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Comparison of the antioxidative action of the two N-acetylcystein containing products: Propomucil® and Fluimucil® in a group of smokers who have seasonal coughing problems

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Abstract

Oxidative stress reflects a state of disturbed balance between pro-oxidants and endogenous systems of antioxidative protection. N-acetyl cysteine (NAC) is well-known antioxidant for its reduction properties which originate from sulfhydryl group of cysteine. It is used as a mucolytic because it reduces viscosity of the bronchial secretion. It alleviates expectoration and hard breathing by disrupting disulfide bonds of mucopolysaccharide. Propolis is used for various purposes due to its antibacterial and anti-inflammatory effects. Complex mixture of various compounds synergistically contributes its overall effect, and bioflavonoids, manifest antioxidant effects. The goal was to examine antioxidative effect of propolis by comparing the oxidative stress status of the respondents before and after ten-day supplementation of NAC or combined supplement product of NAC and propolis. The study includes 20 healthy respondents (18 smokers and 2 nonsmokers), divided into two groups. The first group consists of 10 respondents defined on the combined supplement product of NAC and propolis (200 mg NAC/80 mg propolis, 3 times a day) and the second group consists of 10 respondents defined on one-component preparation of NAC (200 mg NAC 3 times a day). The blood samples were taken before and after a ten-day supplementation of preparations. The following parameters of the prooxidative effect in the serum were determined: products of advanced protein oxidation (AOPP), malondialdehyde (MDA), total oxidative status (TOS), prooxidative-antioxidant balance (PAB). Also, the parameters of antioxidant protection were determined: total antioxidant status (TAS), total sulfhydryl groups (SHG), activity of superoxide-dismutase enzyme (SOD) and paraoxonase 1 (PON1). After supplementation, the combined preparation has significantly increased the parameters of antioxidant protection: SOD, PON and TAS for all subjects in the group. Moreover, one-component preparation of NAC has significantly influenced on the increase of SOD, SHG and on decrease of AOPP. Both preparations improve antioxidant protection and it is showed significant contribution of effect of propolis in combination with NAC.

Key words: oxidative stress, antioxidant protection, N-acetylcysteine, propolis

INTRODUCTION

Oxidative stress reflects a state of disturbed balance between pro-oxidants and endogenous systems of antioxidative protection which can potentially damage the cell and its subtle organelles. Pathophysiology of different acute respiratory diseases also includes segment of the oxidative status disorder, which contributes to general inflammation. Also, the oxidative status disbalance occurs in smokers due to exposure to the free radicals from cigarettes, which are abundantly generated in tobacco smoke [1].

Acute respiratory infections are very common world-wide and also in our country. The frequency of these diseases is high and it makes a significant percentage of total morbidity in the countries all over the world, especially among smokers [2]. High percentage of respiratory diseases in general population can be explained by the direct contact between large area of respiratory system with external environment, with large number of different pollutants [3]. The most common manifestations of acute respiratory infections are cold, acute otitis, acute bronchitis, pneumonia, exacerbation of chronic obstructive pulmonary disease (COPD) and

bronchial asthma [4]. These infections are treated with standard antibiotics therapy, antipyretics and bronchodilators, and especially with mucolytic agents, because one of the most common symptoms is cough.

N-acetylcysteine (NAC) can be found in clinical practice for few decades [5]. NAC is a cysteine derivate with linked acetyl group with nitrogen and as majority of thiols, it can be oxidized with different free radicals. It can serve as nucleophile and it is a good antioxidant because of its reduction properties [5]. NAC is a glutathione precursor and after its oral use, it becomes deacetylated in the intestines. Also, NAC reduces cysteine from cysteine, which is an important mechanism of intracellular metabolism of glutathione in the lungs [6]. It is used as mucolytic because it reduces viscosity of bronchial secretion; it alleviates expectoration and heavy breathing by disrupting disulfide bonds of mucopolysaccharide chains [7].

Propolis is a generic name for resins collected by bees from various plants and it is being used through centuries for various purposes due to its antibacterial and anti-inflammatory effects. Propolis is a complex mixture of various compounds which synergistically contribute to its overall effect, and bioflavonoids, which manifest antioxidant effects [6]. Different studies have shown the efficiency of N-acetylcysteine as anti-inflammatory and antioxidative factor. Recently conducted studies in which subjects were both adults and children, showed the efficiency of preparation which beside the N-acetylcysteine also contains propolis [3,4,6,8–11].

It is well-known fact that tobacco smoke may contribute to the development of different chronic lung and cardiovascular diseases [1]. It causes lipid peroxidation, oxidation of proteins and thus damage to the lungs and other tissues [1]. One package of cigarettes (20 pieces) contains 10^{15} of oxidative radicals [1]. This current study was conducted in a group of healthy subjects who are smokers, in order to test their redox status before and after supplementation with two different antioxidative preparations. Cough caused by smoke, followed by increased production of bronchial secretion are common symptoms that are seen with regular smokers [12]. In relation to that, the study included smokers who complained about productive cough during the winter months. The main goal of this study was to compare antioxidative effect of propolis combined with NAC (PropoMucil®) and mono-NAC preparation (Fluimucil®).

MATERIAL AND METHODS

The study included 20 healthy subjects (18 smokers and 2 nonsmokers), divided into two groups. The first group consisted of 10 subjects who used the combined preparation of NAC and propolis (*PropoMucil*®, *AbelaPharm, Serbia*) and the second group consisted of 10 subjects who used one-component preparation of NAC (*Fluimucil*®, *Zambon, Switzerland*).

The both study groups consisted of 5 younger subjects (22.8 ± 1.63 years) and 5 older subjects (39.6 ± 10.0 years). Age differences were separately analyzed regarding the preparations that the subjects used.

Blood was drawn after an overnight fast in vacutainers with serum separator gel (*Becton, Dickinson and Company, Franklin Lakes, New Jersey*) in two time points: firstly, at the beginning of the study and then after a ten-day supplementation with a suitable preparation with an active NAC component in a predefined dosage form and dosage regimen, as follows:

1. *PropoMucil*® group: 200 mg NAC/80 mg propolis, 3 times a day in the form of granules for oral solution and
2. *Fluimucil*® group: 200 mg NAC, 3 times a day in the form of granules for oral solution.

Comparison of redox status parameters before and after supplementation, was done by using paired T test. Comparison of parameters' change was performed depending on the type of the products, as well as in two age groups by Student t test. Determination of redox status involved the analysis of several selected representative parameters, precisely prooxidants or products of their action on biomolecules: malondialdehyde (MDA), advanced oxidation protein products (AOPP), total oxidative status (TOS) and prooxidative-antioxidant balance (PAB). Also, the following parameters of antioxidant protection were determined: total antioxidant status (TAS), total sulfhydryl groups (SHG), activity of enzymes: superoxide-dismutase (SOD) and paraoxonase 1 (PON1).

Principle of method for the determination of AOPP

After the addition of glacial acetic acid (40 μ L) to a diluted sample with phosphate buffer (pH 7.4) and a potassium iodide solution of 1.16 M (1:5), the absorbance was measured at 340 nm, on the *Ilab 300+ Instrumentation Laboratory, (Milan, Italy)*. The concentration of AOPP is expressed through chloramine T equivalents which are used to produce a standard curve at concentrations of 10–100 μ mol/L, whereby its absorption linearly increases with increasing concentration.

Principle of the method for determining TOS

The main components of the TOS system in the serum are H_2O_2 and lipid hydroperoxides. The oxidants presented in the sample oxidize the ferro-ortho-dianiside complex in the ferric ion. The oxidation reaction is facilitated by the glycerol molecule present in the reaction medium. The resulting ferric ion then builds a colored complex with xylenol-orange in an acidic environment. The intensity of the color is measured by spectrophotometric method, at the *Ilab 300+ Instrumentation Laboratory, (Milan, Italy)*, and it is proportional to the total content of the oxidation molecules in the sample. As standard, an aqueous hydrogen peroxide solution of

a concentration range of 10–200 µmol/L was used, which corresponds to the linearity of the method and the expected concentrations in the biological material.

Principle of the method for the MDA determination

The concentration of MDA is determined as a thiobarbituric acid-reactive substance (TBARS) by a spectrophotometric assay based on the absorption maximum of the malondialdehyde complex and other TBARS with thiobarbituric acid. Absorbance was measured on an *ELISA reader (LBK, Wien, Austria)*.

Determination of PAB

The PAB test determines the concentration of H₂O₂ in the antioxidant environment. Chromogen 3,3',5,5'-tetramethylbenzidine (TMB) reacts with H₂O₂ and with antioxidants (uric acid) at the same time, since they are in the same environment. The reaction of H₂O₂ and chromogen is enzymatically catalyzed by peroxidase, whereby the oxidation of TMB gives intensely blue-colored product. In contrast to that, a reaction between uric acid and chromogen is a non-catalyzed chemical reaction in which TMB cation is reduced to a colorless product. These two components have been selected for prooxidant and antioxidant agents because they do not react with each other and do not interfere with each other's activity against chromogen. Based on the absorbances which are obtained in the standard solutions, the calibration curve is formed and used for the results calculation.

Determination of PON1

The determination of PON1 activity is based on the operation of PON1 enzymes from the sample to the substrate of paraoxone, whereby the conversion of the paraoxone to p-nitrophenol occurs, and the rate of change is monitored kinetically. The enzyme activity is determined at 25°C and at pH 8.5 using 50 mmol/L TRIS-HCl buffer in the presence of NaCl and it is expressed as µmol obtained from p-nitrophenol/min/L or as IU/L. In order to determine PON1 activities, the *Ilab 300+ Instrumentation Laboratory, (Milan, Italy)* was used.

Determination of SOD

The method is based on the ability of SOD to inhibit the spontaneous autooxidation of adrenaline in the alkali environment (pH 10.2) because the adrenaline is quite stable in the acidic solution. Autooxidation of adrenaline was initiated by traces of heavy metals, present as impurities in reagents. The activity of this enzyme is expressed in relative units obtained by measuring the absorbance of the resulting red oxidation product of adrenaline on the *Ilab 300+ Instrumentation Laboratory analyzer, (Milan, Italy)*. One unit of SOD activity was de-

fined as the amount of protein causing 50% inhibition of the autooxidation of adrenaline to adrenochrome.

Determination of SHG

The total content of SHG is determined by the Ellmann method, which is based on the reaction of 2,2'-dinitro-5,5'-dithio-benzoic acid with aliphatic thiol compounds in the alkali environment (pH 9.0) thereby creating 1 mol of p-nitrophenol anion per mol of thiol. Since this anion is yellow, its absorbance is measured at 412 nm at the *Ilab 300+ Instrumentation Laboratory, (Milan, Italy)*.

Determination of TAS

The total antioxidant status was determined by a colorimetric test using stable 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) cation as a chromogen. The ABTS solution itself is colorless. Oxidation to ABTS⁺ cations, using H₂O₂ in an acidic medium (pH 3.6), the solution gives a characteristic emerald color. When colored ABTS⁺ is mixed with an antioxidant, it is reduced to a colorless ABTS, which is manifested by color change. The color intensity decrease is proportional to the total concentration of the all antioxidants existing in the sample. The reaction was performed at the *Ilab 300+ Instrumentation Laboratory, (Milan, Italy)*.

RESULTS

Table 1 shows concentrations of prooxidants and products of their action before and after supplementation, in subjects who used the combined preparation PropoMucil®. Also, the concentrations/activities of antioxidant parameters are shown in the same Table 1. After ten days of supplementation, the trend of reducing all parameters from the group of prooxidants is noticed, but this difference was not statistically significant. The data in all tables are shown as mean values and standard deviations.

Table 1. Prooxidants, products of their activity and antioxidants before and after a ten-day supplementation with the combined preparation of NAC and propolis (PropoMucil®).

Parameter	Baseline	After the supplementation	P
MDA (µmol/L)	1.9±0.6	1.8±0.4	0.919
AOPP (µmol/L)	21.8±10.1	17.8±3.9	0.333
PAB (U/L)	134±34	130±27	0.508
TOS (µmol/L)	19.3±14.0	18.7±11.9	0.878
TAS (µmol/L)	1387±354	1546±531	0.047
SHG (mmol/L)	0.365±0.076	0.388±0.091	0.484
SOD (U/L)	118±12	137±8	0.005
PON1 (U/L)	321±279	376±331	0.012

We also noticed significant increase in the antioxidant protection parameters (SOD, PON1 and TAS). The obtained results are presented graphically (Figure 1), where the effect of the preparations can be noticed in each subjects individually.

The concentrations of prooxidants, the products of their activity and antioxidative parameters of the subjects who used the one-component preparation – Fluimucil® before and after a ten-day supplementation, are shown at the Table 2.

Table 2. Concentrations of prooxidants, products of their action before and after a ten-day supplementation of the subjects who were defined on a one-component preparation.

Parameter	Baseline	After the supplementation	P
MDA (μmol/L)	1.60±0.60	1.50±0.50	0.594
AOPP (μmol/L)	29.4±9.4	14.7±2.8	0.047
PAB (U/L)	128±16	131±25	0.515
TOS (μmol/L)	19.5±12.2	17.1±9.5	0.507
TAS (μmol/L)	1351±345	1411±431	0.721
SHG (mol/L)	0.290±0.080	0.362±0.121	0.028
SOD (U/L)	117±17	138±8	0.005
PON1 (U/L)	325±209	340±205	0.139

Figure 1. Change in the oxidative status parameters of the subjects individually, after the combined preparation usage (PropoMucil®).

Marks: 1 – before, 2 – after, *-P<0.05 after the supplementation

Figure 2. Change in the parameters of the oxidative status of the subjects individually before and after the one-component preparation usage (Fluimucil®).

Marks: 1 – before, 2 – after, *, **, ***-P<0.05, 0.01, 0.001 after the supplementation

Fluimucil® preparation caused significant increase of SOD enzymatic activity and also total SHG both of which are a part of general antioxidant protection. Fluimucil® influenced significantly the decrease of AOPP. The obtained results are also graphically presented (Chart 2), where the change of parameters is presented in each subjects individually.

Comparison of the oxidative status parameters between the combined and one-component preparation, PropoMucil® vs. Fluimucil® supplementation

After examining the results for each individual preparation, a statistical analysis was done by using Student's

t test in order to estimate the differences between these two supplements. In addition to the basic parameters whose concentration was directly measured, the differences in the concentration of the parameters (before – after) were calculated and these values were marked with the addition of the lower case *d* (difference) in front of the parameter of interest.

Although the noticed differences were of the marginal statistical significance, it should not be neglected even this small shift in the PON1 activity before and after supplementation (dPON, Table 3). Difference in PON1 was in favor of the combined preparation, i.e. after the Propomucil® supplementation, values were significantly higher than after the Fluimucil® supplementation. Similarly, as a consequence of supplemen-

Table 3. Comparison of oxidative status parameters before and after ten days' supplementation with different preparations

Parameter (1-before, 2-after)	PropoMucil®	Fluimucil®	P
SOD1(U/L)	118±12	117±17	0.684
SOD2(U/L)	137±8	138±8	0.631
dSOD	19±9	21±6	0.684
PON1(U/L)	321±279	325±209	0.579
PON2(U/L)	376±331	340±205	0.789
dPON	55±58	16±29	0.089*
TAS1(mol/L)	1387±354	1351±345	0.796
TAS2(mol/L)	1546±531	1411±431	0.393
dTAS	159.3±200.5	60.1±161.2	0.315
SHG1(mol/L)	0.365±0.076	0.290±0.080	0.063*
SHG2(mol/L)	0.388±0.091	0.362±0.121	0.436
dSHG	0.023±0.071	0.072±0.090	0.165
AOPP1(mol/L)	21.8±10.1	29.4±9.4	0.353
AOPP2(mol/L)	17.8±3.9	14.7±2.8	0.075*
dAOPP	-4.1±11.1	-4.7±9.4	0.796

* – P values indicate marginal statistical significance (0.050 < P <0.100)

tation, there is also a reduction in AOPP (AOPP2: Table 3). Both preparations decreased the concentration of AOPP, but there is a greater reduction in the one-component preparation – Fluimucil®. Also, the SHG concentrations before supplementation differed slightly, but this is probably not a consequence of supplementation, but because of an initial difference in the values of the subjects (SHG1, Table 3). The calculated values of the difference in the concentration/activity of param-

eters before and after supplementation (d) in the parameter of interest, did not show a statistically significant difference (Table 3), which means that generally speaking, the both preparations equally exhibit an antioxidant effect.

Comparison of antioxidative index between older and younger subjects before and after supplementation

As respondents differ by their age, the results are analyzed between the two age groups. Any variation of concentration of TAS or TOS directly reflects the antioxidant index, which is the ratio of these two parameters. Chart 3 shows antioxidant indexes with all subjects' sub-groups (both elderly and younger, depending on the preparation they used). Within younger respondents group, TAS values were significantly lower than within the older respondents, also TOS values are lower, so this compensated for weaker antioxidant protection. The antioxidative index was statistically higher within younger subjects group, after supplementation with both preparations. The Propomucil® shows a higher trend in the antioxidant index increase, compared to the Fluimucil®, and we could suppose that propolis is responsible for this fortification of supplement's antioxidative potential.

It is noted that NAC increases the activity of SOD enzymes in both age groups. Since the initial activities in the younger ones were higher in relation to the elderly (SOD1; P = 0.007, Table 4), the activity after supplementation was also higher in younger subjects (SOD2; P = 0.009, Table 4). Differences in SOD activity before and after supplementation are not statistically significant in these two groups (dSOD; P = 0.123,

Figure 3. Antioxidant index (TAS/TOS ratio) among older and younger subjects on two different kinds of therapies

P- PropoMucil®, F- Fluimucil®

aa-P<0.01 vs. P group-older subjects, bb-P<0.01 vs. F group – younger subjects

Table 4). This means that the effect of NAC in both age groups is the same on the antioxidant SOD enzyme. The initial MDA values were approximately the same in both groups, however, after the NAC supplementation, a statistically significant decrease in the concentration of MDA (MDA2; $P = 0.029$, Table 4) was observed only in the younger group. In the overall redox balance parameter in the elderly, an unexpected increase was observed after supplementation (PAB2; $P = 0.011$, Table 4), while in the younger ones, these values were reduced but not significantly. The parameter showing the difference in concentration before and after, statistically and significantly varies (dPAB, $P = 0.019$, Table 4), which is reasonable with the increase in the older ones and decrease in the younger ones.

Table 4: Comparison of parameters of oxidative stress between older and younger subjects, before and after NAC supplementation

Parameter (1-before. 2-after)	PropoMucil®	Fluimucil®	P
SOD1(U/L)	109±10	126±14	0.007
SOD2(U/L)	134±7	141±7	0.009
dSOD	22.9±10.9	15.8±8.7	0.123
PON1(U/L)	343±246	303±245	0.853
PON2(U/L)	377±260	340±290	0.796
dPON	33.6±43.8	37.1±56.2	0.971
SHG1(mmol/L)	0.308±0.089	0.346±0.082	0.315
SHG2(mmol/L)	0.323±0.073	0.426±0.110	0.029
dSHG	0.015±0.068	0.080±0.082	0.105
TAS1(mmol/L)	1692±108	1046±52	<0.001
TAS2 (mmol/L)	1914±224	1043±78	<0.001
dTAS	222±199	-3.1±56.84	0.011
MDA1(umol/L)	1.88±0.45	1.60±0.73	0.143
MDA2 (umol/L)	1.87±1.88	1.42±0.59	0.029
dMDA	-0.007±0.463	-0.18±0.87	1.000
PAB1(U/L)	129±29	133±24	0.912
PAB2 (U/L)	138±28	124±22	0.123
dPAB	8.95±8.87	-9.4±16.1	0.019
TOS1(mmol/L)	30.4±8.8	8.43±0.71	<0.001
TOS2 (mmol/L)	27.6±4.9	8.20±0.75	<0.001
dTOS	-2.73±10.95	-0.23±1.09	0.912
AOPP1(mmol/L)	21.5±13.1	19.7±4.4	0.631
AOPP2 (mmol/L)	14.5±3.9	18.0±2.6	0.029
dAOPP	-7.06±13.73	-1.7±2.7	0.971

The initial values of SHG in both groups were approximately the same (SHG1; $P = 0.143$, Table 4). However, after the NAC supplementation, a statistically significant increase in SHG (SHG2; $P = 0.029$, Table 4) was

observed only in the younger group of respondents. This result can be explained by the fact that the values of SHG before taking supplements by the subjects defined on the one-component preparation, were significantly lower than by the subjects who used the combined preparation. The initial and final values of total antioxidant status with the elderly were statistically higher in comparison to the younger ones (Table 4). In the elderly, a significant increase in TAS concentration was observed compared to the younger ones in which there was no increase (TAS1; $P < 0.001$, TAS2; $P = 0.001$, Table 4). The concentration of TOS is statistically different before and after supplements between these two groups; the younger group has a significantly lower value (TOS1; $P < 0.001$, TOS2; $P < 0.001$, Table 4). Differences in TOS concentrations before and after supplementation in both groups were not statistically significant (dTOS; $P = 0.912$, Table 4). The AOPP values differ, at the end of the supplementation, the younger are more concentrated compared to the older group (AOPP2, $P = 0.029$, Table 4).

DISCUSSION

After a ten-day supplementation, the results showed that both preparations have a significant antioxidant effect. In order to estimate the effect of propolis in the combined preparation, these two preparations were compared. The PropoMucil® preparation did not cause a significant decrease in prooxidants, but there is obvious trend in its reduction. This can be explained by the fact that, in total, respondents are still young people who, although smokers, did not have the high initial values of prooxidants, so there was not much “space” for reduction. Similar thing can be found with athletes, who are constantly challenged by increased physical activity from generating free radicals. Athletes develop physiological adaptation mechanisms of antioxidant protection that keep free radicals at a low level [13]. For now, young and healthy smokers well tolerate permanent oxidative stress caused by tobacco smoke, but it’s just a matter when the protective mechanisms became ineffective.

The main component of the both supplements is NAC, and the protective ability of NAC against oxidative damage can be explained by its ability to maintain intracellular reduced glutathione concentration and the ability to remove free radicals by various mechanisms [14]. This effect of NAC is confirmed also in this study by healthy smokers, of two different age-groups.

Various studies have shown the effectiveness of PropoMucil® as a combined preparation, which is often used in the treatment of acute respiratory infections due to its mucolytic, anti-inflammatory, antibacterial and antioxidant effect [3, 4, 6, 11]. These studies have shown that the product is suitable and safe for children and adults with acute respiratory infections and for patients who are suffering from COPD. Propolis contributes to the anti-inflammatory effect, precisely because

it represents a complex mixture of various compounds [15]. The anti-inflammatory effect is reflected by the presence of flavonoids, especially galangin [16]. It has been shown that flavonoid inhibits the activity of cyclooxygenase (COX) and lipoxygenase enzymes, reduces the release of prostaglandin E2 and the expression of inducible isoforms of COX2 [16]. Propolis also contains phenylethyl ester of caffeic acid that inhibits the release of arachidonic acid from the cell membrane, suppressing the COX1 and COX2 enzymes and the COX2 gene expression [16].

One study covered only patients with chronic obstructive disease, where it was proven that NAC compared to placebo has an extraordinary effect in reducing oxidative stress [17]. Three studies which included healthy subjects who were smokers, have shown that supplementation of 600 mg NAC per day, significantly reduced prooxidants and increased antioxidant parameters concentration [18 – 20]. Our current study showed similar results, which speaks in favor of the strong antioxidative effect of NAC.

CONCLUSION

After the supplementation, PropoMucil® significantly increased the parameters of antioxidant protection of SOD, PON1 and TAS. Fluimucil significantly increased SOD and SHG, from the parameters of the prooxidative status, and significantly decreased AOPP. Both preparations have an effect on older and younger subjects, but younger subjects have better improvement in their overall redox status. However, in order to estimate real propolis' influence at the antioxidant capacity in biological systems, especially in the combination with NAC, it is necessary to increase the number of subjects, including healthy ones, but also patients with respiratory diseases, which could obtain the most important benefit from this supplementation.

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POREĐENJE ANTIOKSIDATIVNOG DELOVANJA DVA PROIZVODA KOJI SADRŽE N-ACETILCISTEIN: PROPOMUCILA® I FLUIMUCILA® U GRUPI PUŠAČA SA SEZONSKIM KAŠLJEM

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Kratak sadržaj

Oksidativni stres predstavlja stanje narušene ravnoteže između prooksidanasa i endogenih sistema zaštite. N-acetilcistein (NAC) je dobro poznat antioksidans zbog svojih redukcionih osobina, koje potiču od sulfhidrilnih grupa cisteina. Mukolitičko dejstvo ostvaruje raskidajući disulfidne mostove mukopolisaharida. Olakšava iskašljavanje, ublažava kašalj i time popravljajući kvalitet disanja, smanjuje viskoznost bronhijalnog sekreta. Propolis je smeša smola koje sakupljaju pčele sa biljaka, koristi se za različite svrhe zbog svog antibakterijskog i antiinflamatornog efekta. Kompleksna smeša različitih jedinjenja iz propolisa sinergistički doprinosi njegovom ukupnom efektu, a bioflavonoidi koji ulaze u sastav propolisa, ispoljavaju antioksidativni efekat. Cilj ovog rada je ispitati antioksidativni efekat propolisa poređenjem oksidativno-stresnog statusa ispitanika pre i posle suplementacije NAC-om ili kombinovanim preparatom NAC-a i propolisa. Studija obuhvata 20 zdravih ispitanika (18 pušača i 2 nepušača), podeljenih na dve grupe. Prvu grupu čini 10 ispitanika kojima je dodeljen kombinovani preparat NAC-a i propolisa (200 mg NAC/80mg propolis, 3 puta dnevno), a druga grupa obuhvata 10 ispitanika sa dodeljenim jednokomponentnim preparatom NAC-a (200 mg NAC 3 puta dnevno). Krv je uzorkovana pre i nakon desetodnevne suplementacije preparatima. Određeni su sledeći parametri prooksidanasa i produkti njihovog delovanja u serumu: produkti uznapredovale oksidacije proteina – AOPP (engl. advanced oxidation protein products), malondialdehid (MDA), totalni oksidativni status (TOS), prooksidativno – antioksidativni balans (PAB), kao i parametri antioksidativne zaštite: totalni antioksidativni status (TAS), ukupne sulfhidrilne grupe (SHG), aktivnost enzima superoksiddizmutaze (SOD) i paraoksonaze-1 (PON1). Nakon suplementacije, kombinovani preparat je statistički značajno povećao parametre antioksidativne zaštite SOD, PON i TAS kod svih ispitanika, dok je jednokomponentni značajno uticao na povećanje SOD, SHG i smanjenje AOPP, takođe kod svih ispitanika u grupi. Oba preparata poboljšavaju antioksidativnu zaštitu i dokazan je značajan doprinos efekta propolisa u kombinaciji sa NAC-om.

Ključne reči: oksidativni stres, antioksidativna zaštita, N-acetilcistein; propolis