 4 and week 8 compared to baseline were seen for: less hair falling out as seen on a pillow in the morning after an overnight sleep; less brittleness and dryness; less breakage after tugging on it; and increased shininess.

All attributes of the appearance of the skin improved (Table 3). Significant improvements ($p \leq 0.05$) were observed between baseline and week 8 for: color (less blotchiness), hydrated appearance with less flakiness, and less burning or itchiness after washing. Near-significant improvements ($p=0.08$) were observed for smoothness with fewer bumps related to blackheads or whiteheads and decreased pore size.

Table 2. *Subjective Changes in Hair Appearance**

Attribute	Baseline	Week 4	p values (Baseline vs. week 4)	Week 8	p values (Baseline vs. week 8)
Less hair falling out	3.86±0.93	4.39±0.69	0.02	4.32±0.82	0.05
Brittle or dry	3.07±0.81	3.89±0.88	0.0006	3.93±0.94	0.0006
Fizziness	3.18±1.25	3.39±0.99	NS	3.32±1.22	NS
Dandruff	3.63±1.04 ^	4.00±1.15	NS	4.04±1.23	NS
Tugging at hair cause breakage	3.79±0.83	4.36±0.83	0.01	4.54±0.64	0.0004
Shininess	3.39±0.69	3.96±0.92	0.01	4.11±0.83	0.0009
Floats in water (a good thing)	3.80±1.10 ^	4.18±0.90	NS	4.25±0.89	NS

**Each attribute was rated on a scale of 1 to 5, with 1 being the worst and 5 being the best. Data expressed as mean±SD. P values are calculated by Student's paired t-test, except those with ^, wherethe p values were calculated by Student's unpaired t-test. The significance is determined by p≤0.05; NS=no significance.*

Table 3. *Subjective Changes in Skin Appearance**

	Baseline	Week 4	Week 8	*p* value (Baseline vs. week 8)
Color (e.g., blotchiness, spots)	3.25±0.80	3.64±0.95	3.79±0.83	0.02
Smoothness (e.g., bumps due to blackheads or whiteheads)	3.11±0.79	3.39±0.74	3.46±0.69	NS (p=0.08)
Poresize	3.18±0.94	3.43±0.84	3.64±0.99	NS (p=0.08)
Appear hydrated and lacking flakiness	3.57±0.69	3.93±0.90	4.04±0.69	0.02
Face feeling itchiness or burning after washing	3.71±0.71	4.07±0.9	4.25±0.97	0.02

**Each attribute was rated on a scale of 1 to 5, with 1 being the worst and 5 being the best. Data expressed as mean±SD. P values are calculated by Student's paired t-test. The significance is determined by p≤0.05; NS=No significance. No significant differences were observed between baseline and week 4.*

Table 4. *Subjective Changes in Nail Appearance**

	Baseline	Week 4	P values (Baseline vs. week 4)	Week 8	P values (Baseline vs. week 8)
Smoothness without pits or grooves	3.39±1.07	3.68±0.82	NS	4.11±0.83	0.007
Onecolor, free of spots	4.07±0.87^	4.39±0.79	NS	4.50±0.75	NS (p=0.06)
Ridges or whitelines	3.86±1.04	4.11±0.96	NS	4.14±0.71	NS
Even in thickness	3.54±1.10	3.93±1.15	NS	4.46±0.96	0.001
Swelling, redness around nails	4.30±1.03^	4.43±0.92	NS	4.75±0.52	0.05
Fail to grow after cutting	3.79±1.03	4.29±0.66	0.04	4.64±0.56	0.0003

**Each attribute was rated on a scale of 1 to 5, with 1 being the worst and 5 being the best. Data expressed as mean±SD. P values are calculated by Student's paired t-test, except those with ^, wherethe p values were calculated by Student's unpaired t-test. The significance is determined by p≤0.05; NS = no significance.*

Each nail subjective attribute improved over 8-weeks (Table 4). Only faster nail growth was significantly different at week 4 compared to baseline (p=0.04). Smoothness, evenness in thickness, reduced redness around the nails, and faster nail growth were all significantlyimproved (p≤0.05) between baseline and week 8.

Self photos: Subjects took photographs of themselves at baseline, week 4, and week 8 (Table 5). Each parameter improved over the 8 weeks, using a scale of 1 to 5, with 1 being the best. Redness was significantly reduced at week 4 (2.11±0.58; p=0.003) and week 8 (1.96±0.59; p=0.0003). Pore size significantly reduced at week 4 (2.22±0.51; p=0.009) and week 8 (2.15±0.53; p=0.003). Skin color significantly improved at week 4 (2.07±0.62; p=0.01) and week 8 (2.07±0.62; p=0.01). Using an acne-rating scale, significant improvement was observed at week 8 compared to baseline (1.74±0.81; p=0.05).

Table 5. *Evaluation of Self Photographs of Participants**

Attribute+	Baseline	Week 4	Week 8
Redness	2.74±0.86	2.11±0.58 p=0.003	1.96±0.59 p=0.0003
Pore size	2.67±0.68	2.22±0.51 p=0.009	2.15±0.53 p=0.003
Skin color	2.59±0.80	2.07±0.62 p=0.01	2.07±0.62 p=0.01
Acne	2.26±1.10	1.93±0.92	1.74±0.81 p=0.05

**Data expressed as means±SD; P values calculated by paired t-test and were obtained from comparisons to baseline data.*
+Attributes were scored using a scale of 1 to 5, with lower scores equaling improvement.

Quality of Life

Each attribute improved over the 8-week study (Table 6). Compared to baseline, at week 4 and at week 8, significant improvements (p≤0.05) were observed for: an improved feeling of well-being, feeling full, having more energy, sleeping better, having less stress, and being more focused. No significant change was observed for mood, gastrointestinal issues, and passion.

DISCUSSION

The desire to have a good appearance continues through the life cycle, as evidenced by the billions spent yearly on beauty products.[2] Besides topical agents, consumers ingest pills and foods, believing that they will enhance how they look; most are not science-based and are ineffective. We took the approach in this study to improve the nutritional quality of the diet by providing nutrient-dense functional foods that are also low in unhealthy things like salt, sugar, and saturated fats. The diet of most Americans is nutrient-poor and contains too many unhealthy components.[4] We hypothesized that improving diet quality with nutrients and reducing the intake of salt, sugar, and saturated fats could improve appearance. Body weight remained unchanged during the study, suggesting that the

Table 6. *Changes in General Quality of Life Attributes**

	Baseline	Week 4	*p* values (Baseline vs. week 4)	Week 8	*p* values (Baseline vs. week 8)
General feeling of wellbeing	3.11±1.09^	3.79±0.83	0.01	3.75±0.80	0.02
Feel full	3.25±0.75	3.79±0.74	0.009	3.86±0.76	0.004
Mood	3.50±1.04	3.82±0.82	NS	3.93±0.60	NS (p=0.06)
Energy	3.25±1.00	3.79±0.88	0.04	3.86±0.65	0.01
Gastrointestinal symptoms	3.52±0.98^	3.43±1.17	NS	3.75±0.89	NS
Sleep	2.89±1.17	3.68±0.77	0.004	3.82±0.90	0.002
Stress	2.64±0.91	3.57±0.79	0.0002	3.64±1.06	0.0004
Focus	3.07±1.02	3.86±0.76	0.002	3.89±0.69	0.0008
Passion	3.22±1.22^	3.46±1.26	NS	3.75±1.04	NS

**Each attribute was rated on a scale of 1 to 5, with 1 being the worst and 5 being the best. Data expressed as mean±SD. P values are calculated by Student's paired t-test, except those with ^, wherethe p values were calculated by Student's unpaired t-test.The significance is determined by $p \leq 0.05$; NS = no significance.*

two nutrient-dense foods replaced regular meals rather than providing additional energy.

Over this 8-week study, the participants consumed about two nutrient-rich functional foods daily, which provided 67% of the daily need for vitamins and minerals. All subjective measures of appearance significantly improved related to hair, skin, and nails. Serial photographs from the participants of themselves revealed the benefits after eating the nutrient-dense foods. Each parameter improved over the 8 weeks, and significant changes occurred for reduced redness and pore size, and skin color improved. At week 8, significant improvements were observed for less acne.

In contrast to these subjective measures of appearance, objective measures of skin appearance using a moisture-measuring device and salivary pH did not change over time. No scientific evidence exists between salivary pH and skin integrity, yet the internet touts a relationship suggesting that skin, which is too acidic based on salivary pH, is less appealing than those with normal salivary pHs.[9]

All measurements of the general quality of life improved over 8 weeks. Significant improvements were for feeling better, fullness, having more energy, sleeping better, less stress, and better focus. These findings were not surprising and were observed in other studies where participants consumed one nutrient-dense functional food daily.[14-16]

There were several limitations of this study. First,we did not include a control arm as we considered this to be a pilot study and a proof of concept that nutrient-rich foods affect appearance; subsequent studies by us or others should include control arms. Secondly, we included both normal and overweight individuals which could affect the results of appearance. The third limitation was that exercise could be a factor on appearance, and we did not consider this on in our analyses.

CONCLUSION

One's appearance is of intense interest and the public spends billions annually on mostly unproven therapies. A poor diet is considered to be a major cause of poor-quality skin, cracked or slow growing nails, and hair lacking luster and dryness. We showed that the inclusion of two healthy, nutrient-rich functional foods improved how the participants subjectively viewed their appearance. Hair, skin, and nail significantly improved. In addition, quality of life attributes not related to appearance improved for a feeling of well being, stress, energy, and sleep. Inclusion of nutrient-dense functional foods improves appearance and quality of life. These foods were well received and easy-to-prepare leading to excellent compliance with the dietary protocol of two offerings daily.

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The authors are grateful to the participants, who dutifully completed their weekly data collections forms and provided the necessary photographs of themselves. Based on the feedback from the participants, they were pleased with their results.

Self photographs were assessed by two of us (RR and WC). RR is a licensed esthetician with the Nevada State Board of Cosmetology for more than 20-years, received additional paramedical training in laser treatments and LED Modalities, and does make-up artistry. WC is certified by the American Board of Family Medicine and his practice focuses on integrative medicine. He received additional Fellowships and Diplomatic status from the American Academy of Anti-Aging Medicine in Age Management and Non-Surgical Aesthetic Medicine.

The study was conducted throughout the US as subjects were recruited *via* social media and participated remotely.

Nutrient granted permission to conduct this study.

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Nutrient, Reno, Nevada, supported this study by providing food and appearance-measuring devices at no charge to the participants.

CONFLICTS OF INTEREST

All co-authors, except two, are full-time employees at Nutrient, the company that manufactures and sells the nutrient-dense functional foods used in this study. Dr. Ling conducted statistical analyses as a consultant. Dr. Clearfield is in private practice and serves on the Scientific Advisory Board of Nutrient.

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