The physical properties and laboratory scale flour extraction for Hard Winter wheat varieties grown at Oklahoma State University Experiment Stations in 1999 were analyzed. Twenty cultivars grown in fourteen locations representing six agricultural districts showed a protein content range of 9.3 to 15.7 percent (12 percent moisture basis, mb). The highest and lowest average protein contents were observed in samples from Goodwell irrigated management (14.9 percent, 12 percent mb) and Frederick (10.6 percent, 12 percent mb), respectively. Six of fourteen cultivars showed all values (100 percent distribution, across location) of protein content in the range of 11 to less than 14 percent. Those cultivars were 2163, Big Dawg, Dominator, Champ, Tam 302 and Tomahawk. The other varieties had about 70 percent distribution of protein content in the same range.

Test weight frequency distributions across locations of values equal to or greater than 58 lb/bu showed 2174 (79 percent), Big Dawg, Ogallala, and Tonkawa (72 percent each) as the first and second (tie) places, respectively. Average single kernel weight distributions with values equal to or greater than 28 mg were observed for Big Dawg (93 percent) and all cultivars in Elk City yielded 28 mg or greater values. Extraction rates ranking of cultivars varied within each location of the agricultural districts. Overall, the top ranking cultivars were Ogallala in the Panhandle, Big Dawg in the Central and North Central Districts (except for Alva), and AgSeco 7853 in the West Central. In the Southwest agricultural districts, Coronado consistently ranked higher extraction rates compared to the other cultivars.

INTRODUCTION

This report describes key physical properties of Hard Red Winter wheat cultivars planted in Oklahoma Experimental Stations during the crop year 1999. Since environmental condition during the growing season plays a significant role influencing the quality of wheat, it is of interest to describe the variation of key wheat quality parameters of the top twenty cultivars grown throughout different regions in the state. The record of this information is valuable to the wheat industry since it will give a historical track record that can complement agronomical data already available through other sources (Krenzer et al, 2000) and protein content from previous years (Brusewitz and Stephens, 1979).

METHODOLOGY

Twenty cultivars of Hard Winter wheat were grown by Eugene Krenzer, Ph.D., Extension Specialist, Department of Plant and Soil Sciences, in fourteen locations corresponding to six agricultural districts based on the Oklahoma Agricultural Statistics Service. The cultivars were planted in a randomized complete block design with four replicates in Oklahoma State University Experiment Station plots. Each subplot consisted of five 3.0 m long rows spaced 0.23 m apart. A small plot combine was used to harvest each plot and a sub-sample, number 10 can of about gallon size, was saved. The sub-samples were cleaned twice and the test weight analyzed using AACC method 55-10 (AACC 1995) in a standard quart apparatus. A composite sample was obtained by blending the four replicates per block and used for subsequent analysis.

There were 280 samples collected and stored in a freezer at 8°F for 16 to 24 hours. Protein content was determined by near infrared (NIR) transmittance in a whole grain analyzer (ZX-800 Zeltex Inc., Hagerstown, MD). Selected samples showing protein values higher than 13 percent were analyzed by the Dumas method using a combustion nitrogen analyzer Model MacroN (Foss Heraeus, Elementar) and Kjedahl AACC method 46-13. These methods confirmed the high protein values obtained with NIR. High protein values were attributed to differences in fertilization levels used. Physical analysis to estimate grain uniformity (average single kernel weight, diameter and hardness) were performed using a Single Kernel Characterization System (SKCS Model 4100, Perten Inst.,
from Elk City, taken from 20 cultivars, showed the highest average kernel diameter of ≤2.2 mm. Wheat samples measured ≥2.2 mm (target value) were 2174, Agseco 7853, average diameter at 1.9 mm (Table 1a, b). Cultivars that had the largest average single kernel diameter were Big Dawg and Marshall (Table 3).

Average Single Kernel Diameter
Big Dawg had the largest average single kernel diameter (2.4 mm), while Betty and 2174 (cv) gave the lowest average diameter at 1.9 mm (Table 1a, b). Cultivars that measured ≥2.2 mm (target value) were 2174, Agseco 7853, Lockett and Tonkawa, while the rest of the cultivars had an average kernel diameter of ≤2.2 mm. Wheat samples from Elk City, taken from 20 cultivars, showed the highest average single kernel diameter (2.3 mm) among the locations, whereas Lamont showed the lowest (1.8 mm, Table 2). All the other locations had average single kernel diameter between 1.9 to 2.2 mm.

Average Kernel Hardness
Jagger and Betty were among the highest hardness kernel textured cultivars with an average hardness index >77 while Heyne was the softest with a hardness index of 56 (Table 1a, b). Cultivars that had ≥65 kernel hardness averaged across locations were 2137, 2163, 2174, Big Dawg, Coronado, Custer, Dominator, Kari 92, Lockett, Ogallala, Oro Blanco, Tam 302, Tomahawk and Tonkawa. Wheat samples from Frederick had the lowest hardness index of 57, which is slightly lower than the target of minimum hardness 60. All the other locations ranged from 61 to 77 average hardness index values (Table 2).

Percent Protein
The average protein content of all the cultivars tested was less than 12% (12% mb), averaged across locations with a range of 9.3 to 15.7% (Table 1a, b). When averaged across cultivars, wheat samples from Goodwell irrigated management had the highest average protein content (14.9% on a 12% mb) (Table 2). The location with the lowest average protein content was Frederick with 10.6% and a range of 9.3 to 11.4% (Table 2). These results show the potential protein that the cultivars can produce. The average protein content of the same cultivars grown commercially can vary widely. Differences can be accounted for by management practices, including fertilizer application among other factors.

Test Weight
Cultivars 2174, Agseco 7853, Big-Dawg, Ogallala and Tonkawa had an average test weight of 59+ lb/bu, while Tam 302 and Tomahawk averaged <55 lb/bu, across locations (Table 1a, b). Among the locations that gave test weight >59 lb/bu were Goodwell under both dry land and irrigated management, Gage, Altus, and Elk City while Lamont and Lahoma had the lowest (<55 lb/bu), averaged across cultivars (Table 2).

Average Kernel Hardness
When cultivar values were averaged across locations, Big Dawg had the highest single kernel weight at 33.4 mg, while 2163 and Ogallala had 23.6 mg (Table 1a, b). Cultivars that showed ≥28 mg target value were 2174, Agseco 7853, Chisholm, Coronado, Custer, Lockett and Tonkawa (Table 1a, b). When single kernel weight was averaged across cultivars, samples from Elk City had the highest at 32.5 mg while Lamont had the lowest at 21.3 mg (Table 3). Among the locations that showed ≥28 mg were Alva, Cherokee, Frederick and Goodwell dryland, Gage and Marshall (Table 3).

Average Single Kernel Weight
Percent Distribution Average Across Cultivars and Locations
Average Kernel Size
Large kernel size is defined as kernels that stay on a No. 7 mesh (Tyler No. 7 screen, 2.82 mm) opening while medium kernel size is retained on a No. 9 mesh (Tyler No. 9 screen 2.00 mm) opening. Large kernel size is desirable because it generally produces higher flour extraction. Uniform kernel size (low standard deviation) is also desirable.

Big Dawg (cv) produced the highest proportion of large kernel size at 80% while Ogallala had only 39% (Table 1a, b). Cultivars with >60% large kernel size were 2174, Agseco 7853, Coronado, Custer, Lockett, Tam 302 and Tonkawa, averaged across locations. Locations that produced ≥70% large kernel size were Alva, Elk City and Frederick (Table 2).

Distribution comparison by cultivar across locations (Fig. 1-20, Panel A). The protein content of the cultivars 2163, Big Dawg, Dominator, Champ, Tam 302 and Tomahawk showed all values (100% distribution) in the range of 11 to 14+% protein. The rest of the cultivars, 14 out of 20, had about 70% distribution in the same range. This means that 70% of the samples had a protein content of 11% or higher.

Distribution comparison by location, across cultivars
Distribution comparison by location, across cultivars
Distribution comparison by location, across cultivars
The protein values reported here were used for comparative purposes only. These samples were grown at OSU Agricultural Experiment Stations with optimum fertilizer application and in the absence of grazing practices. The results illustrate the relative potential of the cultivars for seed protein content.
Average Test Weight
Test weight values of the same cultivars tested in Oklahoma Agricultural Stations were reported earlier by Krenzer. Test weight values of 58 (lb/bu) or higher are a target quality characteristic. Test weight values are used as an estimate of flour yield potential. In most recent years, higher wheat test weight lots produce higher flour extraction; but there are exceptions to this observation and this is checked with every new crop. Extraction rates are of special interest to the milling industry.

Average across locations
(Fig. 1-20, Panel B). Cultivars with test weights ≥58 lb/bu at ≥50 frequency distribution were 2137 (50%), Coronado (50%), Chisholm (57%), Custer (57%), Karl 92 (58%), Agseco 7853 (64%), Ogallala (72%), Tonkawa (72%), Big Dawg (72%) and 2174 (79%).

Average across cultivars
(Fig. 21-34, Panel B). Locations with ≥50% frequency distribution of test weight at 58 lb/bu or more were Apache (60%), Alva (65%), Altus (80%), Goodwell irrigated (80%), Elk City (85%), Gage (95%) and Goodwell dryland (100%), while the rest of the locations have 50% or less.

Average Single Kernel Weight
The quality target for average single kernel weight is 28 mg or higher.

Average across locations
(Fig. 1-20, Panel C). Big Dawg showed the highest percent distribution (93%) of average single kernel weight at ≥28 mg or more. Other cultivars that showed ≥50% distribution for this quality target (≥28 mg) were Coronado (50%), Heyne (50%), 2137 (57%), 2174 (57%), Agseco 7853 (57%), Chisholm (57%), Custer (64%), Lockett (64%) and Tonkawa (72%).

Average across cultivars
(Fig. 21-34, Panel C). All samples from Elk City had an average single kernel test weight ≥28 mg, while all samples from Lamont had ≤28 mg. Other cultivars with ≥50 percent distribution of ≥28 mg average single kernel weight were Frederick (50%), Marshall (50%), Alva (60%), Gage (65%), Cherokee (70%) and Goodwell dryland (80%).

Average Single Kernel Diameter
The desired value for average single kernel diameter is 2.2 mm or higher.

Average across locations
(Fig. 1-20, Panel D). All samples from cultivars 2163, Betty, Jagger and Oro Blanco had a single kernel diameter of <2.2 mm. Cultivars that gave ≥50% distribution of kernel diameter at ≥2.2 mm were Coronado (50%), Lockett (50%), Agseco 7853 (57%), 2137 (71%), 2174 (71%) and Big Dawg (93%).

Average across locations
(Fig. 21-34, Panel D). All cultivars (100%) grown at Lamont measured <2.2 mm, while kernel diameters of ≥2.2 mm were observed in Cherokee and Goodwell dryland (50%) and Elk City (70%).

Extraction Rate by Agricultural District
Extraction rate, also referred to as flour yield, was ranked within each location and assessed as a relative comparison among cultivars and locations.

In the Panhandle area (Table 3), Ogallala (cv) produced the highest extraction rate in Gage (65.2%) and Goodwell dryland (65.7%); it also ranked third in Goodwell irrigated (66.6%). Tonkawa (cv) produced the lowest extraction rate (<62%) and ranked the lowest among the cultivars.

In the North Central agricultural district (Table 4), Big Dawg (cv) ranked first in Lahoma (62.4%) and Lamont (62.9%), but ranked fourth in Cherokee (64.4%), and among the lowest (57.5%) in Alva. Tonkawa and Custer ranked the lowest among all the cultivars in all the locations tested.

In the West Central agricultural district (Table 5), Agseco 7853 (cv) yielded the highest extraction rate (65.4%), while Tonkawa (cv) yielded the lowest (59.9%).

In the East Central agricultural district (Table 5), Big Dawg (cv) yielded the highest extraction rate (62.3%), while Custer (cv) produced the lowest (54.5%).

In the Central agricultural district (Table 6), Tomahawk (cv) ranked second in both Chickasha (62.3%) and Marshall (63.8%) locations. Tonkawa (cv) produced the lowest extraction rate followed by Custer (cv).

In the Southwest agricultural district (Table 7), Coronado (cv) consistently ranked among the highest (>64%) out of the cultivars sampled in all the areas, while Jagger (cv) constantly ranked lower (<61%).

CITED REFERENCES


### Table 1a. Summary of Physical Characteristics by Cultivar

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<tr>
<th>Cultivar</th>
<th>Bread Weight</th>
<th>Thousand Kernel Weight</th>
<th>Average Kernel Weight</th>
<th>Average Kernel Size</th>
<th>Total Kernel Weight</th>
<th>Total Weight 100 Kernels</th>
<th>Thousand Kernel Weight 100 Kernels</th>
<th>Average Kernel Weight 100 Kernels</th>
<th>Average Kernel Size 100 Kernels</th>
<th>Dry Matter Weight 100 Kernels</th>
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### Table 1b. Summary of Physical Characteristics by Cultivar

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### Table 2. Summary of Physical Characteristics by Location

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<th>Location</th>
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<td>7.0 ± 6.5</td>
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Table 3. Flour Extraction Yield (%)

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<th>Location</th>
<th>Average Extraction Yield (%)</th>
<th>Standard Deviation</th>
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<td>7.4 ± 6.9</td>
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Table 4. Flour Extraction Yield (%)

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Table 5. Flour Extraction Yield (%)

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1. Calculated extraction rate (%) by Quintault MFL
2. Calculated extraction rate (%) by Shaker MFL

Table 6. Flour Extraction Yield (%)

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Table 7. Flour Extraction Yield (%)

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1. Calculated extraction rate (%) by Quintault MFL
2. Calculated extraction rate (%) by Shaker MFL
Figure 1. Percent Distribution of Protein and Physical Characteristics of Cultivar 2137 Across 14 Locations

A. Percent Distribution of Protein

B. Percent Distribution of Test Weight

C. Percent Distribution of Single Kernel Weight

D. Percent Distribution of Single Kernel Diameter

E. Percent Distribution of Large Kernel Size

F. Percent Distribution of Medium Kernel Size
Figure 2.
Percent Distribution of Protein and Physical Characteristics of Cultivar 2163 Across 14 Locations

- **Protein**
  - Percent Distribution
  - Percent Protein (%):
    - r 10
    - 11
    - 12
    - 13
    - 14

- **Test Weight**
  - Percent Distribution
  - Test Weight (kg/ha):
    - r 54
    - 55
    - 56
    - 57
    - 58

- **Single Kernel Weight**
  - Percent Distribution
  - Average Weight (mg):
    - r 20
    - 21
    - 22
    - 23
    - 24

- **Single Kernel Diameter**
  - Percent Distribution
  - Average Diameter (mm):
    - r 1.3
    - 1.4
    - 1.5
    - 1.6
    - 1.7

- **Large Kernel Size**
  - Percent Distribution
  - Large Kernel Size (%):
    - r 42
    - 43
    - 44
    - 45
    - 46

- **Medium Kernel Size**
  - Percent Distribution
  - Medium Kernel Size (%):
    - r 42
    - 43
    - 44
    - 45
    - 46
Figure 3. Percent Distribution of Protein and Physical Characteristics of Cultivar 2174 Across 14 Locations

A. Percent Distribution of Protein

B. Test Weight

C. Single Kernel Weight

D. Single Kernel Diameter

E. Large Kernel Size

F. Medium Kernel Size
Figure 4.
Percent Distribution of Protein and Physical Characteristics of Cultivar 7853 Across 14 Locations
Figure 5.
Percent Distribution of Protein and Physical Characteristics of Cultivar Betty Across 14 Locations

A. Percent Distribution of Protein

B. Percent Distribution of Test Weight

C. Percent Distribution of Single Kernel Weight

D. Percent Distribution of Single Kernel Diameter

E. Percent Distribution of Large Kernel Size

F. Percent Distribution of Medium Kernel Size
Figure 6.
Percent Distribution of Protein and Physical Characteristics of Cultivar Big Dawg Across 14 Locations

A. Protein

B. Test Weight

C. Single Kernel Weight

D. Single Kernel Diameter

E. Large Kernel Size

F. Medium Kernel Size
Figure 7. Percent Distribution of Protein and Physical Characteristics of Cultivar Champ Across 14 Locations
Figure 8.
Percent Distribution of Protein and Physical Characteristics of Cultivar Chisholm Across 14 Locations

- **A.** Percent Distribution of Protein (32 kDa)
- **B.** Percent Distribution of Test Weight (8.6 g)
- **C.** Percent Distribution of Single Kernel Weight
- **D.** Percent Distribution of Single Kernel Diameter
- **E.** Percent Distribution of Large Kernel Size
- **F.** Percent Distribution of Medium Kernel Size
Figure 9. Percent Distribution of Protein and Physical Characteristics of Cultivar Coronado Across 14 Locations

A. Protein

B. Test Weight

C. Single Kernel Weight

D. Single Kernel Diameter

E. Large Kernel Size

F. Medium Kernel Size
Figure 10.
Percent Distribution of Protein and Physical Characteristics of Cultivar Custer Across 14 Locations
Figure 11.
Percent Distribution of Protein and Physical Characteristics of Cultivar Dominator Across 14 Locations
Figure 12.
Percent Distribution of Protein and Physical Characteristics of Cultivar Heyne Across 14 Locations
Figure 13.
Percent Distribution of Protein and Physical Characteristics of Cultivar Jagger Across 14 Locations
Figure 14. Percent Distribution of Protein and Physical Characteristics of Cultivar Karl Across 14 Locations

A. Protein

B. Test Weight

C. Single Kernel Weight

D. Single Kernel Diameter

E. Large Kernel Size

F. Medium Kernel Size
Figure 15.
Percent Distribution of Protein and Physical Characteristics of Cultivar Lockett Across 14 Locations
Figure 16.
Percent Distribution of Protein and Physical Characteristics of Cultivar Ogallala Across 14 Locations

A. Percent Distribution of Protein (GSMG)

B. Test Weight

C. Single Kernel Weight

D. Single Kernel Diameter

E. Large Kernel Size

F. Medium Kernel Size
Figure 17.
Percent Distribution of Protein and Physical Characteristics of Cultivar Oro Blanco Across 14 Locations
Figure 18.
Percent Distribution of Protein and Physical Characteristics of Cultivar Tam 302 Across 14 Locations

A. Protein

B. Test Weight

C. Single Kernel Weight

D. Single Kernel Diameter

E. Large Kernel Size

F. Medium Kernel Size
Figure 19.
Percent Distribution of Protein and Physical Characteristics of Cultivar Tomahawk Across 14 Locations

A. Percent Distribution of Protein

B. Test Weight

C. Single Kernel Weight

D. Single Kernel Diameter

E. Large Kernel Size

F. Medium Kernel Size
Figure 20.
Percent Distribution of Protein and Physical Characteristics of Cultivar Tonkawa Across 14 Locations
Figure 21. Percent Distribution of Protein and Physical Characteristics at the Altus Location Across 20 Cultivars

A. Percent Distribution of Protein (120mg)

B. Percent Distribution of Test Weight (B/A)

C. Percent Distribution of Single Kernel Weight (mg)

D. Percent Distribution of Single Kernel Diameter (mm)

E. Percent Distribution of Large Kernel Size (10)

F. Percent Distribution of Medium Kernel Size (10)
Figure 22.
Percent Distribution of Protein and Physical Characteristics at the Alva Location Across 20 Cultivars
Figure 23.
Percent Distribution of Protein and Physical Characteristics at the Apache Location Across 20 Cultivars

A) Percent Distribution of Protein

B) Percent Distribution of Test Weight

C) Percent Distribution of Single Kernel Weight

D) Percent Distribution of Single Kernel Diameter

E) Percent Distribution of Large Kernel Size

F) Percent Distribution of Medium Kernel Size
Figure 24.
Percent Distribution of Protein and Physical Characteristics at the Cherokee Location Across 20 Cultivars
Figure 25. Percent Distribution of Protein and Physical Characteristics at the Chickasha Location Across 20 Cultivars

A. Protein

B. Test Weight

C. Single Kernel Weight

D. Single Kernel Diameter

E. Large Kernel Size

F. Medium Kernel Size
Figure 26.
Percent Distribution of Protein and Physical Characteristics at the Elk City Location Across 20 Cultivars

A. Percent Distribution of Protein

B. Percent Distribution of Test Weight

C. Percent Distribution of Single Kernel Weight

D. Percent Distribution of Single Kernel Diameter

E. Percent Distribution of Large Kernel Size

F. Percent Distribution of Medium Kernel Size
Figure 27.
Percent Distribution of Protein and Physical Characteristics at the Frederick Location Across 20 Cultivars

A. Protein Distribution

B. Test Weight Distribution

C. Single Kernel Weight Distribution

D. Single Kernel Diameter Distribution

E. Large Kernel Size Distribution

F. Medium Kernel Size Distribution
Figure 28. Percent Distribution of Protein and Physical Characteristics at the Gage Location Across 20 Cultivars

A. Protein

B. Test Weight

C. Single Kernel Weight

D. Single Kernel Diameter

E. Large Kernel Size

F. Medium Kernel Size
Figure 29. Percent Distribution of Protein and Physical Characteristics at the Goodwell, Dryland Location Across 20 Cultivars

- **Protein**
  - Percent Distribution
  - Categories: 10, 11, 12, 13, 14
  - Values: 10, 40, 50, 25, 15

- **Test Weight**
  - Percent Distribution
  - Categories: 54, 55, 56, 57, 58, 59, 60
  - Values: 13, 13, 13, 13, 10, 10

- **Single Kernel Weight**
  - Percent Distribution
  - Categories: 20, 24, 28, 32, 36
  - Values: 15, 40, 25, 15, 15

- **Average Diameter**
  - Percent Distribution
  - Categories: 1.5, 1.8, 2.2, 2.5, 2.8
  - Values: 13, 40, 29, 29, 29

- **Large Kernel Size**
  - Percent Distribution
  - Categories: 4.0, 4.5, 5.0, 5.5, 6.0
  - Values: 10, 25, 25, 25, 10

- **Medium Kernel Size**
  - Percent Distribution
  - Categories: 4.0, 4.5, 5.0, 5.5, 6.0
  - Values: 50, 13, 25, 5, 1
Figure 30. Percent Distribution of Protein and Physical Characteristics at the Goodwell, Irrigated Location Across 20 Cultivars

A) Percent Distribution of Protein

B) Percent Distribution of Test Weight

C) Percent Distribution of Single Kernel Weight

D) Percent Distribution of Single Kernel Diameter

E) Percent Distribution of Large Kernel Size

F) Percent Distribution of Medium Kernel Size
Figure 31.
Percent Distribution of Protein and Physical Characteristics at the Haskell Location Across 20 Cultivars

A. Percent Distribution of Protein

B. Percent Distribution of Test Weight

C. Percent Distribution of Single Kernel Weight

D. Percent Distribution of Single Kernel Diameter

E. Percent Distribution of Large Kernel Size

F. Percent Distribution of Medium Kernel Size
Figure 32.
Percent Distribution of Protein and Physical Characteristics at the Lahoma Location Across 20 Cultivars

A. Percent Distribution of Protein

B. Test Weight

C. Single Kernel Weight

D. Single Kernel Diameter

E. Large Kernel Size

F. Medium Kernel Size
Figure 33. Percent Distribution of Protein and Physical Characteristics at the Lamont Location Across 20 Cultivars

A. Percent Distribution of Protein

B. Test Weight

C. Single Kernel Weight

D. Single Kernel Diameter

E. Large Kernel Size

F. Medium Kernel Size
Figure 34.
Percent Distribution of Protein and Physical Characteristics at the Marshall Location Across 20 Cultivars

This OSU Experiment Station Research Report is also available on the World Wide Web at: http://www.okstate.edu/ag/fapc