

5HVHDFK \$UWLFOH KWWS ZZZ DOOLHGDFDGHPLHV RUJ MRX

%LRPLQHUTORJ\ RI OXQJ WXPURV

0DFLHM 3DZOLNRZVNL

'HSDUWPHQW RI 0LQHUTORJ\ 3HWURJUDSK\ DQG \*HRFKHPLVWU\ \$  
3RODQG (XURSH

\$EVWUDFW

7KH VWXG\ ZDV GHYRWHG WR GHWHUPLQLQJ ZKHWKHU FDQFHU W  
0RUHRYHU WKH DXWKRU DLPHG WR ILQG WKH DQVZHU IRU WKH IROC  
OHDG WR IRUPDWLRQ RI FDQFHURXV WXPURV RU GR FDQFHU WLVV  
PLQHUTORJ\DWLRQ" 3HUKDSV ERWK SKHQRPHQD DUH SRVVLEOH"  
6WXGLHV ZHUH SHUIRUPHG XVLQJ FODVVL PLQHUTORJ\LFDO PHW  
SUHSDUHG ZLWK WKH XVH RI D PLFURWRPH 2EWDLQHG UHVXOWV FR  
LQ FDQFHU WLVVXHV ,W ZDV UHSUHVHQWHG E\ WZR WSHV RI PL  
PLQHUTORJ\DWLRQ %RWK WSHV DUH SUREDEO\ IDFWRUV FUHDWLO  
IRUPDWLRQ RI FDQFHU 7KLV K\SRWKHVLV KDV WR EH FRQILPHG E\

.H\ZRUG\ OXQJ WXPURV 7LVVXH PLQHUTORJ\DWLRQ \$FFHSWHG RQ )HEUXD

,QWURGXFWLRQ SUHVHQWHG EHORZ 7DEOH \$OO RE  
7DEOHV DQG VKRZHG LQ )LJXUH  
/OXQJ WXPURV GLVFXVHG DQG FRPSDUHG ZLWK OLW

7KHUH DUH PDQ\ YDULHWLHV RI OXQJ WXPURV NQRZQ WR 2QFRORJ\  
0L NRZLDN :DWDEH 7KHLU VKRUW FODVVLILFDWLRQ LV

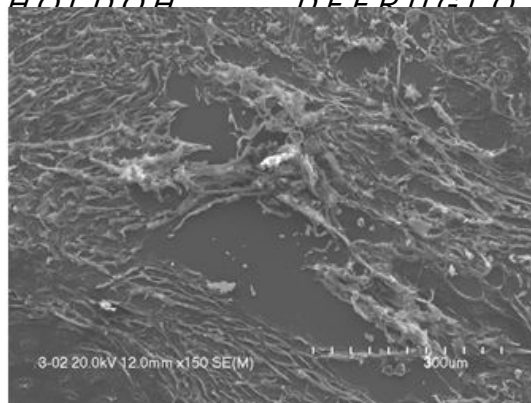
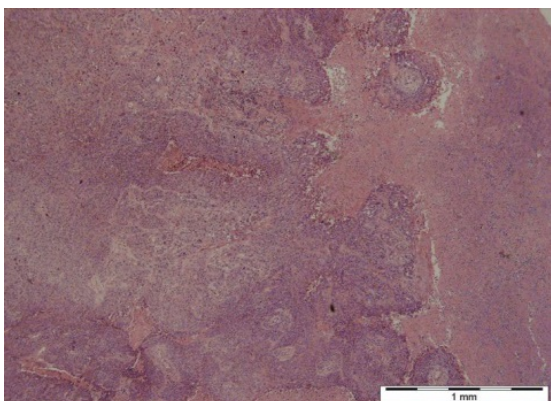
7DEOH 10 FODVVLILFDWLRQ RI PDOLJQDQW OXQJ WXPURV E\ 3DZOLFNL

3ULPDU\ WXPURV			
7[	/DWHQW FDQFHU		
7	1R SULPDU\ WXPURV		
7LV	&DUFLQDPLWX		
7	7XPURV GLDPWHU " FP VXUURXQGHG E\ OXQJ RU YLVFHUO SOHXUD		
7	7XPURV GLDPWHU ! FP LQYDGHV YLVFHUO SOHXUD	DWHOHFWDVLV RU LQIODF	
7	,QYDGHV WKH FKHVW ZDOO GLDSKUDJP SDULHWDO SOHXUD RU SHULFDUGLXP D FORVHU WKDQ FP IURP WKH FDULQD EXW ZLWKRXW LQYDGLQJ WKH FDULQD		
7	,QYDVLQ RI PHGLDVWLQXP KHUW ODUJH YHVVOV WUDFKHD FDULQD HV SOHXUDO HIIXLVLRQ LQ WKH SOHXUDO FDYLW\		
/\PSK QRGH VWDJLQJ			
1	1R O\PSK QRGHV DUH DIIHFWHG		
1	,SVLQDWHUO EURQFKLDO RU KLODU QRGHV		
1	,SVLQDWHUO PHGLDVWLQDO RU VXEFDULQDO QRGHV		
1	&RQWUDQDWHUO PHGLDVWLQDO RU FRQWUDQDWHUO KLODU QRGHV VXSUDFO		
'LVWDQW PHWDVWDVLV			
0	1R GLVWDQW PHWDVWDVLV		
0	'LVWDQW PHWDVWDVLV		
/DWHQW FDQFHU	7[	1	0



6DPSOH &DUFLQRPD SODQRHSLWKHOLDOH DFFRUGLQJ WR :+2

/HIW OXQJ 7XPRU 0DOH \$JH

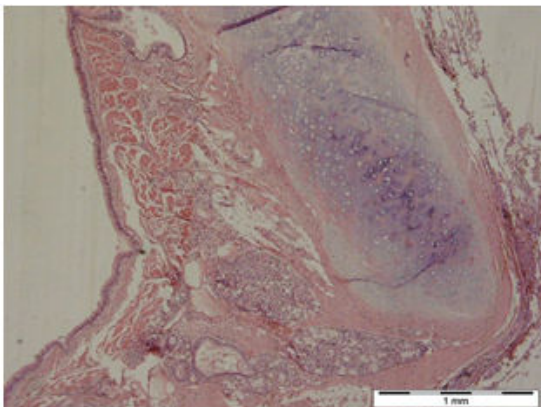


)LJXUH&DUFLQRPD SODQRHSLWKHOLDOH 7LVVXH DUHD FRYHUHG E\ WKH ('6 DQD PDJQLILFDWLRQ DFFRUGLQJ WR VFDOH

)LJXUH&DUFLQRPD SODQRHSLWKHOLDOH 9LVLEOH KLVWRORJLFDQ LPDJH RI SRRU FDUFLQRPD LQILOWUDWLRQ %LRORJLFDQ

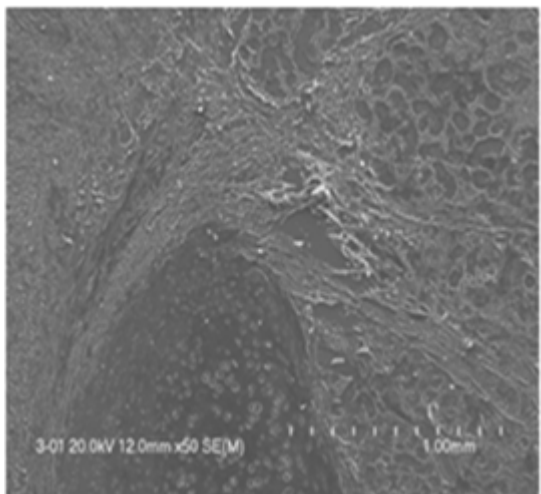
7DEOH HVXOWV RI FKHPFDQ DQDO\VLV RI DFFRUGLQJ WR :+2

(OH PHW & RQW HQW ZW

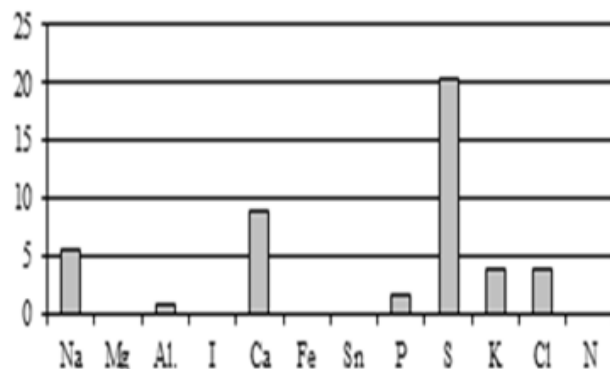


1 D	
0 J	
\$ O	
,	
& D	
) H	
6 Q	
3	
6	
.	
& O	DFFRUGLQJ WR :+2
1	FDUWLQDJH %LRORJLFDQ PLFURVFRSH

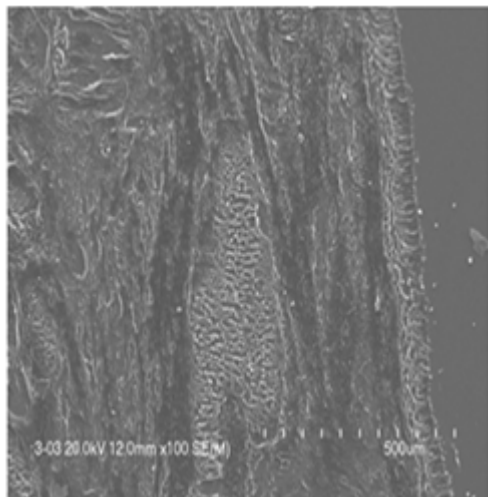
)LJXUH&DUFLQRPD SODQRHSLWKHOLDOH ,PDJH RI LQILOWUDWLRQ RI EURQFKLDO PDJQLILFDWLRQ ;



Wyniki analizy chemicznej próbki Table 2 zawartość (% wag.)

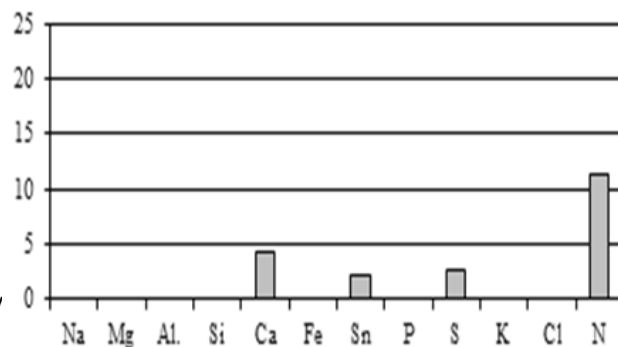


)LJXUH&DUFLQRPD SODQRHSLWKHOLDOH 6HOHFWHG DUHD LV HQODUJHG LQ )LJXUH DFFRUGLQJ WKH PLFURVFRSH RI HOHPH PDJQLILFDWLRQ DFFRUGLQJ WR VFDOH WLVVXH 7DEOH

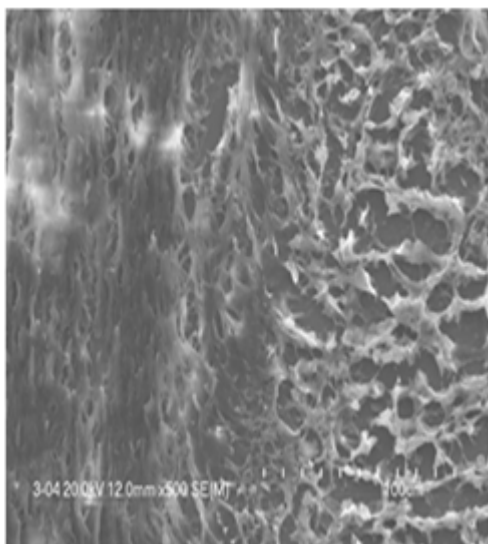


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&O	
1	

Wyniki analizy chemicznej próbki Table 3 zawartość (% wag.)



)LJXUH&DUFLQRPD SODQRHSLWKHOLDOH  
7XPRU WLVVXH LPDJH 6FDQQLQJ PLFURV  
WR VFDOH



)LJXUHUDSK RI WKH FRQWHQW RI HOHPH  
WLVVXH 7DEOH

7DEOH HVXOWV RI FKHP LFDO DQDO\VLV RI

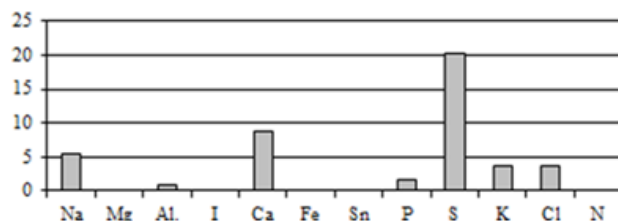
(OHPHQW	6DPSOH ZW
1D	
0J	
\$O	
6L	
&D	
)H	
6Q	
3	
6	DDFRUGLQJ WR :+2
.	DDFRUGLQJ PLFURVFRSH PDJQLILFDWLRQ
&O	
1	VDPSOH )LJXUH

)LJXUH&DUFLQRPD SODQRHSLWKHOLDOH  
(QODUJHG DUHD IURP )LJXUH 6FDQQLQJ PLFURVFRSH  
DDFRUGLQJ WR VFDOH

7DEOH HVXOWV RI FKHP LFDO DQDO\VLV RI VDPSOH )LJXUH

(OHPHQW	&RQWHQW ZW
1D	
0J	
\$O	
6L	
&D	
)H	
6Q	
3	
6	

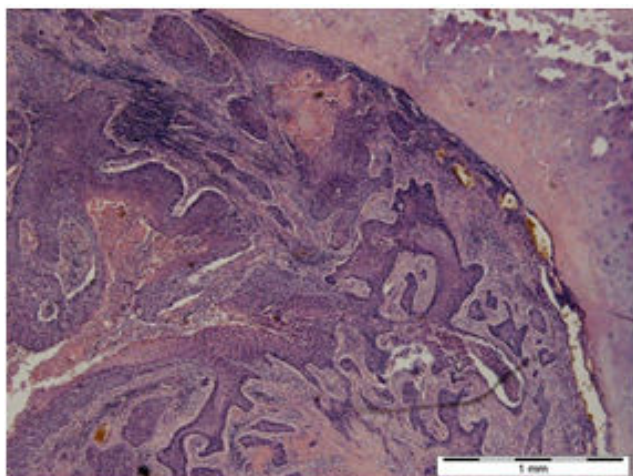
Wyniki analizy chemicznej próbki Table 4 zawartość (% wag.)



)LJXUHUDSK RI WKH FRQWHQW RI HOHPH  
WLVVXH 7DEOH

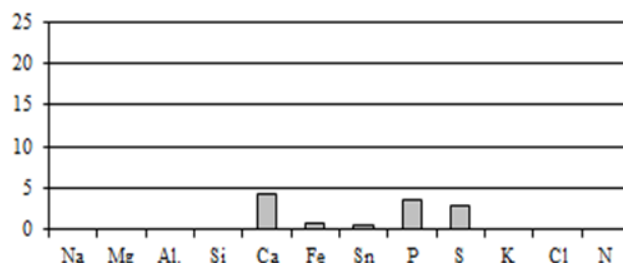
6DPSOH &DUFLQRPD SODQRHSLWKHOLDOH

WR :+2 /HIW OXQJ WXPRU ODOH \$JH



	DFFRUGLQJ
&O	
1	

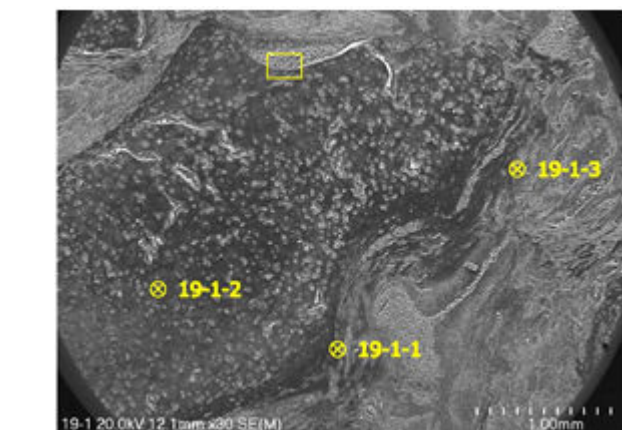
Wyniki analizy chemicznej próbki Table 5 zawartość (% wag.)



)LJXUH\*UDSK RI WKH FRQWHQW RI HOHPH WLWVXH 7DEOH

)LJXUH&DUFLQRPD SODQRHSLWKHOLDOH 9LVLEOH VTXDPRXV FHOO FDUFLQRPD LQ

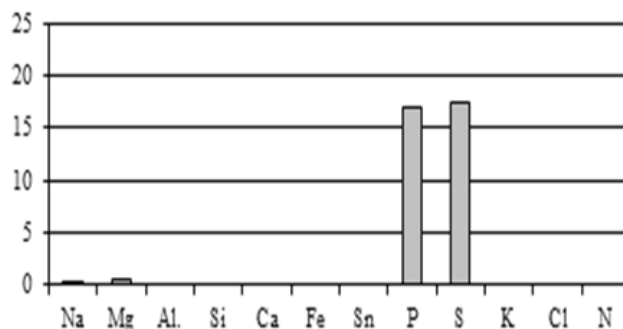
7DEOH HVXOWV RI FKHPDFDO DQDO\VLV RI DFFRUGLQJ WR :+2



(OHPHQW	&RQWHQW ZW
1D	
0J	
\$O	
6L	
&D	
)H	
6Q	
3	
6	
.	
&O	DFFRUGLQJ WR :+2
	6FDQQLQJ PLFURVFRSH

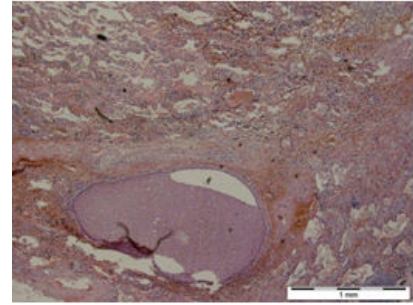
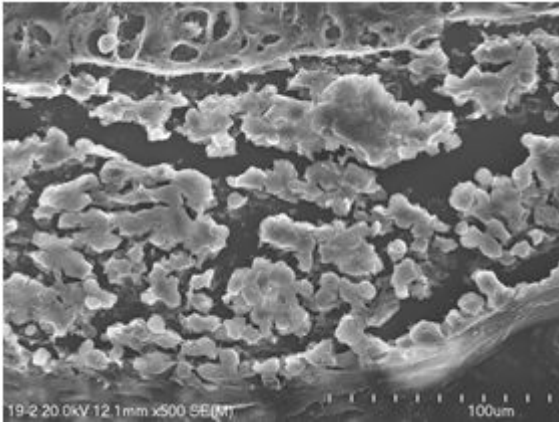
)LJXUH&DUFLQRPD SODQRHSLWKHOLDOH 0DUNHG DUHD LV HQODUJHG LQ )LJXUH PDJQLILFDWLRQ DFFRUGLQJ WR VFDOH

Wyniki analizy chemicznej próbki Table 6 zawartość (% wag.)



)LJXUH\*UDSK RI WKH FRQWHQW RI HOHPH WLWVXH 7DEOH

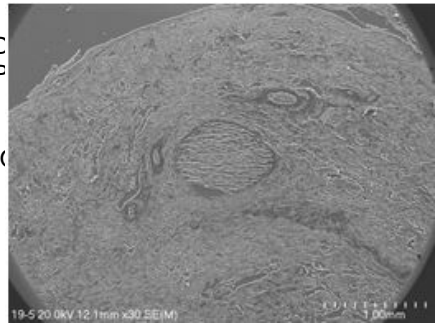
(OHPHQW	&RQWHQW ZW
1D	
0J	
\$O	
6L	
&D	
)H	
6Q	
3	
6	



)LJXUH'LIHUHQWLDWLRQ RI WLVVXH V LQ DFFRUGLQJ WR :+2 %LRORJLFDO PLF

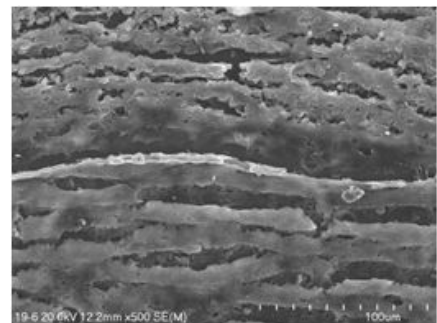
)LJXUH&DUFLQRPD SODQRHSLWKHOLDOH 0LQH UDOLJHG DUHD 6FDQQLQJ PLFURVFRSH VFDOH

7DEOH HVXOWV RI FKHP LFDO DQDO\VLV RI VDPS



)LJXUH \$UHD RI WHVWHG PLQH UDOLJHG SODQRHSLWKHOLDOH DFFRUGLQJ W PDJQLILFDWLRQ DFFRUGLQJ WR VFDOH

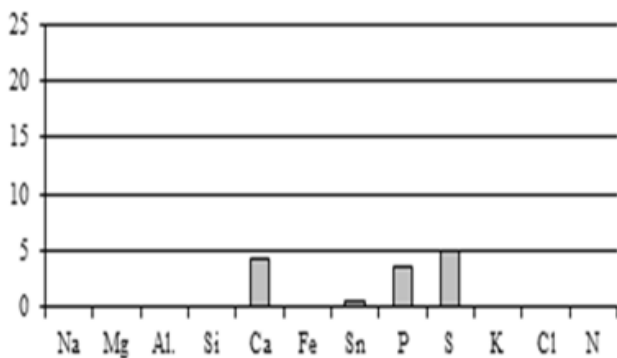
(OHPHQW	&RQWHQW ZW
1 D	
0 J	
\$ O	
6 L	
& D	
) H	
6 Q	
3	
6	
.	
& O	
1	



)LJXUH &DUFLQRPD SODQRHSLWKHOLDOH (QODUJHG WHVWHG DUHD IURP )LJXUH PDJQLILFDWLRQ DFFRUGLQJ WR VFDOH

7DEOH HVXOWV RI FKHP LFDO DQDO\VLV RI

Wyniki analizy chemicznej próbki Table 7 zawartość (% wag.)



)LJXUH\*UDSK RI WKH FRQWHQW RI HOHPHQWV LQ WKH WHVW DUHD RI WXPURV WLVVXH 7DEOH

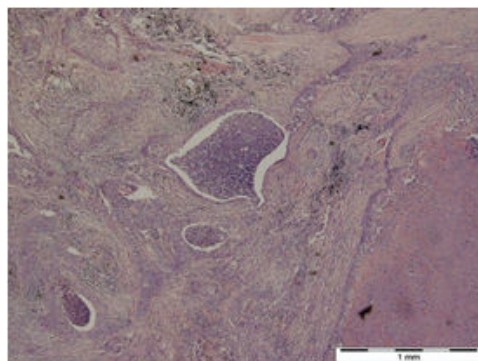
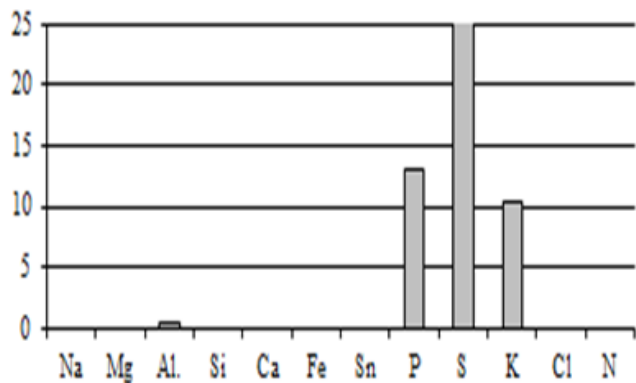
(OHPHQW	&RQWHQW ZW
1 D	
0 J	
\$ O	
6 L	
& D	
) H	
6 Q	
3	
6	

.	
& O	
1	

6DPSOH & DUFLQRPD SODQRHSLV  
WR :+2

/HIW OXQJ WXPRU ODOH \$JH

Wyniki analizy chemicznej próbki Table 8 zawartość (% wag.)

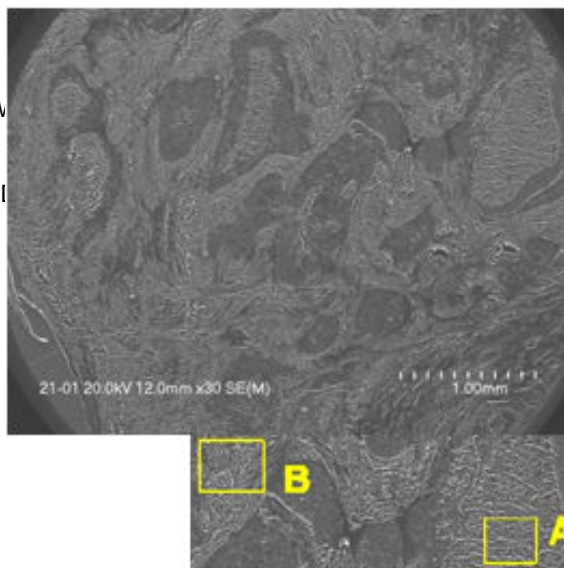


)LJXUH & DUFLQRPD SODQRHSLWKHOLDOH  
%LRORJLFDO PLFURVFRSH PDJQLILFDWLRQ

)LJXUH\*UDSK RI WKH FRQWHQW RI HOHPHQW  
WLVVXH 7DEOH

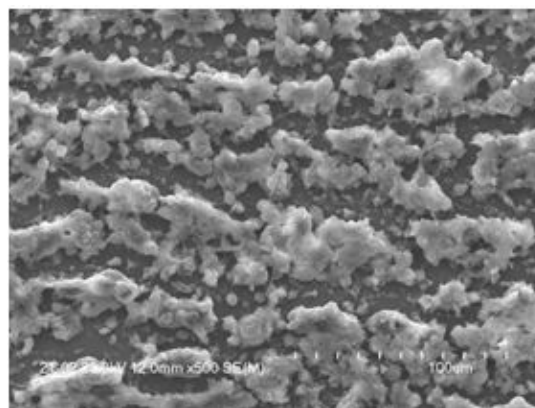
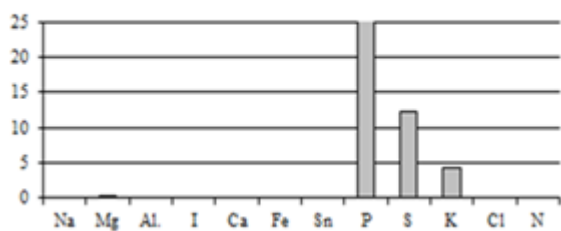
7DEOH HVXOWV RI FKHPDFDO DQDO\VLV RI V

(OHPHQW	&RQWHQW ZW
1D	
0J	
\$O	
.	
&D	
)H	
6Q	
3	
6	
.	
&O	
1	



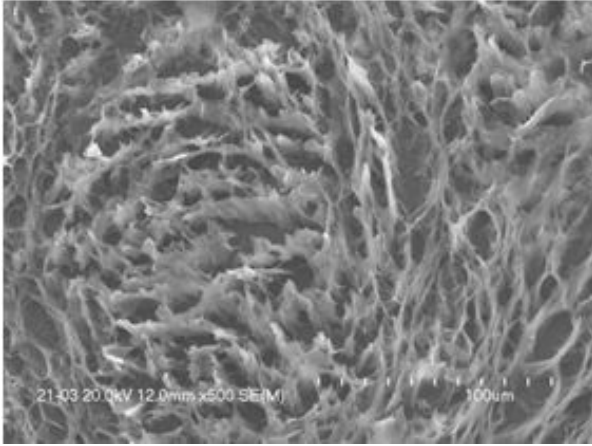
)LJXUH & DUFLQRPD SODQRHSLWKHOLDOH  
ODUNHG DUHD \$ LV HQODUJHG LQ )LJXUH  
PDJQLILFDWLRQ DFFRUGLQJ WR VFDOH

Wyniki analizy chemicznej próbki Table 9 zawartość (% wag.)



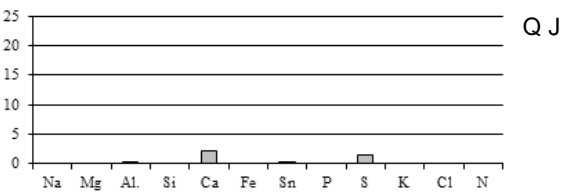
)LJXUH \$UHD % RI PLQH UDOLJHG WLVVXH  
ODJQLILFDWLRQ DFFRUGLQJ WR VFDOH

)LJXUH\*UDSK RI WKH FRQWHQW RI HOHPHQW  
WLVVXH 7DEOH



6 L	
& D	
) H	
6 Q	
3	
6	
.	
& O	
1	

Wyniki analizy chemicznej próbki Table 11 zawartość (% wag.)



)LJXUH 0LQHUTORJHG WLWVXH VWUXFWX  
 SODQRHSLWKHOLDOH DFFRUGLQJ WR :+2  
 PLFURVFRSH PDJQLILFDWLRQ DFFRUGLQJ W

7DEOH HVXOWV RI FKHPLFDO DQDO\VLV RI VD

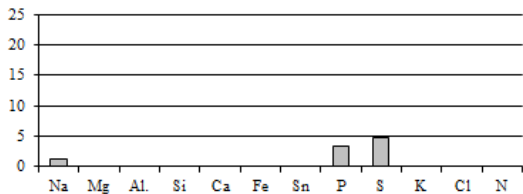
(OHPHQW	&RQWHQW ZW
1 D	
0 J	
\$ O	
6 L	
& D	
) H	
6 Q	
3	
6	
.	
& O	
1	

)LJXUH\*UDSK RI WKH FRQWHQW RI HOHPHQW  
 WLWVXH 7DEOH

7DEOH HVXOWV RI FKHPLFDO DQDO\VLV RI

(OHPHQW	&RQWHQW ZW
1 D	
0 J	
\$ O	
6 L	
& D	
) H	
6 Q	
3	
6	
.	
& O	
1	

Wyniki badań chemicznych próbki Table 10 zawartość (% wag.)

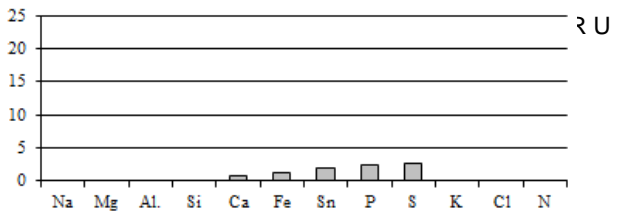


)LJXUH\*UDSK RI WKH FRQWHQW RI HOHPHQW  
 WLWVXH 7DEOH

7DEOH HVXOWV RI FKHPLFDO DQDO\VLV RI V

(OHPHQW	&RQWHQW ZW
1 D	
0 J	
\$ O	

Wyniki analizy chemicznej próbki Table 12 zawartość (% wag.)



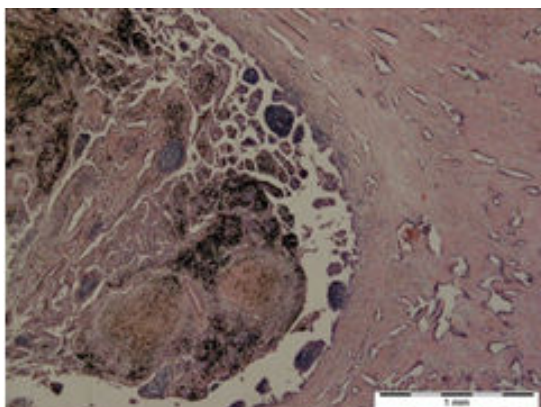
)LJXUH\*UDSK RI WKH FRQWHQW RI HOHPHQW  
 WLWVXH 7DEOH



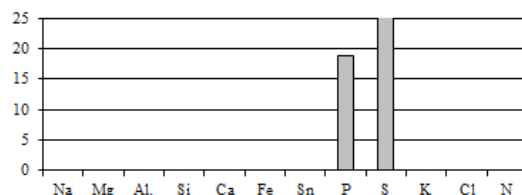
6DPSOH \$GHQRFDUFLQRPD SXOPRQLV DFFRUGLQJ

WR :+2

5LJKW OXQJ WXPRU PDOH DJH

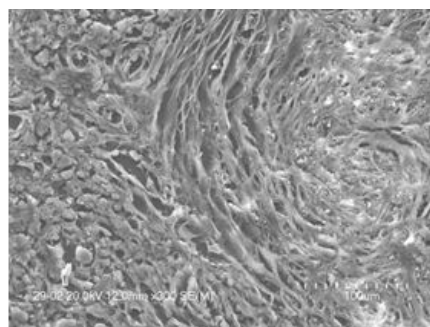


Wyniki analizy chemicznej próbki Table 13 zawartość (% wag.)

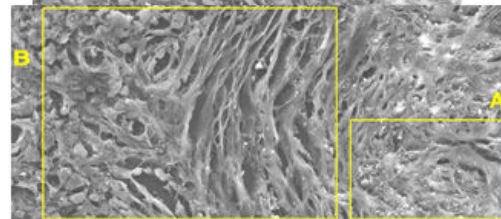
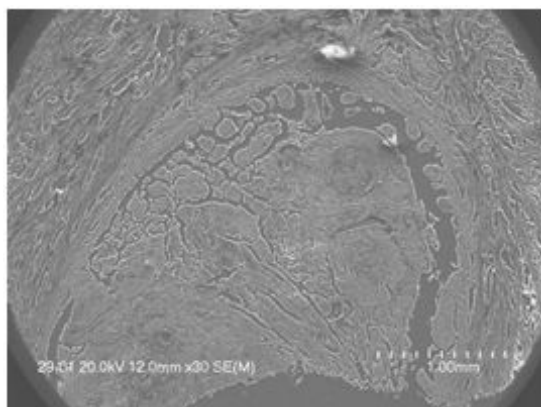


)LJXUH\*UDSK RI WKH FRQWHQW RI HOHPH WLWVXH 7DEOH

)LJXUH\$GHQRFDUFLQRPD SXOPRQLV DFFR DUHDV PDUN WKH GXVW GHSRVLWV RI FDUER PLFURVFRSH PDJQLILFDWLRQ ;

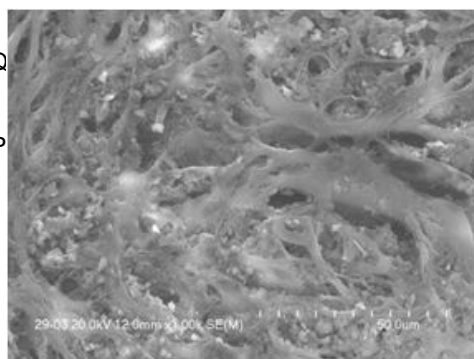


RORJLFD



)LJXUH \$GHQRFDUFLQRPD SXOPRQLV (QODUJHG PLQHUDOLJHG DUHD \$ DQG PDJQLILFDWLRQ DFFRUGLQJ WR VFDOH

)LJXUH 3UHSUDUDWLRQ 6DPSOH ) \$GHQRFDUFLQRPD SXOPRQLV DFFRUGLQJ PLFURVFRSH PDJQLILFDWLRQ DFFRUGLQJ WR



7DEOH HVXOWV RI FKHPLFDO DQDO\VLV RI VDP

)LJXUH\$GHQRFDUFLQRPD SXOPRQLV D RI HOHYDWHG OHYHO RI HOHPHQWV VHH PDJQLILFDWLRQ DFFRUGLQJ WR VFDOH

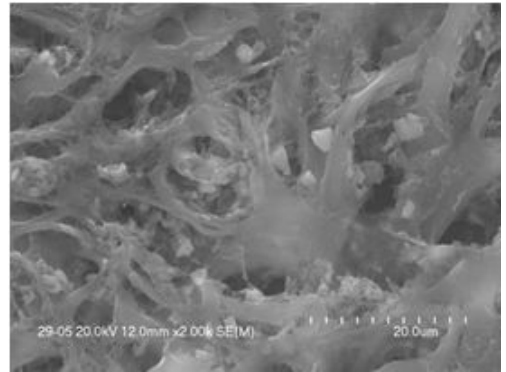
7DEOH HVXOWV RI FKHPLFDO DQDO\VLV RI

(OHPHQW	&RQWHQW ZW
1D	
0J	
\$O	
6L	
&D	
)H	
6Q	
3	
6	
.	
&O	

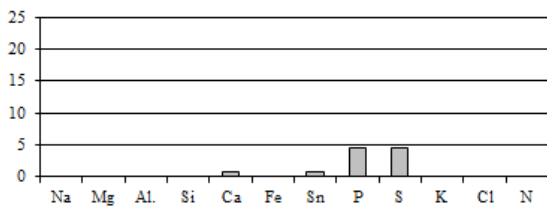
(OHPHQW	&RQWHQW ZW
1D	
0J	
\$O	

6L	
&D	
)H	
6Q	
3	
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&O	
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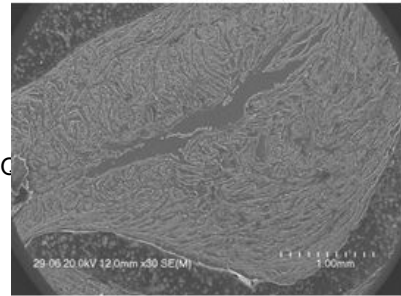
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Wyniki analizy chemicznej próbki Table 14 zawartość (% wag.)

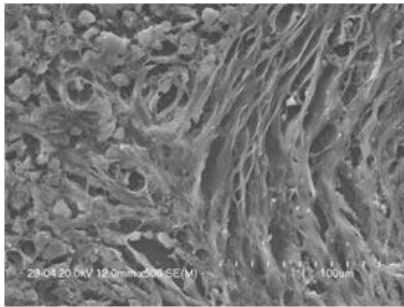


)LJXUH6WUXFWXUH RI DGHQRFDUFLQRPD :+2 :KLWH FDOFLXP SKRVSKDWHV 6 PDJQLILFDWLRQ DFFRUGLQJ WR VFDOH

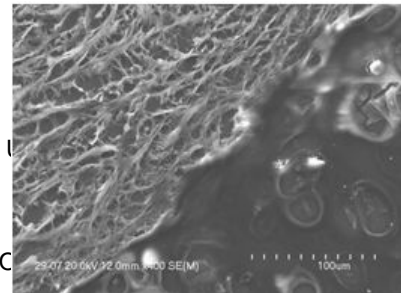


)LJXUH\*UDSK RI WKH FRQWHQW RI HOHPHQWV LQ WLWVXH 7DEOH

WXPRU



)LJXUH\$GHQRFDUFLQRPD SXOPRQLV \$ LV PDJQLILHG LQ )LJXUH 6FDQQLQJ DFFRUGLQJ WR VFDOH



)LJXUH \$GHQRFDUFLQRPD SXOPRQLV DFFR 0LQHUTORJHG WLWVXH 6FDQQLQJ PLFURVFRSH VFDOH

UGLQJ WR

7DEOH HVXOWV RI FKHPLFDO DQDO\VLV RI VDPSC

(OHPHQW	&RQWHQW ZW
1D	
0J	
\$O	
6L	
&D	
)H	
6Q	
3	
6	
.	
&O	

)LJXUH \$GHQRFDUFLQRPD SXOPRQLV &RQWDFW RI PLQHUTORJHG ORZHU DQG 6FDQQLQJ PLFURVFRSH PDJQLILFDWLRQ

'LVFXVVLRQ

7KH VWXGLHV KDYH VKRZQ WZR WIS DQDO\JHG OXQJ FDQFHU WLWVXH V DSSDUHQW PLQHUTORJDWLRQ

+LGGHQ PLQHUTORJDWLRQ

+LGGHQ PLQHUTORJDWLRQ ZDV UHFRJ RI OXQJ FDQFHU &DUFLQRPD SODQR \HDU ROG PDQ ,W ZDV UHFRJQ PLQHUTORJDWLRQ RI RWKHU VSHFL PLFURWRPH FXW WLWVXH VHFWRQV



Citation: 3DZOLNRZVNL 0 %LRPLQHUTORJ\ RI OXQJ WXPURV - &DQFHU ,PPXQRO 7KHU

FDOFLXP SKRVSKRUXV DQG VXOSKXU. REXR\%K 1DQVRE VIKHNE LRVO RYVSRGCO U  
VWUXFWXUHV RI WLWVXH DQG GR Q RRGRRU P QHJLWVZVWRKZVZJY VMDQREZ QDXP  
IRU H[DPSOH PLFURVFRSLFDOO\ IL]MRORJLL L SDWRORJLL 3=:/ 0HG  
‡ +LGGHQ PLQHUTORJ]DWLRQ FDQ EXW GLRNRZQ%W RIGD\WHDZRW R\BUDVILFKVQR  
DSSDUHQW PLQHUTORJ]DWLRQ YLVKLVWR RDRG LPTQDFR\ZHDQD\$Q BR]QD  
FRQFHQWUDWLRQV 7KHVH JUDLQV XS WR VHYHUDO GR]HQ  
PLFURPHWUHV LQ VL]H XVXDOO\ ORFDVZD QFHDUQ DGGQVWRPHQD PRUZYKQDPO  
2EVHUYDWLRQV RI FDOFLXP DQG SKRVSKRUXV \$FRUWHQDQVLRQ  
LQGLFDWH WKDW PLQHUTO JUDLQV 3DZOLNRZVNLH HPHVLRQVZ FQHLWV  
FDOFLXP SKRVSKDWHV RU PRUH UDUH%LHOFNRFL%L FDUERODVHG

&RQFOXVLRQ

,Q FRQFOXVLRQ RQH FDQ K\SRWKHVL\HFWKRW 3ERWR KLGGHQ DQG  
DSSDUHQW WLWVXH PLQHUTORJ]DWLRQ 3DZOLNRZVNLH HPHVLRQVZ FQHLWV  
FDOFLILFDWLRQ PD\ SURPRWH VWUXFWXUHV 6WURD\N1(\$ G\LRPWQH DDOVLDQMD  
GXULQJ WKH GLYLVLQR RI FKURPRVRPHV LQ WKH SURFHVV RI FHOO  
PXOWLSOLFDFWLRQ 7KH FHOO GLYLVLQR 3DZOLNRZVNLH HPHVLRQVZ FQHLWV  
FRQWHQW RI HOHPHQWV WRR ORZ RU:WDRQKIFJKZ RLQ HUXNDLQ WDW RQH FFDQ  
SURPRWH GHIRUPDWLRQV RI WKH '1\$DZOLNRZVNLH HPHVLRQVZ FQHLWV  
UHVSRQVLEOH IRU WKH UDUH RI PLVWZELG\ZRVLRQWUXFKX\$\*6VLKHS\$1  
PLQHUTORJ]DWLRQ RI WLWVXH DQG ERFR]QNDV\WFRYDHSUJEGWFWKVV\W\F  
H[WHUQDO DQG LQWHUQDO IDFWRUV PDUV\$ZP R\H DQG IRUPDWLRQ RI  
WXPURV 5RF]QNDV\WFRYDHSUJEGWFWKVV\W\F

&RQILUPDWLRQ RI WKLV WKHRU\ UHTXL\HUVI 6WURD\N1(\$ G\LRPWQH DDOVLDQMD  
H[SHULPHQWDO UHVHDUFK WKLV UHVHDUFK 6WURD\N1(\$ G\LRPWQH DDOVLDQMD  
GHGLFDWHG WR P\ PRWKHU ZKR GLHG IRDQFHU FDOFLQ 2QFRO

5HIHUFHV

%XQ\DYZURFRKHPDQ 5( 3(7 HYDOXDWLRQ 5( 710 FODVVLILFDWLRQ  
FDQFHU - 1XFO 0HG 7KRUDF &DUGLRYDVF 6XUJ  
'HYHUHX[ 75 0ROHFXODU PHFKDQLV 5( 710 FODVVLILFDWLRQ  
,QWHUDFWLRQ RI HQYLURQPHQWDO DQG JHOHWLF VYDFHUVLGRQWKHBM  
6XSS 6 6 &KLQHVH SRSXODWLRQ /XQJ &DQFHU

\*URQLR-ZVNL3RGVSDZV RPRU7RPHKJL &RUUHVSRRGHQFH WR  
\$QW\NZDUVDMJDUQLDBD VWZRZNDG  
:\GDZQLFWZD /HNDUVNLFK 0DFLHM 3DZOLNRZVNL  
-XV]NR2OF]N3DOHSDLSHUMFVZQLN HSDUWPHQW RI 0LQHUTORJ\ 3HWURJ  
U\]NZ HWLRQBNDXZDUyELHV]ND FyZ  
\*yUQHJRVNDIG\F\QDRGRZLVNRZD \$\*+ 8QLYHUVLW\ RI 6FLHQFH DQG 7HF

-XV]NR.RáRV]DR(G]LH]U]7KH LQIOXHQFH RI UDNYZ 3RODQG  
VHOHFHWG HQYLURQPHQWDO IDFWRUV (XV]NR OXQJ FDQFHU LQFLGHQFH LQ  
LPPLJUDQW SRSXODWLRQ RI LQGXYWULBO DUDHYN]BOKVKGX\$QDO RI  
(QYLURQPHQWDO 6WXGLHV 6XSSO ,,