

Mobile and hand-held near-infrared spectrophotometers in feed evaluation – solutions to challenges?

Prasad, K.V.S.V.^{1*}, Yonas, A.², Adey, M. Y.³, Frederic, K.², Padmakumar, V.¹ and Blümmel, M.²,

International Livestock Research Institute, ¹Hyderabad, India and ²Addis Ababa, Ethiopia

Ethiopian Institute of Agriculture Research³ (EIAR), Addis Ababa, Ethiopia

International Conference on Animal Nutrition (INCAN 2019), Kolkata, India, 17-19 December 2019



What was the problem?

- Feed quality information are indispensable for least cost ration design, feed supply and demand scenarios.
- The prediction of livestock performance and selection in crop and forage improvement programs
- Often lacking of logistical constraints such as sample preparation and laboratory infra-structure and high cost of analytical services

What are the causes?

- Laboratories require huge investments and state of the art technology facilities with specialized work force
- Conventional destructive and invasive laboratory analysis costly, laborious and time consuming
- Often requires hazardous chemicals and will take time to get from overseas markets

(Sharma et al. 2010)

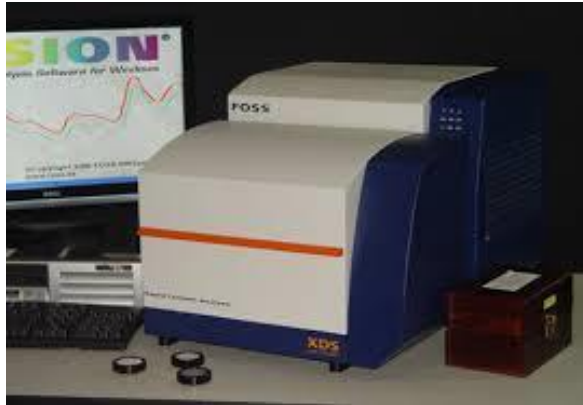
How the problem was addressed?

- Near Infrared Reflectance Spectroscopy (NIRS) has been widely used for predicting feed and fodder quality traits
- However, most NIRS instruments to date are stationary and samples need to be send to a central laboratory for scanning to obtain the results
- Recently mobile and hand-held NIRS instruments have been developed that can theoretically be used at lab, field and farm level

(Prasad and Blümmel, 2015)

Research opportunities and limitations of stationary and mobile NIRS

Stationary FOSS (70 000 \$)



Mobile Phazir (40 000 \$)



Mobile Brimrose (40 000\$)



SCIO < 2 000 \$



TellSpec < 2 000 \$

Objective – mobile & hand-held NIRS testing and evaluation

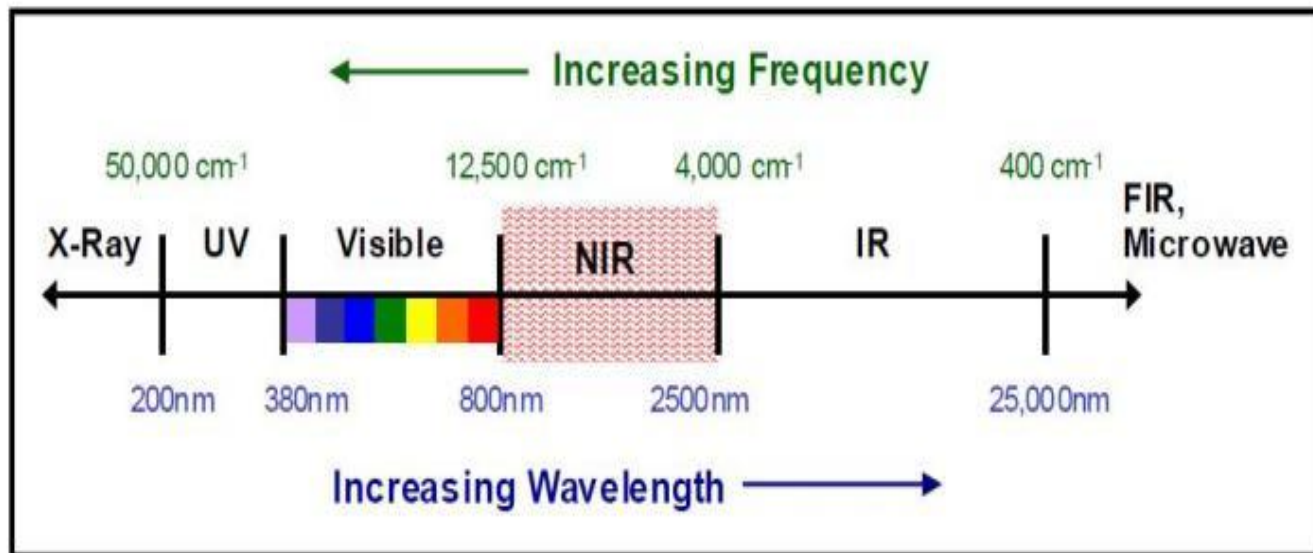
- Explore the use of a Thermo microPhazir mobile NIRS and TellSpec molecular sensors to test key nutrients in feed and feed ingredients used in producing commercial feeds in Ethiopia
- 550 food, feed, forages and concentrate samples dried and ground through 1mm sieve and scanned in a quartz crystal cup



Selection of spectral bandwidth in electromagnetic spectrum (EMS) to build models

Near Infrared Spectroscopy.

- ◆ NIR spectrum just above the visible region of the Electromagnetic spectrum (EMS) 780 to 2500 nm



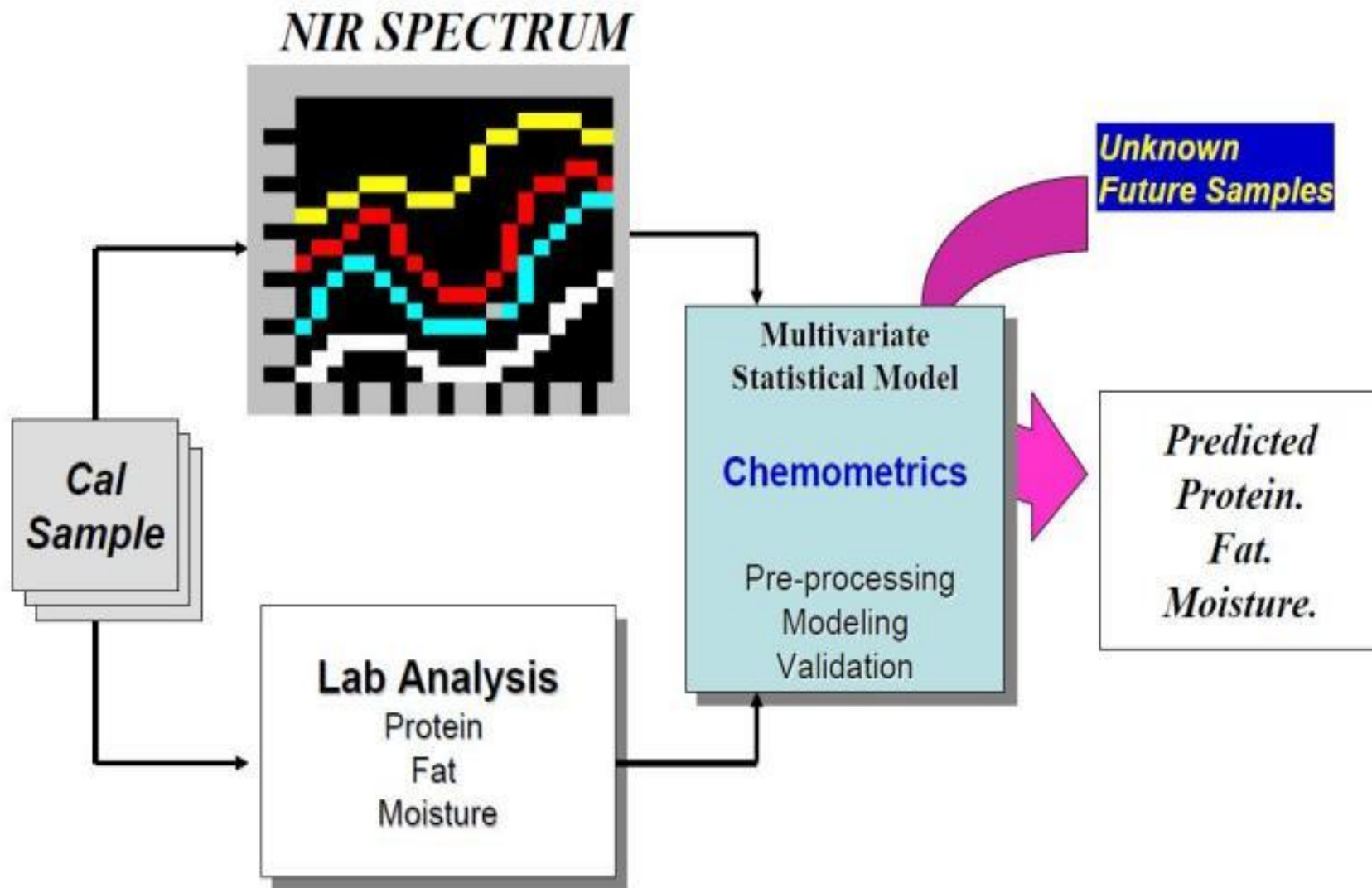
• Frequency = 1 / wavelength

(Shenk et al, 1993)

Materials and methodology

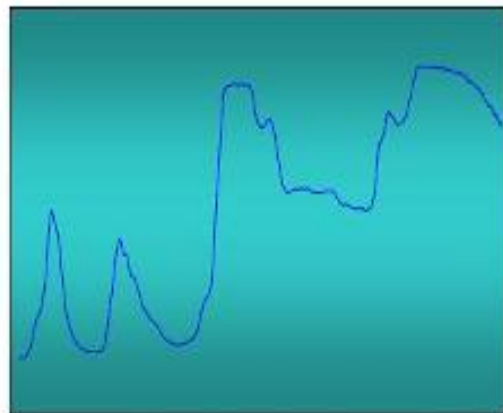
- Used 550 feeds, feed ingredients and roughages
- Analyzed N, NDF, ADF, ADL, IVOMD and ME by proximate and in-vitro studies
- The spectral signature data from both nirs transformed into spectroscopic file formats (complex phenomena) and associated with chemical variables to build the chemometric models
- Calibration models for 275 samples used for blind-predictions of 275 samples

A Brief Overall Flow of NIR Analysis



Chemometrics

Mathematical & Statistical Algorithm for
Extracting and Correlating with Chemical & Physical
Properties



Spectroscopic Data

Chemometrics

Calibration
Modeling

*Chemical & Physical
Properties*

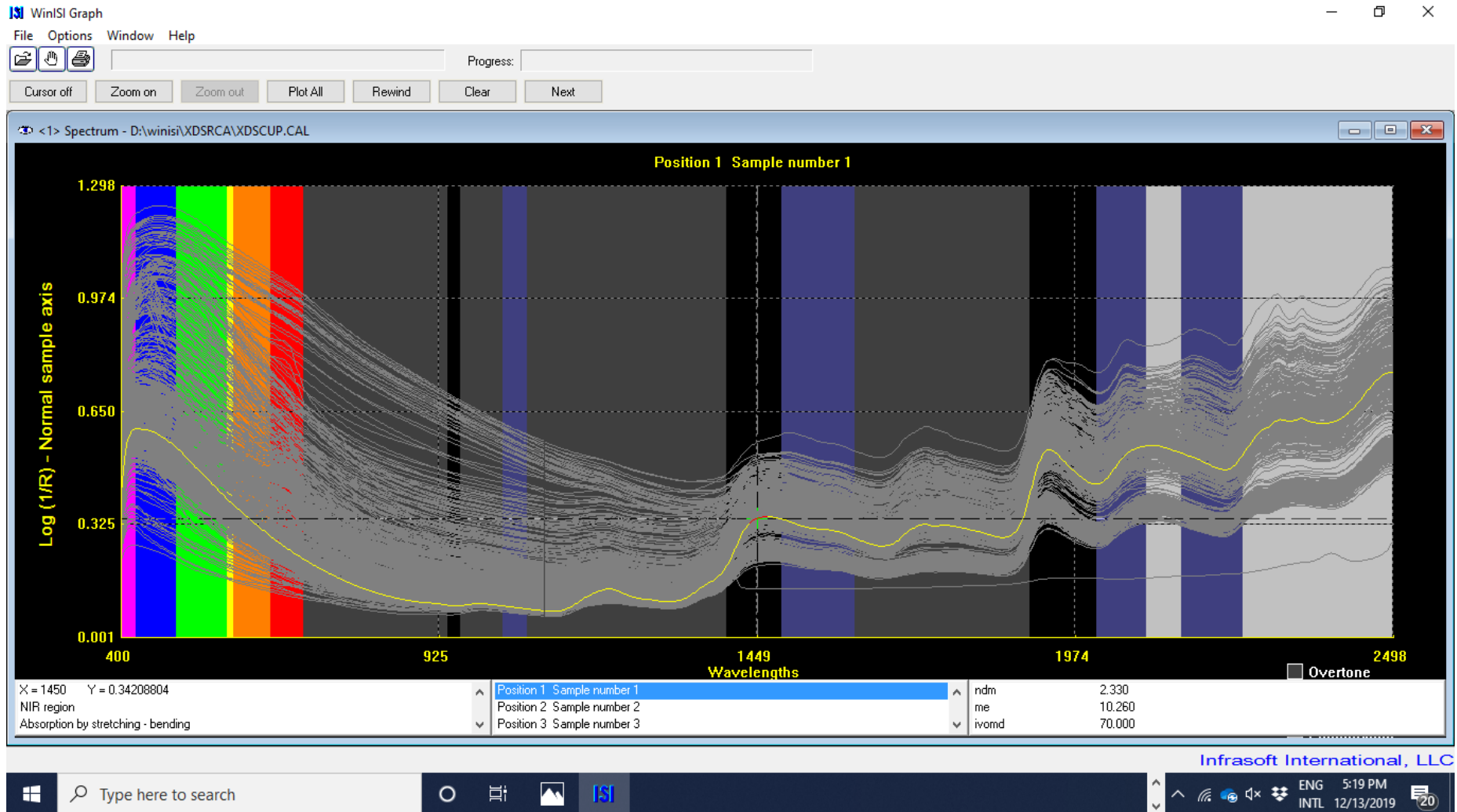
Simple Regression Method (LR)

- Applications limited (based on Beer's Law)
- Hard to apply complex systems

Multivariate Regression Method

- Wide Applications (complex systems)
- Still based on Chemistry
- MPLS, PCR, PLS, ANN.....

FOSS xds rca NIRS analog spectral signature data raw spectra, no derivatization, 2nm gap



FOSS xds rca NIRS digital signature data

bandwidth: 400-2498, 2nm and 1050wls

WinISI File View

File Reference Values Functions Graphics Window Help

Edit - D:\WINISI\XDSRCA\XDSCUP.CAL

File Name: D:\WINISI\XDSRCA\XDSCUP.CAL Spectra and Constituent Data File File Date: Wed Mar 06 22:06:29 2019 Last Update: Fri Dec 13 17:05:06 2019 File ID: Generated by IS!scan!

Master No: 30101147 Instrument Model: XDS Serial No: 30101147 Samples: 550 Deleted: 0 Constituents: 9 No. Data Points: 1050

Moisture Basis: Dry Matter

Segment 1: 400 - 1098, 2 Segment 2: 1100 - 2498, 2

Position	Sample Number	400.00	402.00	404.00	406.00	408.00	410.00	412.00	414.00	416.00	418.00	420.00	422.00	424.00
1	1	0.4131	0.4479	0.4803	0.5089	0.5331	0.5527	0.5681	0.5796	0.5877	0.5928	0.5959	0.5974	0.5981
2	2	0.9473	0.9810	1.0123	1.0400	1.0635	1.0830	1.0986	1.1107	1.1198	1.1263	1.1309	1.1343	1.1372
3	3	0.3990	0.4326	0.4639	0.4914	0.5147	0.5337	0.5486	0.5596	0.5672	0.5721	0.5750	0.5764	0.5770
4	4	0.9062	0.9388	0.9690	0.9957	1.0183	1.0367	1.0510	1.0616	1.0691	1.0743	1.0777	1.0800	1.0816
5	5	0.3939	0.4260	0.4560	0.4825	0.5049	0.5231	0.5372	0.5476	0.5549	0.5596	0.5624	0.5639	0.5646
6	6	0.4889	0.5209	0.5505	0.5763	0.5977	0.6149	0.6285	0.6387	0.6461	0.6511	0.6543	0.6562	0.6573
7	7	0.4478	0.4822	0.5142	0.5424	0.5664	0.5861	0.6019	0.6140	0.6230	0.6294	0.6338	0.6367	0.6389
8	8	0.9847	1.0136	1.0404	1.0639	1.0838	1.1000	1.1129	1.1228	1.1302	1.1357	1.1396	1.1424	1.1446
9	9	0.4269	0.4578	0.4863	0.5114	0.5325	0.5496	0.5629	0.5729	0.5798	0.5842	0.5888	0.5881	0.5885
10	10	0.2671	0.2836	0.2985	0.3109	0.3208	0.3281	0.3333	0.3365	0.3380	0.3383	0.3375	0.3361	0.3341
11	11	0.3844	0.4141	0.4417	0.4659	0.4863	0.5027	0.5154	0.5247	0.5310	0.5350	0.5372	0.5382	0.5383
12	12	0.3716	0.4010	0.4281	0.4518	0.4715	0.4874	0.4997	0.5088	0.5149	0.5188	0.5208	0.5216	0.5216
13	13	0.4824	0.5119	0.5390	0.5626	0.5821	0.5978	0.6101	0.6193	0.6258	0.6300	0.6326	0.6339	0.6346
14	14	0.3215	0.3426	0.3620	0.3788	0.3924	0.4030	0.4110	0.4166	0.4202	0.4222	0.4231	0.4232	0.4229
15	15	0.3995	0.4308	0.4598	0.4854	0.5069	0.5243	0.5379	0.5479	0.5547	0.5590	0.5614	0.5625	0.5627
16	16	0.3876	0.4149	0.4401	0.4621	0.4805	0.4953	0.5067	0.5150	0.5208	0.5244	0.5264	0.5273	0.5274
17	17	0.7044	0.7336	0.7607	0.7845	0.8046	0.8210	0.8339	0.8436	0.8505	0.8552	0.8583	0.8603	0.8616
18	18	0.3927	0.4226	0.4502	0.4745	0.4948	0.5112	0.5238	0.5331	0.5394	0.5435	0.5457	0.5468	0.5470
19	19	0.4448	0.4754	0.5037	0.5285	0.5493	0.5661	0.5792	0.5889	0.5955	0.5997	0.6020	0.6031	0.6034
20	20	0.4431	0.4698	0.4943	0.5153	0.5328	0.5467	0.5574	0.5651	0.5701	0.5731	0.5745	0.5749	0.5747
21	21	0.5207	0.5528	0.5825	0.6084	0.6300	0.6475	0.6612	0.6715	0.6789	0.6840	0.6875	0.6897	0.6912
22	22	0.5446	0.5792	0.6115	0.6402	0.6644	0.6840	0.6994	0.7111	0.7197	0.7257	0.7296	0.7323	0.7343
23	23	0.3947	0.4260	0.4551	0.4806	0.5021	0.5193	0.5326	0.5422	0.5487	0.5526	0.5546	0.5554	0.5552
24	24	0.3598	0.3895	0.4170	0.4409	0.4609	0.4769	0.4892	0.4981	0.5041	0.5078	0.5095	0.5098	0.5093
25	25	0.5440	0.5748	0.6034	0.6284	0.6492	0.6660	0.6792	0.6890	0.6961	0.7009	0.7040	0.7060	0.7074
26	26	0.3615	0.3893	0.4151	0.4376	0.4564	0.4715	0.4830	0.4914	0.4972	0.5008	0.5026	0.5032	0.5030
27	27	0.9995	1.0298	1.0582	1.0836	1.1053	1.1232	1.1374	1.1484	1.1568	1.1631	1.1680	1.1717	1.1749
28	28	0.2833	0.3015	0.3180	0.3320	0.3431	0.3515	0.3575	0.3612	0.3631	0.3634	0.3625	0.3609	0.3587
29	29	0.2734	0.2928	0.3105	0.3256	0.3377	0.3471	0.3538	0.3582	0.3606	0.3613	0.3608	0.3594	0.3573

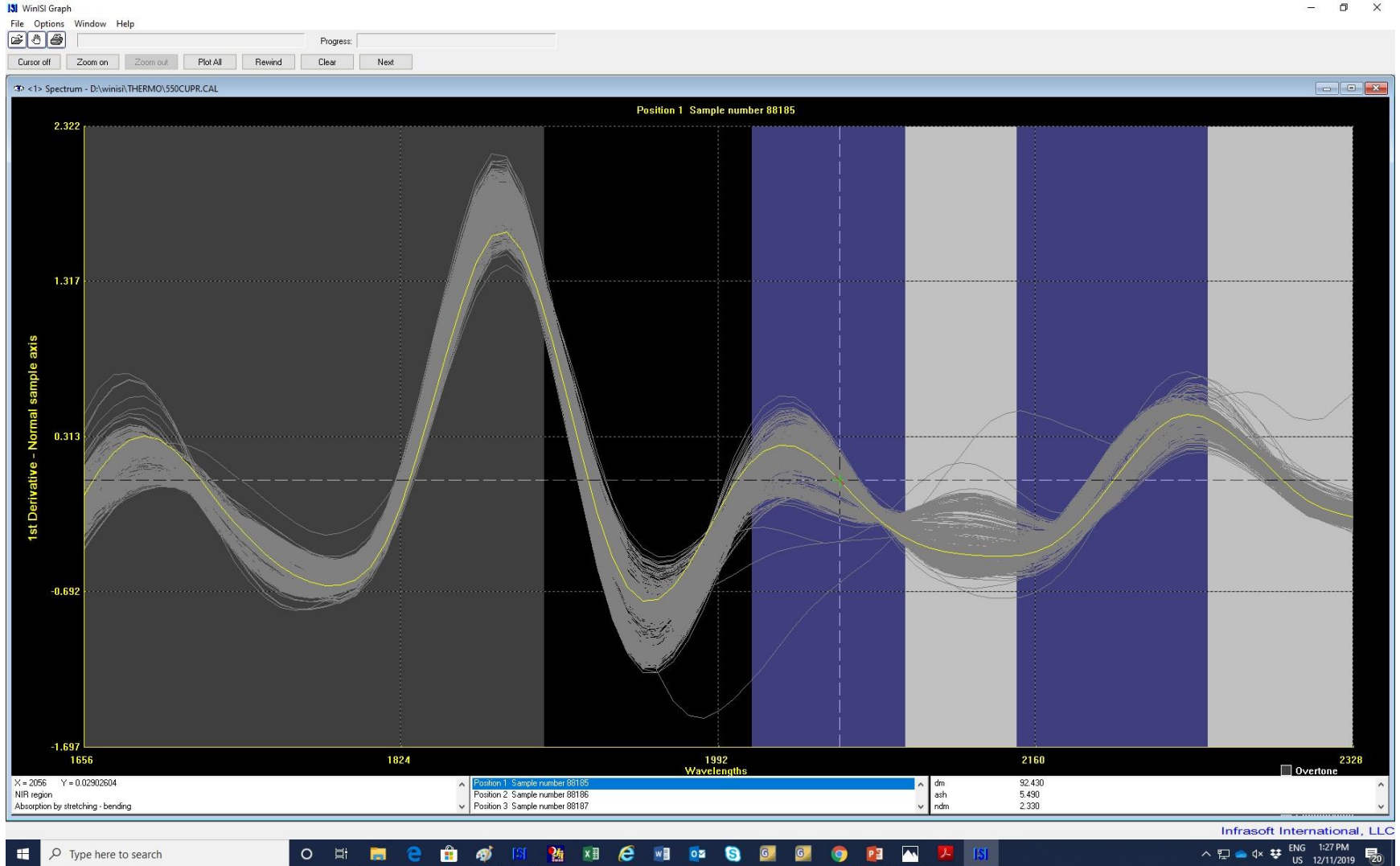
Infrasoft International, LLC.

Type here to search

ENG 5:23 PM
INTL 12/13/2019

Phazir NIRS analog spectral signature data

snv-detrend scatter, 1st derivatization, 8nm gap



Phazir NIRS digital signature data

bandwidth: 1600-2400, 8nm and 100wls

WinSI File View

File Reference Values Functions Graphics Window Help

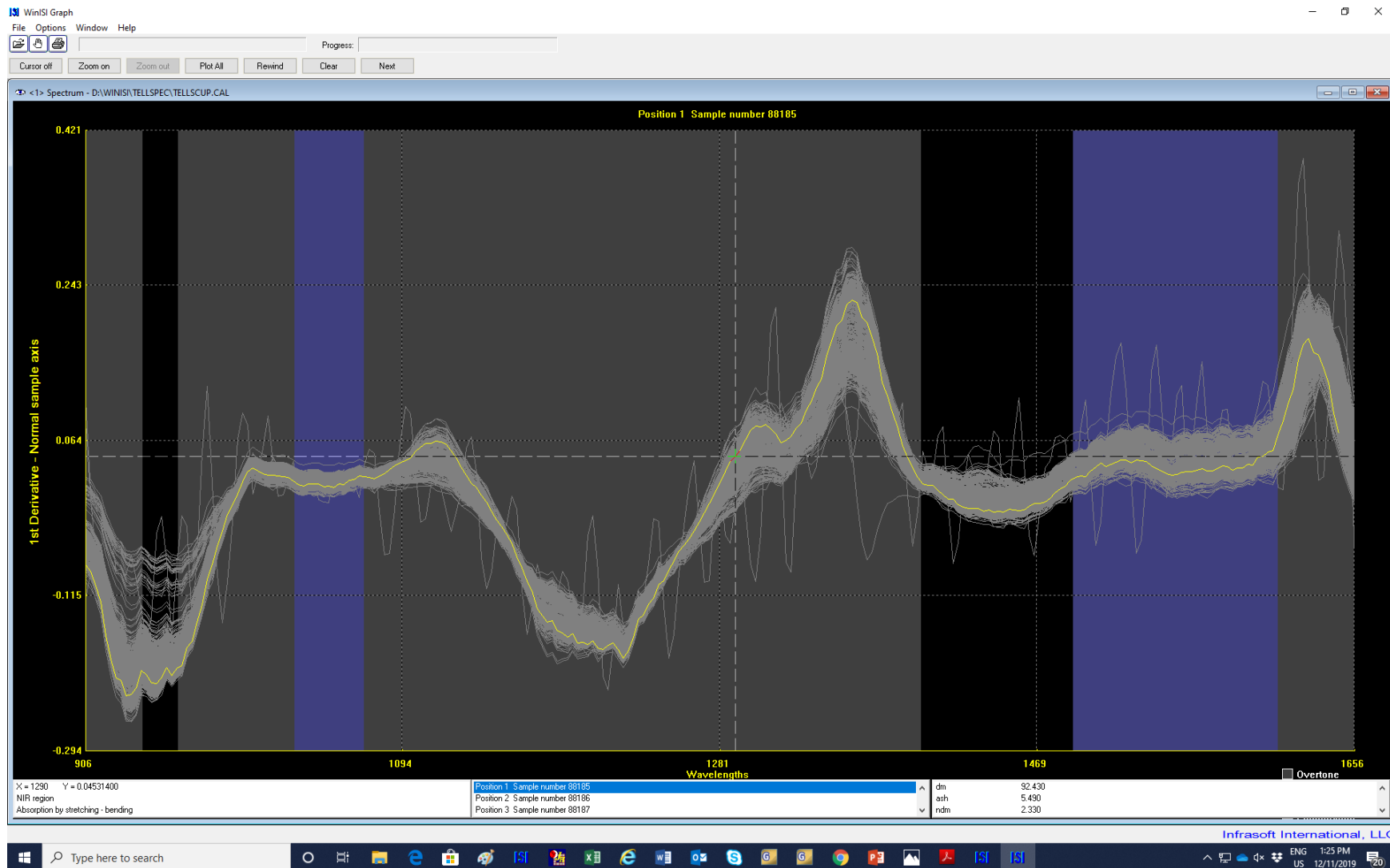
File Name: D:\WINISI\THERMO\550CUPR.CAL Spectra and Constituent Data File File Date: Thu Mar 14 10:10:06 2019 Last Update: Wed Dec 11 13:12:22 2019 File ID: <none> Master No: <none> Instrument Model: Unknown Serial No: 00000000 Samples: 550

Deleted: 0 Constituents: 9 No. Data Points: 100 Moisture Basis: Dry Matter

Segment	Position	Sample Number	ndm	nddm	addm	addm	me	lvomd	1600.00	1600.00	1616.00	1624.00	1632.00	1640.00	1648.00	1656.00	1664.00	1672.00	1680.00	1688.00	1696.00	1704.00
1	88165	2.3300	53.4700	15.5600	3.5300	10.2600	70.0000	0.2689	0.2742	0.2796	0.2867	0.2898	0.2928	0.2958	0.2988	0.3018	0.3048	0.3078	0.3108	0.3138	0.3168	0.3198
2	88166	5.2500	34.0700	27.8600	10.7800	7.9500	58.2400	0.2210	0.2237	0.2264	0.2295	0.2324	0.2354	0.2384	0.2414	0.2444	0.2474	0.2504	0.2534	0.2564	0.2594	0.2624
3	88187	2.4000	52.5200	13.7900	3.1100	10.3300	70.4500	0.3124	0.3173	0.3221	0.3266	0.3305	0.3342	0.3384	0.3424	0.3464	0.3504	0.3544	0.3584	0.3624	0.3664	0.3704
4	88188	5.5300	32.5700	26.9700	9.5200	7.8900	60.1700	0.2248	0.2277	0.2313	0.2336	0.2360	0.2378	0.2393	0.2410	0.2427	0.2444	0.2461	0.2478	0.2495	0.2512	0.2529
5	88189	2.2900	48.7400	13.9000	2.5400	10.3200	70.0500	0.3114	0.3153	0.3206	0.3256	0.3306	0.3356	0.3406	0.3456	0.3506	0.3556	0.3606	0.3656	0.3706	0.3756	0.3806
6	88190	3.3300	39.7500	12.3700	3.0800	9.6200	68.0800	0.2696	0.2745	0.2790	0.2835	0.2885	0.2935	0.2985	0.3035	0.3085	0.3135	0.3185	0.3235	0.3285	0.3335	0.3385
7	88191	2.5100	54.2500	15.2700	4.6200	10.5000	71.6900	0.2981	0.2928	0.2977	0.3022	0.3061	0.3113	0.3122	0.3115	0.3108	0.3101	0.3094	0.3087	0.3080	0.3073	0.3066
8	88192	4.6200	40.9000	34.5200	14.9400	7.2100	54.8600	0.2158	0.2188	0.2217	0.2241	0.2257	0.2272	0.2282	0.2277	0.2251	0.2218	0.2183	0.2137	0.2100	0.2068	0.2038
9	88193	2.5800	45.1200	13.6200	3.7200	10.1300	69.5100	0.2947	0.2986	0.3035	0.3078	0.3117	0.3148	0.3172	0.3182	0.3175	0.3144	0.3108	0.3073	0.3037	0.3002	0.2968
10	88194	1.1700	48.8600	4.5100	1.1300	10.0400	66.2100	0.2599	0.2648	0.2701	0.2753	0.2801	0.2842	0.2881	0.2903	0.2912	0.2898	0.2848	0.2763	0.2685	0.2638	0.2599
11	88195	2.4300	42.9800	12.3000	2.9700	10.2900	70.1500	0.2606	0.2645	0.2687	0.2733	0.2785	0.2833	0.2881	0.2928	0.2975	0.3022	0.3069	0.3116	0.3163	0.3210	0.3257
12	88196	2.3500	40.7200	11.3700	2.6500	10.3300	70.2300	0.3007	0.3061	0.3115	0.3168	0.3216	0.3253	0.3281	0.3299	0.3297	0.3269	0.3211	0.3123	0.3045	0.2991	0.2944
13	88197	3.0000	30.8800	12.9800	3.5800	9.2700	65.4200	0.2412	0.2452	0.2493	0.2533	0.2569	0.2613	0.2654	0.2691	0.2724	0.2753	0.2778	0.2799	0.2816	0.2829	0.2838
14	88198	2.2700	40.1100	7.4800	3.1300	10.1900	68.9600	0.2813	0.2864	0.2913	0.2968	0.3005	0.3046	0.3077	0.3093	0.3094	0.3073	0.3011	0.2919	0.2833	0.2771	0.2718
15	88199	2.3800	43.0500	12.4100	2.9500	10.3100	70.0900	0.2899	0.2951	0.3001	0.3036	0.3062	0.3076	0.3076	0.3067	0.3044	0.3008	0.2944	0.2856	0.2789	0.2738	0.2694
16	88200	2.5600	35.0400	10.4500	3.2100	10.0800	68.7400	0.2673	0.2720	0.2771	0.2822	0.2860	0.2903	0.2950	0.2994	0.3041	0.3088	0.3135	0.3182	0.3229	0.3276	0.3323
17	88201	1.5600	71.8400	57.4700	5.4800	8.3000	56.4800	0.2282	0.2315	0.2355	0.2391	0.2418	0.2446	0.2465	0.2476	0.2468	0.2431	0.2377	0.2297	0.2230	0.2179	0.2134
18	88202	2.4700	42.5000	11.7200	2.5100	10.2200	69.5200	0.2847	0.2884	0.2939	0.2979	0.3019	0.3052	0.3075	0.3084	0.3077	0.3051	0.2997	0.2920	0.2850	0.2787	0.2730
19	88203	2.3400	41.0400	7.7700	2.5400	9.8800	67.3200	0.2859	0.2891	0.2930	0.2968	0.3001	0.3028	0.3047	0.3051	0.3032	0.3007	0.2953	0.2873	0.2806	0.2749	0.2694
20	88204	1.5600	38.7200	11.6500	2.2400	9.1000	61.3200	0.2878	0.2918	0.2961	0.3012	0.3047	0.3081	0.3107	0.3123	0.3119	0.3106	0.3064	0.2987	0.2938	0.2892	0.2847
21	88205	3.2900	20.1400	10.1200	2.3200	9.1400	64.9400	0.2235	0.2274	0.2314	0.2350	0.2384	0.2412	0.2432	0.2441	0.2436	0.2410	0.2362	0.2295	0.2234	0.2181	0.2134
22	88206	3.1500	29.3800	11.0900	2.7500	9.6700	68.4000	0.2283	0.2316	0.2352	0.2392	0.2422	0.2447	0.2465	0.2470	0.2450	0.2433	0.2395	0.2313	0.2253	0.2209	0.2164
23	88207	2.5600	47.1400	14.1400	3.4900	10.3500	70.9500	0.2923	0.2963	0.3010	0.3058	0.3098	0.3122	0.3145	0.3155	0.3150	0.3120	0.3063	0.2983	0.2909	0.2849	0.2794
24	88208	2.6600	41.2600	12.3200	2.8900	10.5800	72.3300	0.2794	0.2833	0.2877	0.2924	0.2960	0.2994	0.3018	0.3026	0.2995	0.2925	0.2824	0.2740	0.2683	0.2637	0.2592
25	88209	3.1100	21.4600	10.6700	2.9000	9.3100	65.7600	0.2229	0.2272	0.2313	0.2352	0.2387	0.2420	0.2443	0.2454	0.2448	0.2427	0.2378	0.2311	0.2252	0.2211	0.2174
26	88210	2.3900	39.1100	11.9300	3.0400	10.3100	70.1500	0.3163	0.3214	0.3269	0.3320	0.3361	0.3396	0.3425	0.3439	0.3439	0.3412	0.3349	0.3262	0.3183	0.3121	0.3066
27	88211	4.0000	33.1200	34.3000	14.5600	7.3600	55.6900	0.2151	0.2174	0.2193	0.2214	0.2225	0.2236	0.2243	0.2239	0.2224	0.2203	0.2178	0.2145	0.2118	0.2094	0.2071
28	88212	1.4200	41.2600	5.7500	1.3600	10.1200	67.0400	0.2548	0.2588	0.2632	0.2678	0.2718	0.2748	0.2765	0.2748	0.2701	0.2638	0.2541	0.2468	0.2404	0.2349	0.2294
29	88213	1.8400	9.0200	3.1500	0.8700	10.1500	67.8400	0.2234	0.2288	0.2344	0.2401	0.2446	0.2491	0.2529	0.2558	0.2571	0.2560	0.2508	0.2431	0.2370	0.2338	0.2308
30	88214	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4228	0.4239	0.4236	0.4246	0.4247	0.4248	0.4238	0.4238	0.4238	0.4238	0.4233	0.4227	0.4208	0.4189	0.4170
31	88215	6.2100	23.2800	22.2600	8.2000	8.1100	62.8000	0.1950	0.1973	0.1999	0.2019	0.2033	0.2049	0.2054	0.2048	0.2032	0.2001	0.1962	0.1915	0.1877	0.1849	0.1821
32	88216	7.8300	15.2500	13.0000	3.0000	9.6900	74.8100	0.2201	0.2232	0.2263	0.2298	0.2328	0.2351	0.2361	0.2349	0.2311	0.2281	0.2239	0.2169	0.2096	0.2036	0.1988
33	88217	3.3300	22.9300	12.1100	3.4500	9.9000	69.7000	0.2321	0.2366	0.2405	0.2447	0.2481	0.2512	0.2534	0.2539	0.2531	0.2495	0.2439	0.2363	0.2291	0.2241	0.2194
34	88218	2.3300	15.5700	5.8200	1.5300	10.5300	71.0900	0.2538	0.2583	0.2637	0.2692	0.2732	0.2774	0.2810	0.2832	0.2835	0.2818	0.2765	0.2683	0.2617	0.2574	0.2537
35	88219	1.4300	15.5400	4.8200	1.5000	10.2200	67.6200	0.2024	0.2070	0.2123	0.2172	0.2213	0.2258	0.2289	0.2291	0.2320	0.2307	0.2257	0.2180	0.2112	0.2071	0.2034
36	88220	2.6200	40.9500	14.6300	3.3700	10.1600	69.6200	0.2807	0.2846	0.2893	0.2935	0.2967	0.3002	0.3022	0.3012	0.2998	0.2943	0.2866	0.2796	0.2740	0.2694	0.2657
37	88221	0.9200	66.5800	65.3100	6.6200	7.9400	53.5900	0.2272	0.2314	0.2375	0.2428	0.2471	0.2509	0.2537	0.2552	0.2558	0.2550	0.2540	0.2506	0.2467	0.2425	0.2383
38	88222	4.4400	16.3500	20.7600	8.7500	8.7500	64.3000	0.1903	0.1931	0.1961	0.1986	0.2005	0.2021	0.2027	0.2017	0.1990	0.1952	0.1899	0.1825	0.1775	0.1729	0.1684
39	88223	3.9500	31.1000	11.8400	3.1400	9.8100	65.1200	0.2867	0.2904	0.2948	0.2988	0.3028	0.3068	0.3108	0.3148	0.3188	0.3228	0.3268	0.3308	0.3348	0.3388	0.3428
40	88224	4.2800	30.6200	26.6800	10.0400	7.2800	54.6400	0.2175	0.2207	0.2232	0.2255	0.2273	0.2280	0.2285	0.2285	0.2282	0.2252	0.2229	0.2185	0.2126	0.2073	0.2025
41	88225	1.3400	35.0100	13.3900	2.9600	8.3600	56.9500	0.2607	0.2641	0.2673	0.2716	0.2742	0.2767	0.2788	0.2796	0.2775	0.2746	0.2703	0.2655	0.2602	0.2549	0.2496
42	88226	1.3400	15.4700	4.5800	1.1000	9.9700	65.8900	0.1973	0.2023	0.2076	0.2126	0.2173	0.2212	0.2248	0.2270	0.2277	0.2263	0.2217	0.2138	0.2072	0.2033	0.1994
43	88227	1.5900	54.5500	25.9500	6.6700	7.9400	55.6500	0.3064	0.3094	0.3137	0.3165	0.3189	0.3215	0.3228	0.3226	0.3216	0.3192	0.3163	0.3134	0.3108	0.3084	0.3060
44	88228	2.1500	32.3500	17.2800	5.9700	8.2600	58.1400	0.2739	0.2786	0.2836	0.2876	0.2915	0.2947	0.2967	0.2972	0.2963	0.2940	0.2894	0.2828	0.2771	0.2728	0.2684
45	88229	4.7300	15.6400	20.0100	6.3200	8.9900	66.0700	0.1737	0.1763	0.1787	0.1811	0.1822	0.1831	0.1841	0.1831	0.1811	0.1719	0.1656	0.1594	0.1543	0.1498	0.1454
46	88230	1.9600	39.8400	12.2900	3.0700	10.0700	68.1400	0.2631	0.2674	0.2721	0.2766	0.2802	0.2838	0.2865	0.2871	0.2866	0.2842	0.2789	0.2715	0.2646	0.2599	0.2554
47	88231	2.4400	47.4400	15.15																		

TellSpec NIRS analog spectral signature data

snv-detrend scatter, 1st derivatization, 3nm gap



TellSpec NIRS digital signature data

bandwidth: 900-1700, 3nm and 256wls

WinSI File View

File Reference Values Functions Graphics Window Help

Edit - D:\WINISI\TELLSPEC\TELLSPEC.CAL

File Name: D:\WINISI\TELLSPEC\TELLSPEC.CAL Spectra and Constituent Data File File Date: Wed Feb 27 01:08:07 2019 Last Update: Wed Dec 11 13:20:54 2019 File ID: <none> Master No: <none> Instrument Model: Unknown Serial No: 00000000 Samples: 550

Deleted: 0 Constituents: 9 No. Data Points: 256 Moisture Basis: Dry Matter

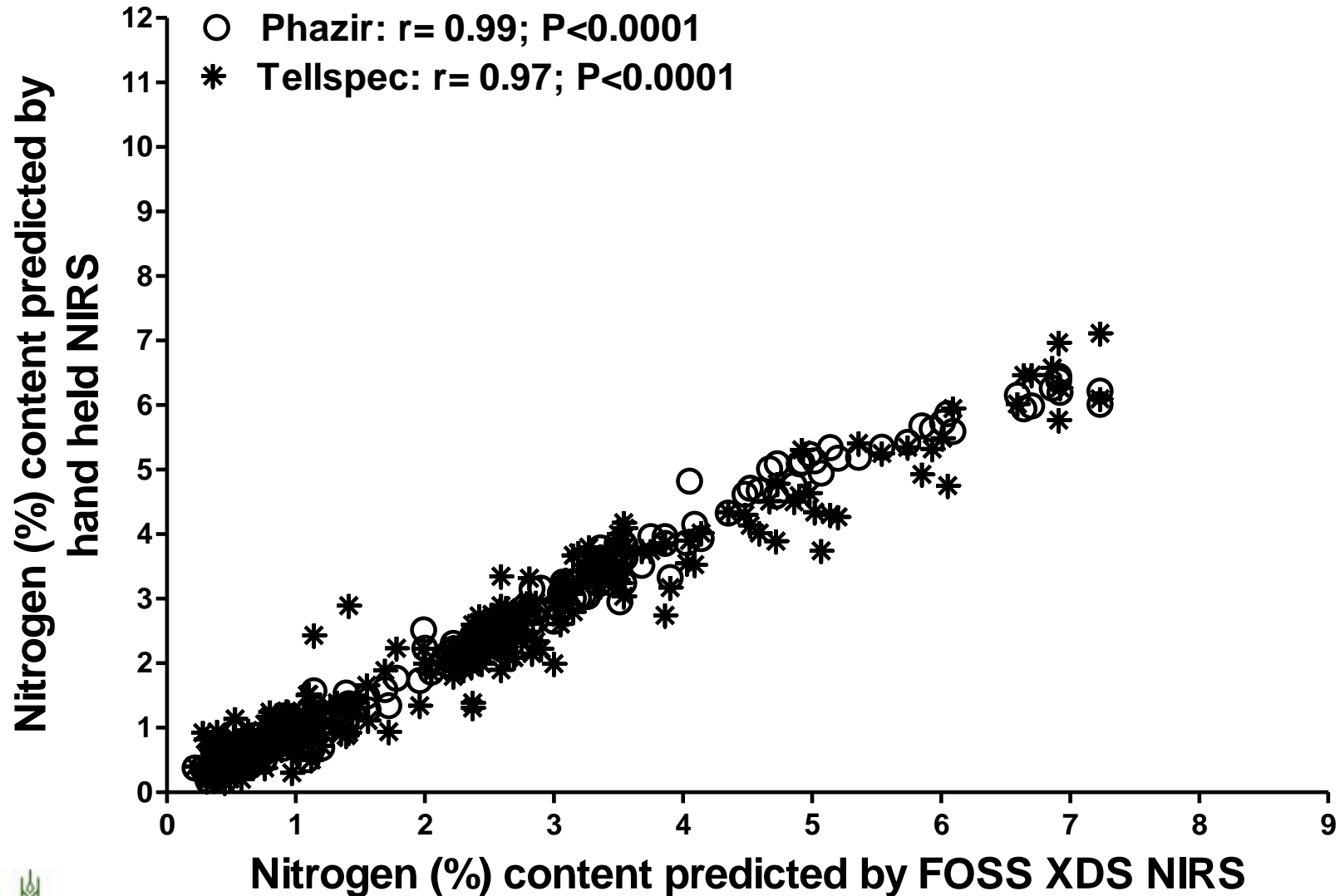
Segment 1 900 - 1665.3

Position	Sample Number	ndm	ndfm	nddm	nddm	me	ivomd	900.00	903.00	906.00	909.00	912.00	915.00	918.00	921.00	924.00	927.00	930.00	933.00	936.00	939.00
1	88185	2.3300	53.4700	15.5600	3.5300	10.2600	70.0000	0.1729	0.1961	0.2081	0.2270	0.2494	0.2728	0.2900	0.3236	0.3612	0.4035	0.4321	0.4759	0.5206	0.5631
2	88186	5.2500	34.0700	27.8600	10.7000	7.5500	59.2400	0.1419	0.1536	0.0949	0.0943	0.1294	0.1498	0.1648	0.1928	0.1886	0.2231	0.2490	0.2815	0.2793	0.3142
3	88187	2.4000	52.5200	13.7900	3.1100	10.3300	70.4500	0.1885	0.2135	0.2238	0.2522	0.2600	0.2836	0.3095	0.3566	0.3750	0.4177	0.4499	0.4935	0.5371	0.5802
4	88188	5.5300	32.5700	26.9700	9.5200	7.8900	60.1700	0.1057	0.1122	0.1285	0.1386	0.1455	0.1618	0.1704	0.1913	0.2137	0.2426	0.2586	0.2865	0.3143	0.3446
5	88189	2.2900	48.7400	13.9000	2.5400	10.3200	70.0500	0.2041	0.2228	0.2347	0.2507	0.2781	0.3056	0.3253	0.3623	0.4008	0.4493	0.4817	0.5310	0.5764	0.6255
6	88190	3.3300	39.7500	12.3700	3.0800	9.6200	68.0800	0.1658	0.1916	0.2004	0.2121	0.2392	0.2617	0.2775	0.3104	0.3454	0.3851	0.4123	0.4554	0.4961	0.5361
7	88191	2.5100	54.2500	15.2700	4.6200	10.5000	71.6900	0.2676	0.2998	0.3241	0.3527	0.3838	0.4218	0.4478	0.4979	0.5565	0.6223	0.6658	0.7338	0.8029	0.8703
8	88192	4.6200	40.9000	34.5200	14.9400	7.2100	54.8600	0.0974	0.1196	0.1172	0.1258	0.1392	0.1514	0.1605	0.1807	0.2023	0.2254	0.2430	0.2690	0.2962	0.3203
9	88193	2.5900	45.1200	13.6200	3.7200	10.1300	69.5100	0.2444	0.2742	0.3008	0.3230	0.3437	0.3769	0.4023	0.4450	0.4965	0.5551	0.5958	0.6546	0.7145	0.7751
10	88194	1.1700	48.8600	4.5100	1.1300	10.0400	66.2100	0.1795	0.2051	0.2154	0.2349	0.2578	0.2815	0.2989	0.3327	0.3712	0.4139	0.4440	0.4892	0.5357	0.5799
11	88195	2.4300	42.9800	12.3000	2.9700	10.2900	70.1500	0.1900	0.2173	0.2287	0.2496	0.2744	0.2995	0.3162	0.3542	0.4410	0.4734	0.5221	0.5722	0.6197	0.6739
12	88196	2.3500	40.7200	11.3700	2.6500	10.3000	70.2300	0.1781	0.2025	0.2132	0.2331	0.2550	0.2791	0.2963	0.3294	0.3675	0.4095	0.4388	0.4857	0.5296	0.5735
13	88197	3.0000	30.6800	12.9800	3.5800	9.2700	65.4200	0.1505	0.1759	0.1818	0.1988	0.2195	0.2394	0.2537	0.2831	0.3157	0.3512	0.3764	0.4149	0.4544	0.4911
14	88198	2.2700	40.1100	7.4000	3.1300	10.1900	68.9600	0.2402	0.2797	0.2898	0.3122	0.3382	0.3686	0.3922	0.4362	0.5390	0.5795	0.6387	0.6949	0.7511	0.8087
15	88199	2.3800	43.0500	12.4100	2.9500	10.3100	70.0900	0.1784	0.2043	0.2137	0.2340	0.2570	0.2803	0.2975	0.3312	0.3691	0.4116	0.4415	0.4870	0.5340	0.5796
16	88200	2.5600	35.0400	10.4500	3.2100	10.0800	68.7400	0.1872	0.2179	0.2288	0.2466	0.2739	0.2985	0.3160	0.3500	0.3940	0.4380	0.4650	0.5186	0.5690	0.6151
17	88201	1.5600	71.8400	57.4700	5.4800	8.3000	56.4600	0.1749	0.1998	0.2098	0.2293	0.2515	0.2745	0.2913	0.3233	0.3608	0.4022	0.4311	0.4754	0.5216	0.5657
18	88202	2.4700	42.5000	11.7200	2.5100	10.2200	69.8200	0.1828	0.2166	0.2266	0.2342	0.2795	0.2973	0.3311	0.3673	0.4101	0.4407	0.4866	0.5320	0.5774	0.6225
19	88203	2.3400	41.0400	11.7700	2.5400	9.8800	67.8300	0.2407	0.2867	0.2902	0.3188	0.3567	0.3875	0.4122	0.4597	0.5130	0.5683	0.6109	0.6743	0.7399	0.7978
20	88204	1.5600	38.7200	11.6500	2.2400	9.1000	61.3200	0.1612	0.1847	0.1940	0.2109	0.2319	0.2527	0.2680	0.2984	0.3325	0.3969	0.4383	0.4812	0.5212	0.5621
21	88205	3.2900	20.1400	10.1200	2.3200	9.1400	64.9400	0.2802	0.3201	0.3405	0.3699	0.3961	0.4332	0.4600	0.5127	0.5697	0.6364	0.6834	0.7560	0.8269	0.8987
22	88206	3.1500	29.3800	11.0900	2.7500	9.6700	68.4000	0.2555	0.3009	0.3196	0.3464	0.3769	0.4096	0.4351	0.4949	0.5433	0.6040	0.6477	0.7167	0.7894	0.8541
23	88207	2.5600	47.1400	14.1400	3.4900	10.3500	70.9500	0.1669	0.1888	0.1998	0.2169	0.2384	0.2598	0.2761	0.3066	0.3413	0.3807	0.4080	0.4500	0.4931	0.5352
24	88208	2.6600	41.2600	12.3200	2.6800	10.5800	72.3300	0.1871	0.2133	0.2258	0.2447	0.2611	0.2831	0.3110	0.3454	0.3851	0.4291	0.4599	0.5075	0.5574	0.6044
25	88209	3.1100	21.4600	10.6700	2.9000	9.3100	65.7600	0.2470	0.2817	0.2961	0.3236	0.3561	0.3893	0.4131	0.4598	0.5136	0.5729	0.6148	0.6802	0.7478	0.8126
26	88210	2.3900	39.1100	11.9300	3.0400	10.3100	70.1500	0.1811	0.2064	0.2169	0.2369	0.2605	0.2842	0.3014	0.3351	0.3732	0.4167	0.4931	0.5415	0.5873	0.6328
27	88211	4.0000	33.1200	34.3000	14.5600	7.3600	55.6900	0.0952	0.1081	0.1123	0.1234	0.1363	0.1505	0.1592	0.1782	0.1993	0.2243	0.2411	0.2680	0.2952	0.3238
28	88212	1.4200	41.2600	5.7900	1.3600	10.1200	67.0400	0.1762	0.1965	0.2152	0.2362	0.2586	0.2768	0.2926	0.3242	0.3625	0.4043	0.4323	0.4768	0.5247	0.5695
29	88213	1.8400	30.0200	3.1600	0.8700	10.1500	67.9400	0.1960	0.2236	0.2348	0.2555	0.2806	0.3054	0.3239	0.3599	0.4006	0.4460	0.4783	0.5280	0.5793	0.6281
30	88214	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1897	0.2159	0.2261	0.2461	0.2704	0.2937	0.3109	0.3448	0.3829	0.4268	0.4704	0.5041	0.5535	0.6003
31	88215	6.2100	23.2800	22.2600	8.0000	8.1100	62.8000	0.1154	0.1325	0.1384	0.1516	0.1684	0.1847	0.1960	0.2192	0.2450	0.2748	0.2958	0.3285	0.3632	0.3967
32	88216	7.8300	15.2500	13.0000	3.2000	9.6900	74.8100	0.2260	0.2580	0.2742	0.2961	0.3254	0.3594	0.3773	0.4199	0.4686	0.5229	0.5617	0.6216	0.6840	0.7441
33	88217	3.3300	22.9300	12.1100	3.4500	9.9000	69.7000	0.2775	0.3169	0.3336	0.3630	0.3990	0.4354	0.4618	0.5133	0.5719	0.6373	0.6831	0.7559	0.8300	0.9020
34	88218	2.3300	15.5700	5.8200	1.5300	10.5300	71.0900	0.1945	0.2211	0.2321	0.2528	0.2772	0.3015	0.3202	0.3551	0.3954	0.4403	0.4720	0.5208	0.5714	0.6202
35	88219	1.4300	15.9400	4.8200	1.5000	10.2200	67.6200	0.1999	0.2269	0.2378	0.2593	0.2829	0.3072	0.3257	0.3608	0.4013	0.4461	0.4781	0.5274	0.5786	0.6270
36	88220	2.6200	40.0500	14.6300	3.3700	10.1600	69.6200	0.1895	0.2163	0.2267	0.2475	0.2714	0.2953	0.3135	0.3479	0.3873	0.4311	0.4632	0.5113	0.5617	0.6097
37	88221	0.9200	66.9800	65.3100	6.6200	7.9400	53.3900	0.1448	0.1649	0.1738	0.1896	0.2098	0.2297	0.2439	0.2716	0.3030	0.3391	0.3645	0.4037	0.4443	0.4847
38	88222	4.4400	16.2500	20.7600	7.9100	8.7600	64.3000	0.1961	0.2228	0.2340	0.2581	0.2827	0.3092	0.3281	0.3646	0.4076	0.4551	0.4889	0.5397	0.5954	0.6490
39	88223	3.0500	31.1000	11.8400	3.1400	9.2100	65.1200	0.1495	0.1705	0.1789	0.1948	0.2148	0.2338	0.2479	0.2754	0.3062	0.3414	0.3859	0.4041	0.4448	0.4837
40	88224	4.2800	30.6200	26.6800	10.0400	7.2800	54.6400	0.1135	0.1283	0.1374	0.1515	0.1681	0.1846	0.1952	0.2179	0.2452	0.2750	0.2962	0.3286	0.3659	0.4012
41	88225	1.3400	35.0100	13.3900	2.9600	8.3600	56.9500	0.2380	0.2744	0.2879	0.3172	0.3453	0.3766	0.3980	0.4424	0.4936	0.5502	0.5993	0.6517	0.7198	0.7811
42	88226	1.3400	15.4700	4.5800	1.1000	9.9700	65.8900	0.2789	0.3077	0.3316	0.3623	0.3980	0.4354	0.4596	0.5080	0.5659	0.6318	0.6744	0.7428	0.8173	0.8881
43	88227	1.5900	54.5900	25.9500	6.6700	7.9400	55.6500	0.1322	0.1507	0.1568	0.1733	0.1908	0.2081	0.2197	0.2450	0.2738	0.3055	0.3278	0.3624	0.3995	0.4357
44	88228	2.1500	32.3500	17.2800	5.9700	8.2600	58.1400	0.2521	0.2880	0.3026	0.3297	0.3622	0.3944	0.4176	0.4639	0.5163	0.5744	0.6198	0.6809	0.7495	0.8149
45	88229	4.7300	15.6400	20.0100	6.3200	8.9900	66.0700	0.1789	0.2058	0.2174	0.2398	0.2612	0.2851	0.3017	0.3360	0.3756	0.4177	0.4488	0.4968	0.5479	0.5975
46	88230	1.9600	39.8400	12.2900	3.0700	10.0700	68.1400	0.1850	0.2092	0.2198	0.2387	0.2611	0.2851	0.3021	0.3349	0.3723	0.4147	0.4451	0.4916	0.5395	0.5871
47	88231	2.4400	47.4400	15.1500	3.6700	10.4900	71.4900	0.2845	0.3248	0.3451	0.3733	0.4108	0.4466	0.4729	0.5240	0.5841	0.6494	0.6996	0.7687	0.8454	0.9177
48	88232	1.9700	32.9500	18.5300	5.6400	8.2600	58.6000	0.2586	0.2942	0.3073	0.3398	0.3664	0.3900	0.4155	0.4515	0.5123	0.5732	0.6175	0.6847	0.7507	0.8202
49	88233	2.4300	40.3600	12.6100	3.0800	10.3100	70.2900	0.1794	0.2044</												

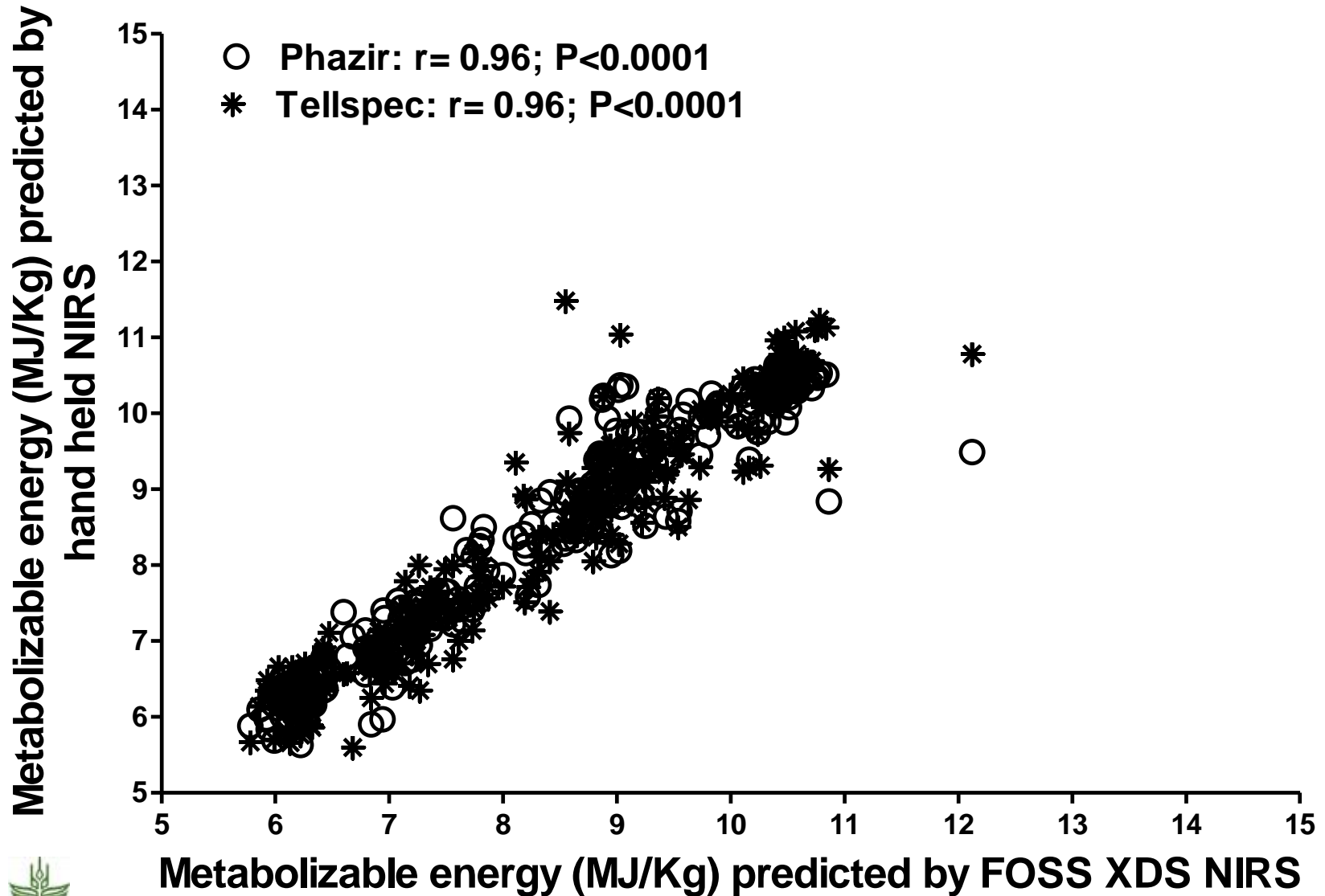
Results – Phazir and TellSpec nirs calibration and validation model statistics and good-of-fitness for quality traits

Table 1	Phazir calibration			Phazir validation			TellSpec calibration			TellSpec validation		
Constituent	n	R ² _{cal}	SEC	n	R ² _{val}	SEV	n	R ² _{cal}	SEC	n	R ² _{val}	SEV
N (%)	252	0.98	0.22	275	0.90	0.55	252	0.95	0.37	275	0.87	0.65
NDF (%)	260	0.98	3.46	275	0.95	5.05	261	0.92	6.20	275	0.89	7.56
ADF (%)	262	0.98	2.43	275	0.97	3.33	252	0.96	3.36	275	0.89	5.97
ADL (%)	260	0.85	1.41	275	0.67	2.36	257	0.84	1.45	275	0.58	2.68
IVOMD (%)	260	0.96	2.08	275	0.91	3.47	260	0.95	2.63	275	0.88	4.11
ME (MJ/Kg)	263	0.96	0.33	275	0.90	2.51	261	0.96	0.31	275	0.89	0.55

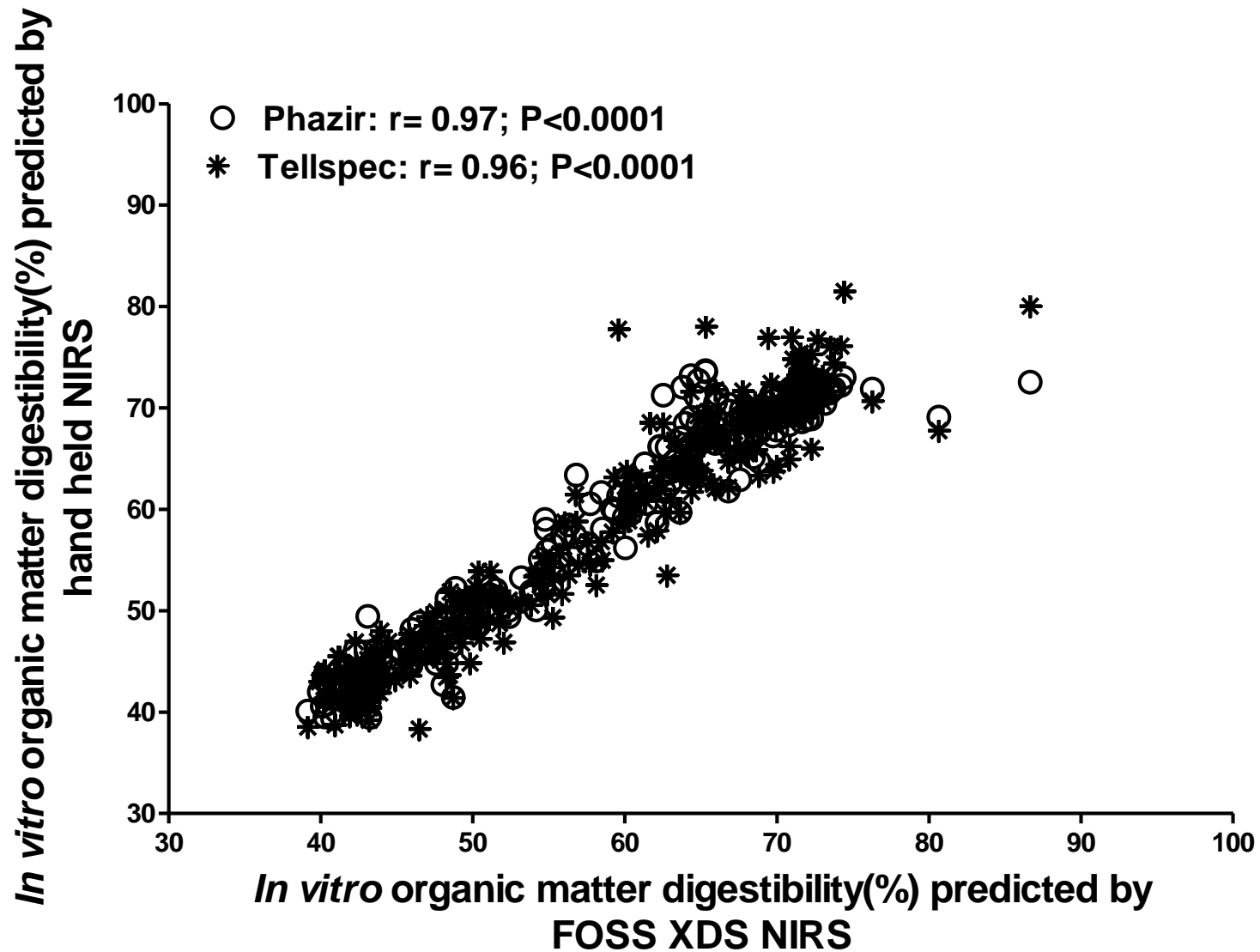
Relations between blind predicted results of Phazir and TellSpec with XDS nirs for nitrogen content



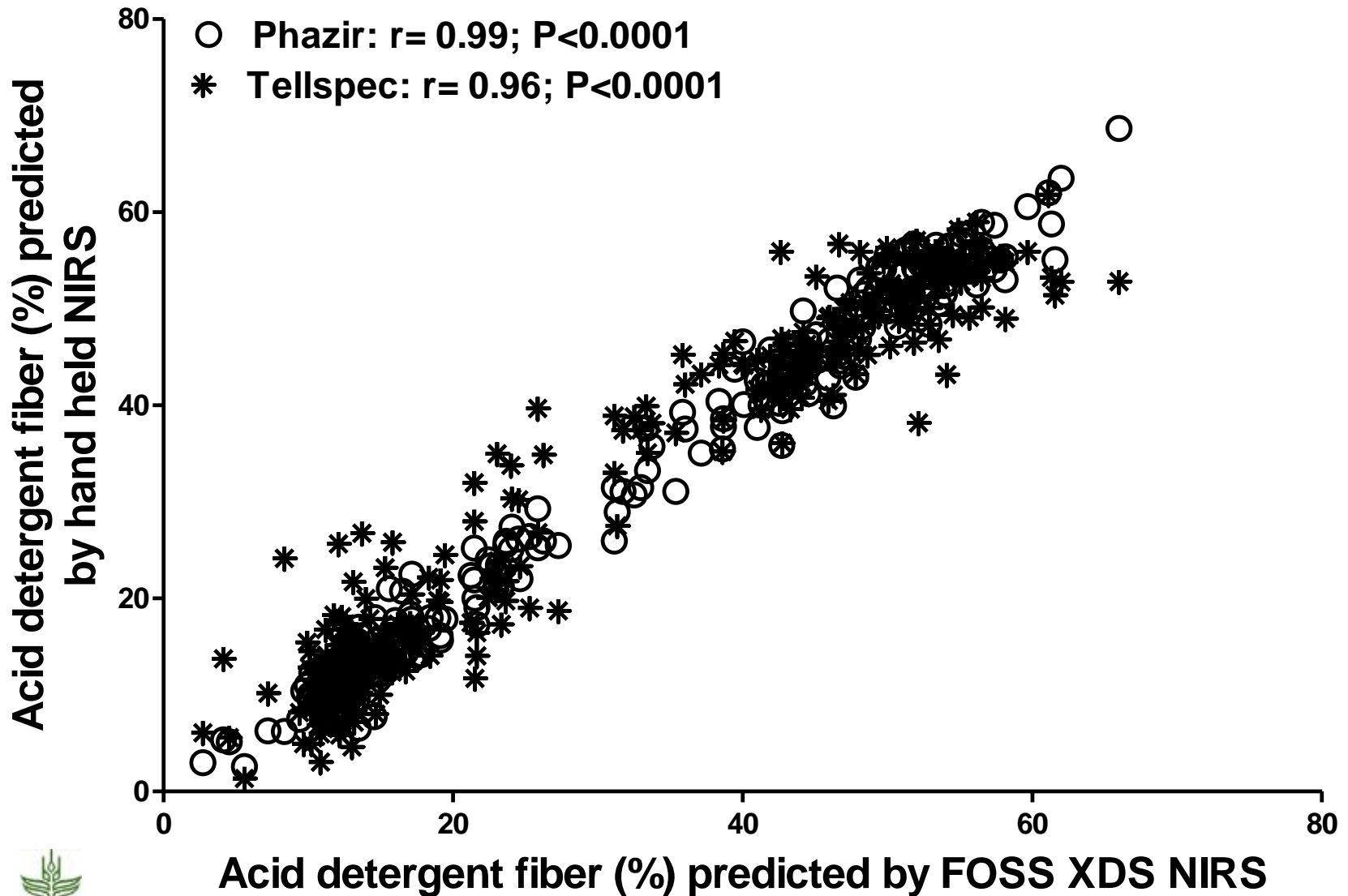
Relations between blind predicted results of Phazir and TellSpec with XDS nirs for ME content



Relations between blind predicted results of Phazir and TellSpec with XDS nirs for IVOMD content



Relations between blind predicted results of Phazir and TellSpec with XDS nirs for ADF content



Products and Expertise for All Markets

- **Pharmaceutical**
- **Chemical**
- **Polymer**
- **Textile**
- **Tobacco**

Process



- **Food Processing**
- **Dairy**
- **Beverage**
- **Meat**
- **Agriculture**
- **Feed and Forages**
- **Sugar Cane**



Key findings and extended application use

- Low cost TellSpec nirs is close to FOSS performance (>70 000\$)
- Thermo microPhazir still cost about >40 000\$
- Test in the field, fodder markets and feed processing units with fresh and un-processed materials is possible
- User friendly and can be used by consumers, traders and extension officers
- Win-win situation through lab to field and vice versa

Thank you very much for your attention!

and

better lives through livestock

ilri.org

ILRI thanks all donors and organizations who globally supported its work through their contributions to the **CGIAR system**

Patron: Professor Peter C Doherty AC, FAA, FRS

Animal scientist, Nobel Prize Laureate for Physiology or Medicine–1996

Box 30709, Nairobi 00100 Kenya
Phone +254 20 422 3000
Fax +254 20 422 3001
Email ilri-kenya@cgiar.org

ilri.org
better lives through livestock
ILRI is a CGIAR research centre

Box 5689, Addis Ababa, Ethiopia
Phone +251 11 617 2000
Fax +251 11 667 6923
Email ilri-ethiopia@cgiar.org

ILRI has offices in East Africa • South Asia • Southeast and East Asia • Southern Africa • West Africa



This presentation is licensed for use under the Creative Commons Attribution 4.0 International Licence.