

## A GENETIC STUDY OF IRANIAN POPULATIONS: RED CELL ENZYMES

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### ABSTRACT

A total of 1695 blood samples collected from ten ethnically distinct populations of Iran (Turks and Kurds of Rezaieh, Lurs, Zabolis, Baluchis, Turks and Kurds of Shirvan, Zoroastrians, Tehranis, and Kermanis) were examined for six polymorphic red cell enzyme systems, namely red cell acid phosphatase (AP), adenylate kinase (AK), phosphoglucomutase (PGM<sub>1</sub>), esterase D (ESD), adenosine deaminase (ADA), and 6-phosphogluconate dehydrogenase (6-PGD). The gene frequencies obtained from these samples were combined with the hitherto reported corresponding data from other Iranian groups to determine the genetic structure of the Iranian population as a whole. The

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population of Iran was then compared with reported frequencies for neighbouring populations, as well as with those for European and Indian groups. The generalized feature of red cell enzyme gene frequencies for the whole country of about 31% P<sup>a</sup>; 67% P<sup>b</sup>; 2% P<sup>c</sup>; 6% AK<sup>2</sup>; 31% pGM<sup>2</sup>; 19% EsD<sup>2</sup>; 13% ADA<sup>2</sup>; and 3% pGD<sup>C</sup>, all show a departure from the values found in the countries to the west and an approach to those in the Indian region.

## INTRODUCTION

In the first two papers of this series we reported on the distribution of several blood group and serum protein polymorphisms, respectively, in ten population groups from Iran. This paper discusses the gene frequencies of six polymorphic red cell enzymes, completing the genetic data obtained from these ten samples. The authors' data will be combined with those of the earlier studies on other Iranian groups (see Table 2) to determine the genetic structure of the Iranian population as a whole. The population of Iran will then be compared with reported red cell enzyme frequencies for neighbouring populations (2, 7, 8, 10, 11, 12, 13, 14, 16, 17, 18, 24, 25, 26, 27, 28, 29, 30, 34, 36), as well as with those for European and Indian groups. A fourth paper in this series will discuss the population genetic significance, which is evident from all hitherto tested genetic markers in Iran and neighbouring countries.

## MATERIALS AND METHODS

In five field surveys between 1979 and 1982 blood samples were collected from ten ethnically distinct Iranian populations. There were 138 Turks and 147 Kurds from Rezaieh in the north west, 178 Lurs from Luristan in the south west, 118 Zabolis and 111 Baluchis from Sistan and Baluchistan in the south east, 116 Turks and 103 Kurds from Shirvan in the north east, 120 Zoroastrians from Yazd in Central, 352 Tehranis and 310 Kermanis from Kerman in the south east of Iran.

EDTA was added to the blood samples as an anticoagulant. Haemolysates were prepared from washed red cells by rapidly freezing to  $-30^{\circ}\text{C}$ . The electrophoretic studies were performed partly in Tehran and partly, by transporting the samples in dry ice to the Department of Anthropology, in the University of Durham, U.K. The determination of red cell enzyme types was performed according to the methods described in Harris and Hopkinson (1976).

## RESULTS AND DISCUSSION

The numbers of the phenotypes and the respective gene frequencies in the six red cell enzyme systems are shown in Table 1. In no system was there any deviation from Hardy-Weinberg expectations. Table 2 shows the gene frequencies of the six red cell enzyme systems in various Iranian populations.

### *Acid Phosphatase (AP)*

Previous studies on the AP system show that the frequency of the  $P^a$  gene ranges from 11.50 to 45.50% and that of the  $P^b$  gene from 53.40 to 88.50% in Iranians. The rarest,  $P^c$ , allele was present in most Iranian populations studied and its frequency ranges from 0.45 to 4.26%. The present values of  $P^a$  (21.01-36.99%),  $P^b$  (63.01-77.73%) and  $P^c$  (Zero-1.96%) fit well into the general Iranian ranges. In general, AP frequencies for Iranians, about 31%  $P^a$ , 67%  $P^b$ , and 1.81%  $P^c$ , show that the population is characterized by a higher  $P^b$ , but lower  $P^a$  and  $P^c$  frequencies, compared with those averaging about  $P^a$  32,  $P^b$  61 and  $P^c$  6% found in Europeans. The AP frequencies in Iranians show more similarity to those in Indians (22). It seems that the frequencies of  $P^a$  and  $P^c$  decrease but that of  $P^b$  increase from west to east in Iran.

Reported AP frequencies for neighbouring populations show that, with the exception of the Arab groups of Kuwait and Saudi Arabia with their much lower  $P^a$  but higher  $P^b$  frequencies, which appear to be more like those found in Africans, in these populations also the frequency of the  $P^b$  gene is higher, but that of  $P^a$  and  $P^c$  genes are lower, compared with Europeans.

The higher incidence of the  $P^b$  allele in Iran and neighbouring countries agrees with the suggestion of a possible correlation of high  $P^b$  frequency and increasing mean annual temperature (3,38).

*Adenylate Kinase (AK)*

For the AK system the  $AK^2$  gene frequency ranges from 1.38 to 10.81% in the ten Iranian samples. Values obtained in the previous AK studies in Iran fall within this range of variation. The mean  $AK^2$  value of around 6% for Iranians is higher than frequencies varying between 2.5 and 6% in Europeans, but lower than the higher values (around 10%) in Indians (22).

In neighbouring populations also, with the exception of the Arab groups of Iraq, Kuwait and Saudi Arabia with their relatively lower values, the frequency of the  $AK^2$  gene is higher than that found in Europeans but lower than in Indians.

In general, the frequency of the  $AK^2$  gene seems to increase from Europe to India and the Iranian frequency is intermediate.

*Phosphoglucomutase ( $PGM_1$ )*

The results of the earlier PGM studies together with those of the present investigation show that the frequencies of the  $PGM^2$  gene range from 22.08 to 43.56% in Iranians. Generally,  $PGM^2$  values averaging about 31% in Iranians are higher than those around 20% in northern Europeans and more similar to the high frequencies (around 30%) in southern European and Indian populations (22).

Reported PGM frequencies for neighbouring populations show that, with the exception of the Afghans with their relatively lower values, the frequency of the  $PGM^2$  gene

in these populations also is higher than that in northern Europeans.

#### *Esterase D (ESD)*

The only previous ESD study in Iran is that of Akbari et al (1984) who reported ESD<sup>2</sup> gene frequencies of 11.20 and 19.50% in the Bandari and the Turkoman, respectively. The ESD<sup>2</sup> gene frequencies in the ten Iranian samples in the present study range from 12.61 to 29.55%. Generally, ESD<sup>2</sup> values averaging about 19% in Iranians are much higher than those around 11% in Europeans (5, 20, 39), but, slightly lower than in Indians in whom the ESD<sup>2</sup> value is around 22% (25).

Published data on the ESD system for neighbouring populations show that, with the exception of the Afghans with their relatively lower values, the frequency of the ESD<sup>2</sup> gene in these populations also is much higher than in Europeans.

#### *Adenosine deaminase (ADA)*

As can be seen from Table 1 only five out of the ten Iranian samples were examined for the ADA system. The results of the earlier ADA studies together with those of the present investigation show that the frequencies of the ADA<sup>2</sup> gene range from 6.80 to 19.56% in Iranians. These values, averaging about 13%, are higher than those around 7% found in Europeans and more similar to the higher values in Indians (22).

Available reports on ADA frequencies for neighbouring populations show that, with the exception of the Arab groups of Kuwait and Saudi Arabia with their relatively lower values, the frequency of the ADA<sup>2</sup> gene in these populations also is higher than in Europeans.

Generally, the frequency of the ADA<sup>2</sup> gene seems to show an eastward increase from 9 percent in Turkey to 13 percent in Iran and Afghanistan, to still higher values in India.

#### 6- *Phosphogluconate dehydrogenase* (6-PGD)

For the 6-PGD system also, as for ADA, only five out of ten Iranian samples were examined but the samples are not the same for both systems. Previous studies show that the frequency of the PGD<sup>C</sup> gene ranges from zero to 7.14%. The present values, varying between zero and 6.43%, fit well into the general range for the country as a whole. In general, PGD<sup>C</sup> frequencies averaging about 3% in Iranians are similar to those varying between 1 and 4% found in Europeans (22).

Reported frequencies for neighbouring populations show that, with the exception of the Arabs of Kuwait and Saudi Arabia with their higher values, the frequency of the PGD<sup>C</sup> gene in these populations also is similar to that in Europeans.

In conclusion, the generalized feature of red cell enzyme gene frequencies for the whole country of about 31% P<sup>a</sup>, 67% P<sup>b</sup>, 2% P<sup>c</sup>, 6% AK<sup>2</sup>, 31% PGM<sup>2</sup>, 19%ESD<sup>2</sup>, 13%ADA<sup>2</sup>,

and 3% PGD<sup>C</sup>, all show a departure from the values found in the countries to the west and an approach to those in the Indian region.

## REFERENCES

- 1- Akbari, M.T., Papiha, S.S., Roberts, D.F. and Farhud, D.D. (1984): Serogenetic investigation of two populations of Iran. *Hum. Hered.* 34: 371-377.
- 2- Altay, C., Say, B and Tuncbilek, E (1974): Frequency of red cell adenosine deaminase and 6-phosphogluconate dehydrogenase in a sample of the Turkish population. *Hum. Hered.* 24,3: 306-308.
- 3- Ananthakrishnan, R and Walter, H (1972): Some notes on the geographical distribution of the human red Cell acid phosphatase phenotypes. *Humangenetik* 15: 177-181.
- 4- Atighetchi, S and Farhud, D.D. (1982): L'etude du polymorphisme enzymatique des enzymes 6PGD et AK en Iran. *Iranian. J. Publ. Health.* 11: 23-31.
- 5- Benkmann, H.G and Goedde, H. W(1974): Esterase D Polymorphism: Gene frequencies and family data. *Humangenetik.* 24: 325-327.
- 6- Bowman, J.E and Ronaghy, H (1967): Haemoglobin, glucose-6-phosphate dehydrogenase, phosphogluconate dehydrogenase, and adenylate kinase polymorphism in Moslems in Iran. *Amer. J. Phys. Anthrop.* 27, 2: 119-123.



- 7- Brinkmann, B., Reiter, J and Kruger, O(1973): Genhaufigkeiten einiger Enzym polymorphismen in Mittelmeerländern. Humangenetik. 20: 141-146.
- 8- Cartwright, R.A., Bethel, I.L., Hargreaves, H., Izatt, M., Jolly, J., Mitchell, R.J., Sawhney, K.S., Smith, M., Sunderland, E and Teasdale, D (1976): The red blood cell Esterase D polymorphism in Europe and Asia. Hum. Genet. 33: 161-166.
- 9- Farhud, D.D., Ananthakrishnan, R., Walter, H and Loser, J (1973): Electrophoretic investigations of some red cell enzymes in Iran. Hum. Hered. 23: 263-266.
- 10- Godber, Marilyn J., Kopec, Ada C., Mourant, A.E., Tills, D and Lehmann, E.E(1973): Biological studies of Yemenite and Kurdish Jews in Israel and other groups in south west Asia. IX. The hereditary blood factors of the Yemenite and Kurdish Jews. Phil. Trans., S.B.266: 169-184.
- 11- Goedde, H.W., Benkmann, H.G., Agarwal, D.P., Hirth, L., Bienzle, U., Dietrich, M., Hoppe, H.H., orlowski, J., Kohne, E and Kleinhauer, E (1979): Genetic studies in Saudi Arabia: Red cell enzyme, Haemoglobin and serum protein polymorphisms. Amer. J. Phys. Anthrop. 50, 2: 271-278.
- 12- Goedde, H.W., Benkmann, H.G., Flatz, G., Rahimi, A.G., Kaifie, S and Delbruck, H (1977): Red cell enzyme Polymorphisms in different populations of Afghanistan. Ann. Hum. Biol. 4,3: 225-232.

- 13- Goldschmidt, Elizabeth (1967): Summary and conclusions. 9th Int. Congr. Life Ass. Med. Tel-Aviv. 200-206.
- 14- Goldschmidt, Elizabeth., Fried, K., Steinberg, A.G. and Cohen, T (1976): The Karaite Community of Iraq in Israel: A genetic study. Amer. J. Hum. Genet. 28, 3: 243-252.
- 15- Harris, H and Hopkinson, D.A (1976): Handbook of enzyme electrophoresis in human genetics (North-Holland, Amsterdam).
- 16- Hopkinson, D.A. and Harris, H (1966): Rare phosphoglucomutase phenotypes. Ann. Hum. Genet. 30: 167-181.
- 17- Hummel, K., Pulverer, G., Schaal, K.P. and Wiedtman, V(1970): Haufigkeit der sichttypen in den Erbsystemen Haptoglobin, GC, Saure Erythrocyten phosphatase, phosphoglucomutase und Adenylate kinase sowie den Erbeigenschaften Gm(1), Gm(2), und Inv(1) bei Deutschen (aus dem Raum Freiburg. Br. und Koln) und bei Turken. Humangenetik. 8: 330-333.
- 18- Khaled, E., Al-Nassar, P., Michael Conneally., Catherine G., Palmer and Pao-10 yu (1981): The genetic structure of the Kuwaiti population. Hum. Genet. 57: 192-198.
- 19- Kirk, R.L., Bronya, Keats., Black, N.M., Mcdermid, E.M., Ala, F., Karimi, M., Nickbin, B., Shabazi, H and Kmet, J (1977): Genes and people in the Caspian littoral: A population genetic study in northern Iran. Amer. J. Phys. Anthrop. 46: 377-390.

- 20- Koster, B., Leupold, H and Mauff, G (1975): Esterase D Polymorphism: High voltage agarose-gel electrophoresis and distribution of phenotypes in different European populations. *Humangenetik*. 28: 75-78.
- 21- Lehmann, H., Ala, F., Hedayat, S., Montazemi, K., Karimi-Nejad, H., Lightman, S., Kopec, A.C., Mourant, A.E., Teesdale, P and Tills, D (1973): The hereditary blood factors of the Kurds of Iran. *Phil. Trans. R. Soc. Lond.* 266: 195-205
- 22- Mourant, A.E., Kopec, A.C and Domaniewska Sobczak, K (1976): The distribution of the human blood groups and other polymorphisms. 2nd ed. (Oxford University Press, London).
- 23- Ohkura, K., Miyashita, T., Nakajima, H., Matsumoto, H., Matsutomo, K., Rahbar, S and Hedayat, S (1984): Distribution of polymorphic traits in Mazandaranian and Guilanian in Iran. *Hum. Hered.* 34: 27-39.
- 24- Papiha, S.S and Al-Agidi, S.K. (1976): Esterase D and superoxide dismutase polymorphisms in Iraq. *Hum. Hered.* 26,5: 394-400.
- 25- Papiha, S.S and Nahar, A (1977): The world distribution of the electrophoretic variants of the red cell enzyme esterase D. *Hum. Hered.* 27: 424-432.
- 26- Papiha, S.S., Roberts, D.F and Rahimi, A.G (1977): Genetic polymorphisms in Afghanistan. *Ann. Hum. Biol.* 4,3: 233-241.
- 27- Rapley, S., Robson, E.B., Harris, H and Smith, S.M. (1967): data on incidence, segregation and linkage

- relations of the adenylate kinase (AK) polymorphism. Ann. Hum. Genet. 31: 237-242.
- 28- Richard, P (1976): Hemotypologie des Kurds. Doctorate Thesis, Toulouse. France. 85 PP.
- 29- Saha, N., Bayoumi, R.A. Elsheikh, F.S., Samuel, A.P. W., Elfadil, I. Elhouri, I.S, sebai, Z.A and Sabaa, H.M.A (1980): Some blood genetic markers of selected tribes in western Saudi Arabia. Amer. J. Phys. Anthrop. 52, 4: 595-600.
- 30- Sawhney, K.S. (1975): Genetic polymorphisms in selected populations in south and south east Asia. Ph.D. Thesis. University of Durham. U.K.
- 31- Sawhney, K.S., Sunderland, E and Farhud, D.D(1981): Study of red cell enzyme systems in Tehran and Isfahan Iranians. Jpn.J. Hum. Genet. 26: 289-294.
- 32- Simhai, B(1974): Enzymatic genetic polymorphisms among Persian Jews in Israel. M.Sc. Thesis. The Hebrew University of Jerusalem. Israel.
- 33- Simhai, B(1978): Enzyme polymorphisms in Iranian Armenians. 7th National Genetic Congress. Jundishapur University, Ahvaz. Iran.
- 34- Szeinberg, A and Tomashevsky-Tamir, S(1971): Red cell adenylate kinase and phosphoglucomutase polymorphism in several population groups in Israel. Hum. Hered. 21: 289.
- 35- Tills, D., Vanden Branden, J.L., Clements, V.R. and Mourant, A.E (1971): The world distribution of electrophoretic variants of the red cell enzyme

adenylate kinase (ATP: AMP phosphotransferase) EC 2.7.4.3. Hum. Hered. 21: 302-304.

- 36- Tills, D., Warlow, A., Mourant, A.E., Kopec, A.C., Edholm, O.G and Garradr, G(1977): The blood groups and other hereditary blood factors of Yemenite and Kurdish Jews. Ann. Hum. Biol. 4,3: 259-274.
- 37- Vanden Branden, J.L., Clements, V.R., Mourant, A.E and Tills, D (1971): The distribution in human populations of genetic variants of Adenosine deaminase.Hum. Hered. 21: 60-62.
- 38- Walter, H and Bajatzadeh, M(1968): Studies on the distribution of the human red cell acid phosphatase in Iranians and other populations. Acta. Genet., Basel, 18: 421-428.
- 39- Welch, S and Lee, J (1974): The population distribution of genetic variants of human esterase D. Human-genetik. 24: 329-331.

Table 1. Phenotypes and gene frequencies for red cell enzyme systems in ten populations of Iran

System	Rezaieh Rezaieh									
	Turks	Kurds	Lurs	Zabolis	Baluchis	Turks Shirvan	Kurds Shirvan	Zoroas- trians	Tehrani	Kermanis
AP										
AA	12	17	16	19	17	11	8	4	49	31
BA	48	74	61	44	47	40	28	42	145	133
BB	65	55	94	51	46	62	63	70	146	134
CA	-	-	2	1	-	-	-	-	1	4
CB	-	-	5	2	1	2	2	3	11	5
Total	125	146	178	117	111	115	101	119	352	307
$p^a$	28.80	36.99	26.69	35.47	36.49	26.96	21.78	21.01	34.66	32.41
$p^b$	71.20	63.01	71.35	63.25	63.06	72.17	77.23	77.73	63.64	66.12
$p^c$	0.00	0.00	1.96	1.28	0.45	0.87	0.99	1.26	1.70	1.47
$\chi^2$	0.51	1.11	1.76	3.00	1.32	2.18	3.91	1.44	5.81	0.68
AK										
1-1	120	141	154	94	88	103	91	105	306	268
2-1	7	4	22	23	22	13	12	15	51	38
2-2	-	-	2	1	1	-	-	-	-	3
Total	127	145	178	118	111	116	103	120	357	309
AK <sup>1</sup>	97.24	98.62	92.70	89.40	89.19	94.40	94.17	93.75	92.86	92.88
AK <sup>2</sup>	2.76	1.38	7.30	10.60	10.81	5.60	5.83	6.25	7.14	7.12
$\chi^2$	0.10	0.03	1.35	0.10	0.09	0.41	0.39	0.53	2.11	1.52

Table 1. Continued

System	Turks Rezaieh	Kurds Rezaieh	Lurs	Zabolis	Baluchis	Turks Shirvan	Kurds Shirvan	Zoroastrians	Tehrani	Kermanis
PCM <sub>1</sub>										
1-1	36	47	90	53	45	50	40	60	152	123
2-1	42	68	68	51	54	50	40	40	153	144
2-2	23	23	17	13	11	10	12	4	41	43
Total	101	138	175	117	110	110	92	104	346	310
PCM <sup>1</sup>	56.44	58.70	70.86	67.09	65.45	68.18	65.22	76.92	66.04	62.91
PCM <sup>2</sup>	43.56	41.30	29.14	32.91	34.55	31.82	34.78	23.08	33.96	37.09
$\chi^2$	2.40	0.04	0.61	0.02	0.80	0.25	0.16	0.72	0.07	0.01
ESD										
1-1	66	81	136	86	57	88	71	74	229	204
2-1	54	57	36	25	41	25	27	35	105	91
2-2	9	5	6	3	12	2	3	2	11	11
Total	129	143	178	117	110	115	101	111	345	306
ESD <sup>1</sup>	72.09	76.57	86.52	85.47	70.45	87.39	83.66	82.43	81.60	81.54
ESD <sup>2</sup>	27.91	23.43	13.48	14.53	29.55	12.61	16.34	17.57	18.40	18.46
$\chi^2$	0.21	1.76	3.15	0.16	1.21	0.02	0.05	0.87	0.06	0.05

Table 1. Continued

System	Turks		Kurds		Lurs	Zabolis	Baluchis	Turks		Kurds		Zoroas-	Tehranis	Kermanis
	Rezaieh	Rezaieh	Rezaieh	Rezaieh				Shirvan	Shirvan	Shirvan	trians			
ADA														
1-1	104	106	-	-	-	-	-	83	74	31	-	-	-	-
2-1	30	38	-	-	-	-	-	33	23	12	-	-	-	-
2-2	4	3	-	-	-	-	-	2	4	3	-	-	-	-
Total	138	147	-	-	-	-	-	118	101	46	-	-	-	-
ADA <sup>1</sup>	85.46	85.04	-	-	-	-	-	84.33	84.66	80.44	-	-	-	-
ADA <sup>2</sup>	14.54	14.96	-	-	-	-	-	15.67	15.34	19.56	-	-	-	-
$\chi^2$	1.09	0.04	-	-	-	-	-	0.39	1.54	1.35	-	-	-	-
6PGD														
AA	-	-	-	-	-	-	-	80	61	66	79	278	-	-
CA	-	-	-	-	-	-	-	10	9	-	3	22	-	-
CC	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Total	-	-	-	-	-	-	-	90	70	66	82	301	-	-
PGD <sup>a</sup>	-	-	-	-	-	-	-	94.44	93.57	100.00	98.17	96.01	-	-
FGD <sup>c</sup>	-	-	-	-	-	-	-	5.56	6.43	0.00	1.83	3.99	-	-
$\chi^2$	-	-	-	-	-	-	-	0.31	0.33	0.00	0.03	0.62	-	-



Table 2. Red cell enzyme gene frequencies in various populations of Iran

Sample	AP		AK		PGM <sub>1</sub>		ESD		ADA		6PGD		Authors
	P <sup>a</sup>	P <sup>b</sup>	AK <sup>1</sup>	AK <sup>2</sup>	PGM <sup>1</sup>	PGM <sup>2</sup>	ESD <sup>1</sup>	ESD <sup>2</sup>	ADA <sup>1</sup>	ADA <sup>2</sup>	PGD <sup>a</sup>	PGD <sup>c</sup>	
Kurdish Jews	35.11	63.36	-	-	-	-	-	-	-	-	-	-	Goldschmidt et al (1967)
Iranians	36.74	61.22	-	-	-	-	-	-	-	-	-	-	"
Moslems Shiraz	-	-	95.03	4.97	-	-	-	-	-	-	-	-	Bowman and Ronaghy (1967)
North Western Iran	25.50	71.10	3.40	-	-	-	-	-	-	-	-	-	Walter and Bajatzaden (1966)
Northern Iran	28.80	67.40	3.80	-	-	-	-	-	-	-	-	-	"
Western Iran	30.00	67.40	2.60	-	-	-	-	-	-	-	-	-	"
Eastern Iran	30.30	67.20	2.50	-	-	-	-	-	-	-	-	-	"
Central and Southern Iran	30.90	65.70	3.40	-	-	-	-	-	-	-	-	-	"
Tehran	34.10	62.70	3.20	-	-	-	-	-	-	-	-	-	"
Kurds	-	-	-	-	-	-	-	-	88.20	11.80	-	-	Vanden Braden et al (1971)
Kurds	-	-	93.13	6.87	-	-	-	-	182	-	95.33	4.67	Tills et al (1971)
Kurds sanandaj	31.90	66.67	1.43	92.45	7.55	68.40	31.60	-	84.29	15.71	97.17	2.83	Lehmann et al (1973)
	105		106		106				105		106		

Table 2. Continued

Sample	AP		P <sup>c</sup>	AK		PGM <sub>1</sub>		ESD		ADA		6PGD		Authors
	p <sub>a</sub>	p <sub>b</sub>		AK <sup>1</sup>	AK <sup>2</sup>	PGM <sup>1</sup>	PGM <sup>2</sup>	ESD <sup>1</sup>	ESD <sup>2</sup>	ADA <sup>1</sup>	ADA <sup>2</sup>	FGD <sup>a</sup>	FGD <sup>c</sup>	
Kurds Baneh, Marivan	34.41	64.29 77	1.30	92.86 77	7.14	77.92	22.08 77	-	-	92.86	7.14	92.86	7.14	Lehmann et al (1973)
Kurdish Jews Tehran	34.57	61.17 94	4.26	93.62 94	6.38	75.53 68.50 <sup>94</sup>	24.47 31.50	-	-	-	-	95.21 98.47 <sup>94</sup>	4.79 1.53	Godber et al (1973) Farhudi et al (1973)
Kurdish Jews	34.20	63.00 164	2.80	96.80 164	3.20	71.70 164	28.30 164	-	-	85.80	14.20	97.70	2.30	Simnar (1974)
Kurdish Jews	37.27	58.96 106	3.77	92.92 106	7.08	77.36 106	22.64 106	-	-	-	-	95.28 106	4.25	Tills et al (1977)
Tavalesh Astara	27.10	72.10 61	0.80	95.10 61	4.90	63.90 61	36.10 61	-	-	91.80	8.20	100.00	0.00	(Kirk et al (1977))
Babol, Shahi Amol	28.90	71.10 64	0.00	94.50 64	5.50	73.40 64	26.60 64	-	-	82.00	18.00	96.90	3.10	"
Shahsavari, Rudsar Rudbar, Rasht Lengarud, Lahijan Bandar-Pahlavi	35.50	62.20 86	2.30	90.70 86	9.30	63.40 86	36.60 86	-	-	87.20	12.80	98.80	1.20	"
Gonbad	37.10	60.60 155	2.30	95.20 155	4.80	60.00 155	40.00 155	-	-	89.40	10.60 155	94.80	5.20	"
Southern Gorgan, Behshahr, Sari	37.70	62.30 53	0.00	98.10 53	1.90	58.50 53	41.50 53	-	-	84.90	15.10	98.10	1.90	"
Northern Gorgan	45.50	53.40 44	1.10	93.20 44	6.80	70.50 44	29.50 44	-	-	93.20	6.80	96.10	3.90	"
Armenians	24.70	72.10 180	3.20	-	-	74.00 180	26.00 180	-	-	-	-	98.00	2.00	Simhai (1978)
Isfahan	27.27	71.43 77	1.30	95.78 83	4.22	75.00 86	25.00 86	-	-	-	-	97.19	2.81	Sawhney et al (1981)

Table 2. Continued

Samples	AP		pc	AK		PGH <sup>1</sup>		ESD		ADA		6PGD		Authors
	pa	pb		AK <sup>1</sup>	AK <sup>2</sup>	PGH <sup>1</sup>	PGH <sup>2</sup>	ESD <sup>1</sup>	ESD <sup>2</sup>	ADA <sup>1</sup>	ADA <sup>2</sup>	PGD <sup>1</sup>	PGD <sup>2</sup>	
Tehran	34.16	63.67	2.17	94.64	5.36	76.36	23.64	-	-	-	-	97.58	2.42	Sahebney et al (1981); 165
Moslems Tehran	-	-	-	94.21	5.79	-	-	-	-	-	-	98.20	1.80	Atighetehi & Farhad (1982); 111
Mazandaranians	34.50	62.50	3.00	-	-	73.20	26.80	-	-	-	-	-	-	Shkura et al (1984); "
Guilanians	25.00	74.10	0.90	-	-	73.30	26.70	-	-	-	-	-	-	"
Eandari	11.50	88.50	0.00	96.10	3.90	-	-	88.80	11.20	93.20	6.80	-	-	Akbari et al (1984); 117
Turkoman	32.40	65.60	2.00	98.50	1.50	58.80	41.20	80.50	19.50	91.30	8.70	99.50	0.50	"
Turks Rezaieh	28.80	71.20	0.00	97.24	2.76	56.44	43.56	72.09	27.91	85.46	14.54	-	-	Present study; 95
Kurds Rezaieh	36.99	63.01	0.00	98.62	1.38	58.70	41.30	76.57	23.43	85.04	14.96	-	-	"
Lurs	26.69	71.35	1.96	92.70	7.30	70.86	29.14	86.52	13.48	-	-	-	-	"
Zabolis	35.47	63.25	1.28	89.40	10.60	67.09	32.91	85.47	14.53	-	-	-	-	"
Saluchis	36.45	63.06	0.45	89.19	10.81	65.45	34.55	70.45	29.55	-	-	-	-	"
Turks Shirvan	26.96	72.17	0.87	94.40	5.60	68.18	31.82	87.39	12.61	84.33	15.67	94.44	5.56	"
Kurds Sirvan	21.78	77.23	0.99	94.17	5.83	65.22	34.78	83.66	16.34	84.66	15.34	93.57	6.43	"
Zoroastrians	21.01	77.73	1.26	93.75	6.25	76.92	23.08	82.43	17.57	80.44	19.56	100.00	0.00	"
Tehrains	34.66	63.64	1.70	92.86	7.14	66.04	33.96	81.60	18.40	-	-	98.17	1.83	"
Zermanis	32.41	66.12	1.47	92.88	7.12	62.91	37.09	81.54	18.46	-	-	96.01	3.99	"